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Front Cover

This close-up photo of a harem of greater spear-nosed bats (*Phyllostomus hastatus*) was taken in Cueva Club de Montaña in central Panama. The cave was not long—just 46 meters of passage—but had nice speleothems, and there were six species of bats using it as a day roost (*P. hastatus, Artibeus jamaicensis, Saccopteryx leptura, Desmodus rotundus, Carollia perspicillata*, and *Glossophaga* sp.). Five harems of *P. hastatus* were noted, and this harem had 19 bats (including the dominant male). The total bat population in the cave was roughly 450 bats. Photo by Keith Christenson.

The Seminole Bat (*Lasiurus seminolus*) and Virginia Big-eared Bat (*Corynorhinus townsendii virginianus*) in Pennsylvania

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Of the eleven bat species currently listed in Pennsylvania (Merritt, 1987), the rarest is the Seminole bat (*Lasiurus seminolus*), with only two records (Poole, 1932; Poole, 1949). Both specimens—one from Hopewell, Berks Co., in 1931, and one from Fishing Creek, Lancaster Co., in 1945—were taken by S. Wishnieski of the Reading Public Museum. The circumstances under which these bats occurred in Pennsylvania remain suspect, although it is postulated that severe weather during fall migration may have played a role. Since collection of these specimens, no others were reported, until one was submitted to the Pennsylvania State Veterinary Laboratory for rabies testing during October 2006.

The specimen was preserved as a skin and skull in the collection of the Pennsylvania Veterinary Laboratory (#0611665). Total length of the bat was 97 mm; length of tail, 44 mm; length of forearm, 37 mm; length of hind foot, 8 mm; and height of ear, 10 mm. Body mass could not be ascertained due to desiccation of the specimen. All measurements fall within the ranges of those listed by Wilkins (1987) for the Seminole bat, although these measurements do overlap with those of the red bat, *Lasiurus borealis* (Shump and Shump, 1982). The skull of the Seminole bat was too badly damaged to conduct any morphometric comparisons. Figure 1 shows this Seminole bat compared to a male and female red bat. Although the photograph is grayscale, note the darkness of the fur on the lower specimen. Identification of the specimen as a Seminole bat was based primarily on these differences in pelage.

The Seminole bat was found 0.1 km N and 0.1 km E of Stahlstown, Westmoreland Co. Primary habitat in the area consists of forested ridges and open valleys, although the bat was found dead next to a private residence and may have been killed by domestic cats. There is a chance that the bat was transported to Pennsylvania by the property owner, since the family had recently visited Asseteague Island, Virginia. Nevertheless, Seminole bats are not generally reported from Virginia either (Wilkins, 1987).

The Virginia big-eared bat (*Corynorhinus townsendii virginianus*) has never been listed as part of Pennsylvania's native mammalian fauna (Merritt, 1987), although skeletal remains of a big-eared bat were part of paleontological material recovered from Frankstown Cave, Blair Co. (Guilday, 1961). However, that material could not be assigned to subspecies due to a lack of cranial elements, although Guilday (1961) postulated that it was indistinguishable from modern specimens of the Virginia big-eared bat from West Virginia.

Recently, biologists in Pennsylvania compiled a list of specimens of all mammals from the state that are held at various museums in the United States and Canada (Hart and Davis, 2004). During creation of this database, a single specimen of the

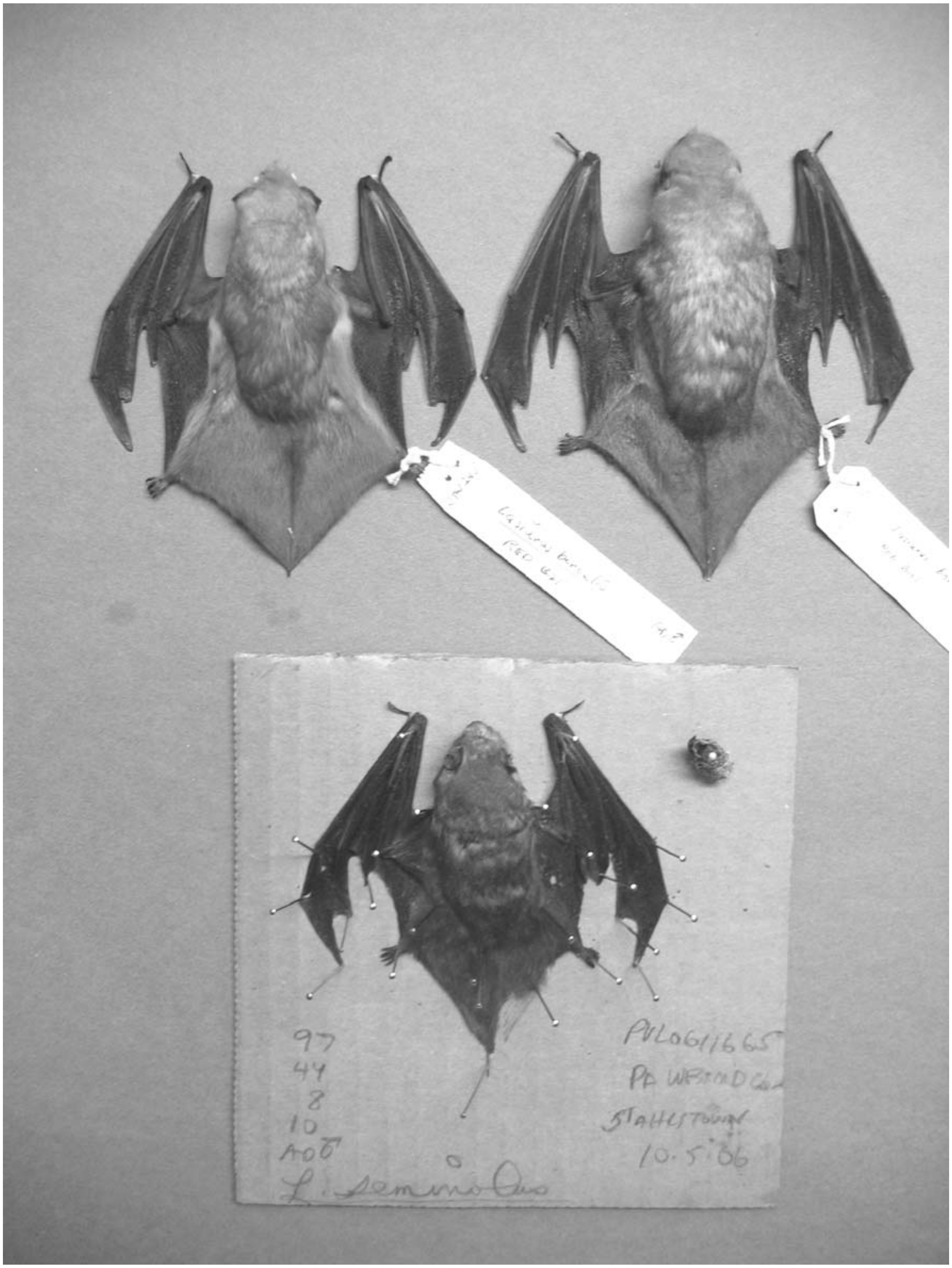

Figure 1. A male and female eastern red bat (top) and a male Seminole bat (bottom) from Pennsylvania. Note darker pelage in the Seminole bat.

Virginia big-eared bat from Pennsylvania was discovered in the Museum of Vertebrate Zoology at the University of California, Berkeley (#168668). Contact with James L. Patton at the museum revealed that Philip Krutzsch had collected and preserved the specimen in alcohol on 29 December 1957, as part of a series of bats from Pennsylvania. Although the specimen was unavailable for inspection, a photograph was sent, and the specimen definitely is recognizable as a big-eared bat, although the species is not apparent (Fig. 2). Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) has not been reported north of southern Virginia (Jones, 1977), extreme southwestern West Virginia (Craig Stihler, pers. comm.), and Kentucky (Barbour and Davis, 1969; Jones, 1977), so the specimen at Berkeley likely is *C. townsendii*.

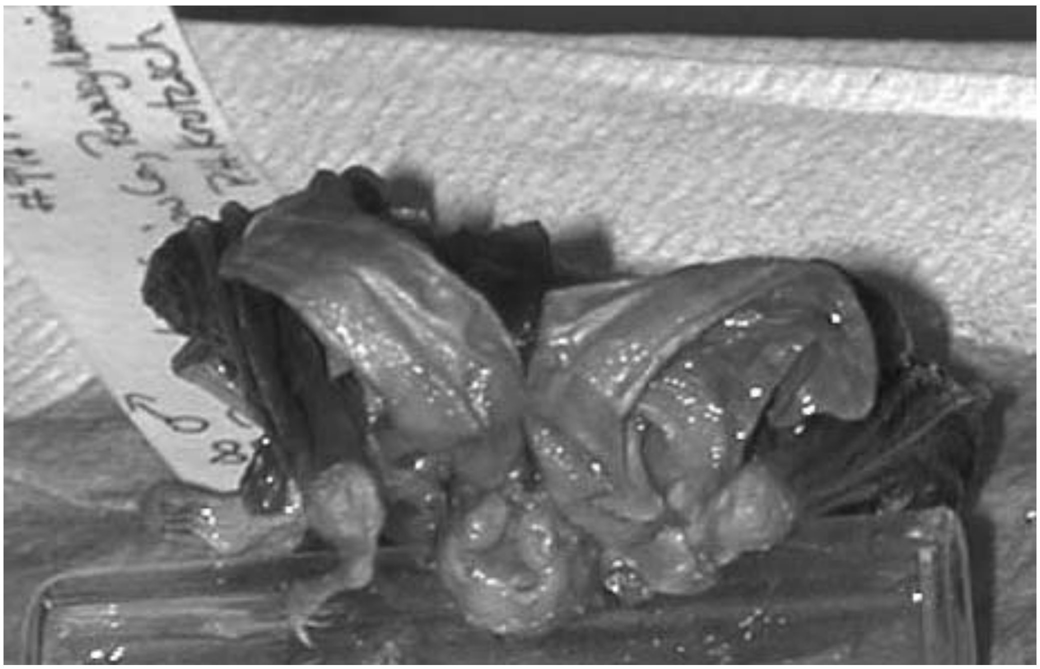

Figure 2. A Virginia big-eared bat from Pennsylvania in the collection of the Museum of Vertebrate Zoology, University of California, Berkeley.

Information concerning this specimen came from Krutzsch's original field notes. The bat, an adult male, was taken in a portion of Barton's Cave, Fayette Co. (39˚46'N 79˚41'W), with temperatures ranging from 8.8–10.0˚ C; this part of Barton's Cave is only ca. 120-m long and contains a small stream. The bat was roosting in association with 4 eastern pipistrelles (*Perimyotis subflavus*) and 11 little brown bats (*Myotis lucifugus*); all bats were in deep hibernation and covered with droplets of moisture. "The lumped nosed bat hung from the ceiling, and its ears were rolled as is classic for hibernating *Corynorhinus*" (P. Krutzsch, unpublished observation). During subsequent visits by Krutzsch, no other Virginia big-eared bats were located. Similarly, intensive mid-winter surveys conducted by the Pennsylvania Game Commission over the last 20 years at Barton's Cave and other hibernacula across Pennsylvania failed to reveal any recent winter populations, and no reports of summer colonies exist.

Acknowledgments.—The authors thank J. L. Patton (Museum of Vertebrate Zoology) for providing photos of the big-eared bat, and W. Meshaka (State Museum of Pennsylvania) and M. Gannon (Pennsylvania State University-Altoona) for reviewing the manuscript. The Dimitroff family provided hospitality to the lead author during his visit to interview them concerning the Seminole bat. This paper is dedicated by the first author to his mentor, colleague, and friend, Gordon L. Kirkland, Jr., deceased.

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RECENT LITERATURE

Authors are requested to send reprints or PDF files of their published papers to the Editor for Recent Literature, Dr. Jacques P. Veilleux (Department of Biology, Franklin Pierce University, Rindge, NH 03461, U.S.A., e-mail: **veilleuxj@franklinpierce.edu**) for inclusion in this section. Receipt of reprints is preferred, as it will facilitate complete and correct citation. However, if reprints and/or PDF files are 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 and appreciated.

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BOOK REVIEW

Bats of Indiana. John O. Whitaker, Jr., Virgil Brack, Jr., Dale W. Sparks, James B. Cope, and Scott Johnson. Indiana State University, Center for North American Bat Research and Conservation, Terre Haute, Indiana. 59 pp., 2007.

I have known most the authors of this book for years and have respected them since the beginning of my career. One of the most important lessons that I learned from Dr. Whitaker is that, regardless of friendships or history, we as scientists must stay true to our profession. With that admonition in mind, I write this review of “Bats of Indiana,” as unbiased as I can.

In the introduction, the authors indicated that this book was written for the people of Indiana so that they may learn about bats and ultimately champion their conservation. I think this book went a long way toward that end. With the exception of one error about freezing carcasses for rabies testing, the facts of this book are on track, as expected. However, the authors could have done a better job of writing toward their intended audience, as well as a better job of refining this book. The division of labor among the authors in preparing the manuscript was fairly obvious from variation in writing style in the different sections. The book can be divided into two broad parts—general introductory information pertaining to bats and a series of species accounts.

The first half of the book, which contains the introductory information, is written in a technical fashion, as one would expect from a manuscript intended for a professional journal. Although it is fine reading for scientists, it lacks the draw and readability that a book for the layperson should have. Like many scientific manuscripts, the text is a bit choppy, occasionally jumping between facts and ideas, with little transition or guidance. As scientists and biologists, we work hard to remove unneeded verbosity from our writing; however, a good book for public education must retain this feature, to a degree, to capture and retain the readers, their imagination, and their passion. Unfortunately, the authors also break a few cardinal rules, such as switching between Fahrenheit and Celsius scales of temperature measurement and between metric and English units of mass and distance, and occasionally repeating themselves within a few sentences (e.g., defining the term host specific twice within four sentences). These problems appear to be the result of poor proof reading. Furthermore, the authors sometimes use words and formatting that the public is not likely to understand; for example, even though there is a glossary, terms such as extirpated, guard hairs, or forearm length are not included. Listing authorities for each species, as well as the appearance of odd scientific name in the text, can be confusing to the general public without some explanation. I would have liked the authors to explain a few of the simpler concepts about bats, such as what is a *Myotis* and why we are suddenly calling a particular species a little brown myotis instead of a little brown bat. A short section on how biologists identify bats would help to explain why information such as forearm length and presence of a calcar are provided.

I found the 12 species accounts to be well written, informative, and entertaining. The narratives about each species’ habits often read like a story, with interesting anecdotes, such as a mink preying on Indiana bats and creating caches, or how the little brown myotis “drops into the air from its day time roost…flies to a nearby pond. . .[and] skims the surface, getting a drink by dragging its lower jaw in the water” (p. 27). It is difficult to pick out many good examples of this because they are so seamlessly interwoven within the general information. However, I am certain this approach will increase the interest and retention of the readers, as they find a wealth of knowledge to lead them toward the author's goal of learning and hopefully conserving bats and their habitats.

I found the descriptions of the species within the accounts to be less helpful than I would have liked for the intended audience. The descriptions were perfect for an aspiring bat biologist, who will be handling these bats and identifying them in the field, but the general public will not and should not be handling bats. Therefore, the public needs more than discussions of toe hairs and calcars to identify these bats, even if those are the most reliable traits.

The range maps for the species were well done. Mapping the actual locations of bat captures was very helpful and interesting, and I am sure that creating the maps was very time consuming. The phrase "R = rabies lab record" appears in the legend for each range map and R's appear on the range maps; however, it is unclear what they mean. Readers may interpret these to indicate that a rabid bat was recorded from each location. This could create unwarranted concerns in a public that poorly understands rabies and especially rabies in bats.

One line drawing and 40 photographs accompany the text. However, the photos were of mixed quality. Some pictures of parasites and insect fragments extracted from feces were amazing, but other photos looked extremely dated due to either content or poor color reproduction. Nevertheless, the content of most photos was still helpful, and some previously unpublished photographs, such as the comparison between the Indiana and little brown myotis on p. 37, were an excellent addition.

Despite the minor flaws, I commend the authors on supplying an excellent source of information for teachers and the general public. These types of books are worthwhile and provide reliable and helpful information to the public and our next generation.

Tim Carter, Ball State University, Muncie, IN 47306; E-mail: tccarter@bsu.edu

NEWS

Elodie Maitre (Dr. Bernard Sigé's lab) received her doctorate from the University Claude Bernard Lyon 1, France, in April 2008. Here is a summary of her findings and information about ordering a copy of her doctoral thesis, entitled "The Paleokarstic Chiroptera of Western Europe, from the Middle Eocene Epoch to the Early Oligocene Epoch, based on New Material from the Quercy Region (SW France): Systematics, Phylogeny, Paleobiology."

> The relevant material from 90 mostly paleokarstic localities of the Quercy plateau area (SW France) has been gathered together in order to study in a significant extent the evolution and diversity of the bats from the middle Eocene (~ 44 Myr) up to the early late Oligocene (~ 29 Myr). The morphological and biometrical observations and comparisons of the tooth material allowed recognizing 7 families, 10 genera, and 52 species. Several taxa of various rank are described as new ones (1 family, 2 genera, 1 subgenus, and 21 species).
>
> Thanks to these data and the long involved time extent (more than 10 myr), this work suggested some phyletic hypothesis. Among others are discussed the relationships between the new mixopterygid fossil family and the fossil and extant emballonurid and hipposiderid families, and by the way their phylogenetic molecular data. The peculiar *Necromantis* genus being now documented, its peculiar lower molar pattern was exemplified as defining the plesiomorphic necromantodont pattern among bats. Even if the *Necromantis* affinities still remain unclear, the new data allowed showing its previous megadermatid attribution to be irrelevant.
>
> Thanks to the available bat data, the relative age assessment of yet unstudied and undated localities, characterized by bat species with a given size and tooth morphology, were proposed referring to standard biochronal stages. Also, further data were supplied for faunas previously dated with the numerical age method.
>
> The taxonomic biodiversity of the studied faunas was evaluated using other available data (humerus, wing-shape, tooth wear) and when possible it was illustrated from the studied material. This approach showed us the unavoidable need to record the present bat faunas in order to correctly understand the fossil ones. So, two quantitative analyses are realized bringing out information about the structure of the fauna. First a Principal Component Analysis of the toothshape showed that the premolars (P4/4) and molars length/ width ratio is characteristic for each genus. Second, the comparison of fossil and present bat cenograms suggested that the body weight distribution of a given community is linked to the nature of the environment in which it evolves. Finally, these analyses allowed us to deduce some bat evolutionary modalities, either by the variation of weight interval, either by the proportions of the different weight categories. They showed that extinctions preferentially affect species being extreme as regards morphology or weight. In particular, this allowed discussing the effect of Stehlin's "Grande Coupure" faunal event over the Western European bats at the Eocene-Oligocene boundary.

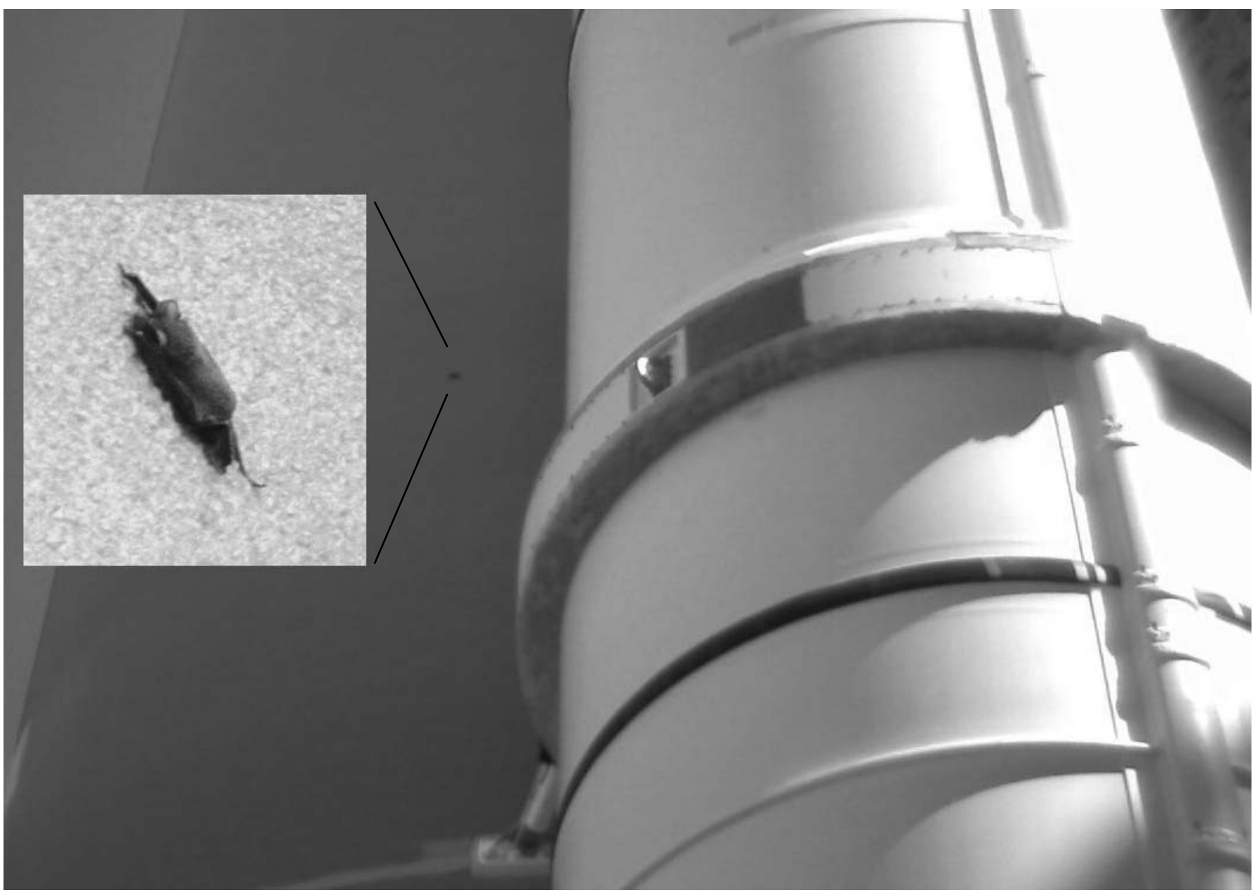
To order a copy of the thesis on CD, please contact Elodie (elodie.maitre@ens-lyon.fr), and include your complete mailing address and arrangements for payment. The cost is 5.50 Euros (includes CD, pocket, and postal costs).

Request for Information

Bernard Sigé (Castres, France) is requesting information regarding an educational TV program on Bracken Cave that he recently saw. The program presented detailed information about the cave and the *Tadarida* that inhabit it, showing spectacular footage of the dense black cloud as the bats exit the cave. If anyone has information about this program and, hopefully, how to obtain a copy of it, please let us know (Bernard-Sige@orange.fr OR griffm@lycoming.edu).

STS-119 Bat-ronaut Part of Discovery's Mission

Perhaps some of you viewed the space shuttle Discovery's launch on Sunday, March 15th. But did you see the stowaway bat attempting to hitch a ride on it? A free-tailed bat (most likely *Eumops glaucinus*, the Florida Mastiff Bat) was seen clinging to Discovery's attached external fuel tank. The bat was first seen on Sunday morning as the tank was being filled with liquid hydrogen and liquid oxygen propellant. IR imagery showed that he was alive and not frozen like many would think (according to our source, the surface of the external tank's foam was probably between 60–80º F on that day). The bat did change position from time to time throughout the countdown but never flew away, and ultimately a waiver was written to accept the stowaway. The bat was dubbed the "STS-119 Bat-ronaut" by Mission Control. For more information about this story see:
http://www.space.com/missionlaunches/090315-sts119-bat-stowaway.html
http://www.nasa.gov/mission_pages/shuttle/shuttlemissions/sts119/launchbat.html



Information courtesy of Renee Ross, member of the Flight Data File team for the current NASA mission. Photographs courtesy of NASA.

ANNOUNCEMENTS

2009 Bat Conservation International Workshops

Bat Conservation International (BCI) is once again offering a series of field workshops to train interested individuals in current research and management techniques for the study of bats. **Bat Conservation and Management Workshops** will be held in Arizona (5–10 May or 11–16 May), Kentucky (14–19 July), and Pennsylvania (14–19 August). An **Acoustic Monitoring Workshop** will be held in Arizona (11–16 May) and will include discussions of current research along with hands-on demonstrations and fieldwork. Information and application forms are available at http://batcon.org/workshops or contact Peg Lau Hee (workshops@batcon.org) if you have questions.

Bat Study Techniques Workshop

To provide training for biologists wanting to conduct bat studies, we are pleased to present a comprehensive 3-day, 3-night curriculum on basic bat study techniques. This course was jointly developed by Bat Conservation International and Bat Conservation and Management, Inc. The sessions are scheduled for 26–28 May 2009 near Morristown NJ and 21–23 August 2009 near Uniontown PA. Information and registration forms are available at:
http://www.batmanagement.com/Programs/programcentral.html

New Distance Learning Course on Bat Biology

In September 2009, the University of Western Ontario (London, ON) will offer a one-semester distance learning course on bat biology, which includes both lecture and laboratory components. The course, Biology 32222z, “Biology of Bats,” uses bats to explore biodiversity, from form and function, behavior and ecology to evolution and adaptive radiation. The course will cover details of flight and echolocation as well as the origin and evolution of bats and how the latter has been influenced by zoogeography. Also included will be interactions between bats and people and bat conservation issues. The goal of the course is to use bats as a model for exploring biological systems. For more information about the course and registration, contact Dr. Brock Fenton (bfenton@uwo.ca).

Request for Manuscripts — *Bat Research News*

Original research/speculative review articles, short to moderate length, on a bat-related topic would be most welcomed. Please submit manuscripts as MSWord documents to Allen Kurta, Editor for Feature Articles (akurta@emich.edu). If you have questions, contact either Al (akurta@emich.edu) or Margaret Griffiths (griffm@lycoming.edu). Thank you for considering submitting some of your work to *BRN*.

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If you plan to move, please **send** your **new address** to the managing editor/publisher, Margaret Griffiths (griffm@lycoming.edu), as soon as possible. The U.S. Postal Service is changing how it handles undelivered bulk mail items. The good news is this means that bulk mail items (e.g., *BRN*) will be forwarded—provided you file a “Change of Address Form” with your local post office—or returned to sender. The bad news is *BRN* will be required to pay the First Class postage on each and every item that is forwarded or returned. Thank you in advance for helping us keep costs down!

FUTURE MEETINGS and EVENTS

19–26 July 2009
The 15th International Congress of Speleology will be held in Kerrville, Texas. Call for Papers and other information about the Congress can be found at: http://www.ics2009.us/papers.html

9–14 August 2009
The 10th International Mammalogical Congress will be held in Mendoza, Argentina. Proposals for symposia are welcome, and preliminary registration can be made at this time. For more information please see: http://www.cricyt.edu.ar/imc10/

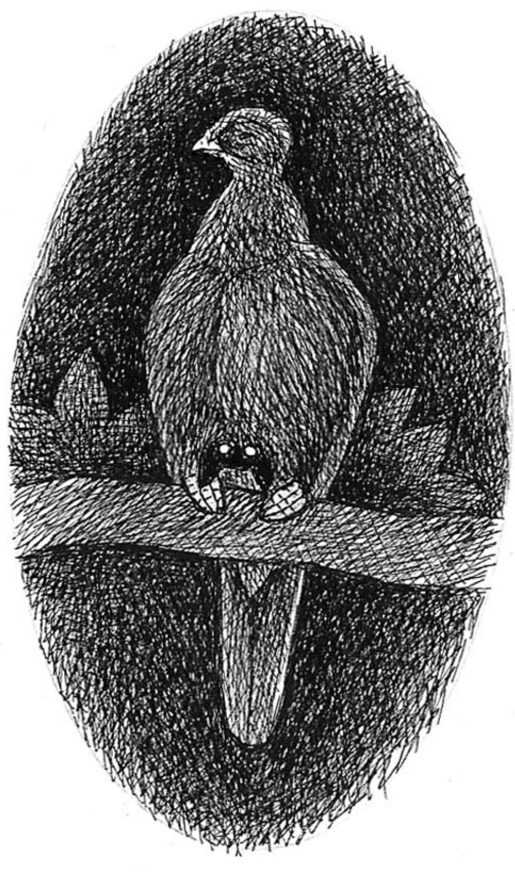
4–7 November 2009
The 39th Annual NASBR will be held in Portland, Oregon. Please see http://www.nasbr.org/ for information.

2010
The XVth International Bat Research Conference (IBRC) will be held in Czech Republic, dates to be announced.

2010
The 40th Annual NASBR will be held in Denver, CO. Please see http://www.nasbr.org/ for information.

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

BAT RESEARCH NEWS



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A hairy-legged vampire bat, *Diphylla ecaudata*, peers out from the body of a pea hen in Bill Schutt's "Dark Banquet: Blood and the Curious Lives of Blood-Feeding Creatures" (reviewed in this issue). Figure copyright 2008 by Patricia J. Wynne.

Notes on Mortality of Eastern Red Bats (*Lasiurus borealis*), Including a Copulating Pair, in Great Smoky Mountains National Park, Tennessee

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In a 30-day period, staff members of the Great Smoky Mountains Institute at Tremont (GSMIT), a residential environmental education center located in the western section of Great Smoky Mountains National Park, Tennessee (35°38'24.0" N, 83°41'20.7" W; elevation 410 m), found four freshly killed eastern red bats (*Lasiurus borealis*). Two specimens were found along Tremont Road, a 3.4-km-long, paved, two-lane road leading to GSMIT. The road parallels the Middle Prong of the Little River and is bordered by hardwood and evergreen forest that is comprised of species such as red maple (*Acer rubrum*), black birch (*Betula lenta*), sweetgum (*Liquidambar styraciflua*), and eastern hemlock (*Tsuga canadensis*). Bats often use the road and nearby stream as foraging corridors (J. P. Love, personal observation).

On 11 September 2007, a staff member of GSMIT hit a female *L. borealis* with his vehicle's front windshield at ca. 2100 h on Tremont Rd. The specimen was placed in a freezer, and standard measurements (in mm) were taken the following day. Total length of the specimen was 101; tail length, 40; length of hind foot, 8; height of ear, 9; height of left tragus (right tragus was missing), 4; and length of forearm, 42. Body mass was 13.7 g. The specimen appeared to have died from blunt trauma to the head, as the face was disfigured and blood-stained.

On 19 September 2007, another staff member found a freshly-dead male *L. borealis* while driving along the same road. The specimen also was placed in a freezer, and standard measurements were taken the following day: total length, 98; tail length, 45; length of hind foot, 9; height of ear, 9; height of tragus, 4; and length of forearm, 37. Body mass was 9.3 g. Because of the nature of its external injuries (fractured ulna and radius), it is likely that this bat also was hit by a vehicle while flying.

In addition to the two *L. borealis* found along Tremont Road, a pair of copulating *L. borealis* was found dead, but still warm, in a paved parking lot at GSMIT on 11 October 2007. The male appeared to have died from blunt trauma to the head, but there were no visible external injuries to the female. The specimens were still locked in copulation. The right thumb of the male was lodged in the upper right wing membrane of the female, ca. 7 mm below the wrist, between the female's forearm and fifth metacarpal, whereas the left thumb of the male was firmly latched in the skin on the back of the female, 24 mm from the tip of the nose. This position caused the right wing of the female to be "pinched," possibly causing the pair to plummet out of control to the ground. This particular parking lot is open only to staff, is located at the end of the road, and often has educational groups walking along it, so vehicles generally travel at velocities <15 km/h. For these reasons, it is unlikely that the pair died by colliding with a vehicle, and I speculate that the cause of death was the impact of the fall. The pair was placed in a freezer and measured the next day. Because the bats were still locked in copulation, I did not measure total length, tail length, or weight. Measurements for the male were: length of hind foot, 7; height of ear, 8; height of tragus, 4; and length of forearm, 39. Length of hind foot of the female was 9; height of ear, 8; height of tragus, 5 mm; and length of forearm, 42. All specimens were discarded after measurements were taken.

Accounts of mortality in *L. borealis* include predation by blue jays (*Cyanocitta cristata*—Allan, 1947) and loggerhead shrikes (*Lanius ludovicianus*—Sarkozi and Brooks, 2003), as well as collision with various human-made objects. Eastern red bats have collided with wind turbines (Johnson et al., 2003), buildings (Timm, 1989), and airplanes (Martin et al., 2005). Furthermore, collisions between *L. borealis* and vehicles have been documented previously in Michigan (Farmer, 1998), Puerto Rico (Starrett and Rolle, 1962), and Wisconsin (Long, 1976).

There are previous accounts of *L. borealis* tumbling from the sky while locked in copulation (Glass, 1965; Saugey et al., 1989, 1998; Stuewer, 1948), though this is the first account of death presumably resulting from the impact of the fall. Mating by *L. borealis* occasionally occurs in spring (Linzey, 1995; Saugey et al., 1998), but like most North American species, *L. borealis* generally mates in August and September (Dodd and Adkins, 2007; Glass, 1965; Layne, 1958; Shump and Shump, 1982; Stuewer, 1948; Whitaker and Mumford, 1972). Although Saugey et al. (1998:95) mention copulating pairs "in September and October," the date of 11 October for the pair found at GSMIT appears to be the latest specific date for mating by *L. borealis*.

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IN MEMORIAM

Gerhard Neuweiler: 1935–2008

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Gerhard Neuweiler, one of the pioneers in the study of bat echolocation, died on 15 August 2008, in a hospital in Munich after a prolonged illness. He was born on 18 May 1935, in a small village in the Black Forest region of Germany. After public school, he attended the Gymnasium in Calw and started his academic career as a student at the University of Tübingen. There, he studied the physiology of vision in flying foxes, under the supervision of Franz Möhres, receiving his Dr. rer. nat. (Doctorate in Natural Sciences) degree in 1962. During 1963–1964, he pursued his studies with Megachiroptera at the Department of Zoology of the University of Madras in India, as a fellow of the government of India and of the German Academic Exchange Service. In 1964, he returned to Tübingen as an assistant professor (1964–1970), and after his Habilitation (postdoctoral lecture qualification) in 1970, he was promoted to associate professor in the Department of Animal Physiology. At this time, his interest turned from vision and social behavior of flying foxes to the echolocation behavior of microchiropteran bats. His initial work in this field is documented by important papers on the echolocation behavior and spatial memory of *Megaderma lyra* and on the auditory threshold of *Rhinolophus ferrumequinum*.

During this time, Gerhard and others developed the concept of working together democratically in a so called "*Arbeitsgruppe*," meaning a team of scientists with overlapping fields and common research interests. This concept proved to be very productive, promoting Gerhard's career enormously. He soon became the Chair of Zoology at the University of Frankfurt (1972–1980) and subsequently was named to the highly renowned Chair of Zoology at the University of Munich (1980–2003), where he continued to work in the tradition of Karl von Frisch and Hansjochem Autrum. In the field of echolocation, Gerhard's name is closely linked with the term "acoustic fovea," a specialization of the auditory system that is found in bats using long constant frequency echolocation signals and Doppler shift compensation. In a farewell party after his retirement, he made the statement that he considered this the main finding in his scientific career. However, he also published important reviews on "Foraging Ecology and Audition in Echolocating Bats" (Trends in Ecology and Evolution, 4:160–166, 1988) and on "Auditory Adaptations for Prey Capture in Echolocating Bats" (Physiological Reviews, 70:615–641, 1990), as well as a well-known book entitled *Die Biologie der Fledermäuse* (Thieme Verlag, Stuttgart, Germany, 1993), which has been translated into English (Oxford University Press, New York, Oxford, United Kingdom, 2000).

In the last years of his life, Gerhard became a friend of the composer György Ligeti, whom he met during a one-year stay (2000–2001) at the School of Advanced Studies in Berlin. The friendship resulted in a book on "*Motorische Intelligenz*," in which the two authors exchange their opinion on the fascinating relationship between neurobiology and contemporary music (G. Ligeti and G. Neuweiler, *Motorische Intelligenz—Zwischen Musik und Naturwissenschaft*, Verlag Klaus Wagenbach, Berlin, 2007). By the end of his stay at the School of Advanced Studies in Berlin, Gerhard also finished a textbook on comparative neurobiology (*Neuro- und Sinnesphysiologie*, Springer Verlag, Berlin, 2005). His last book, which was published shortly after his death, can be seen as his philosophical legacy as scientist and teacher (*Und wir sind es doch—die Krone der Evolution*, Verlag Klaus Wagenbach, Berlin, 2008).

Gerhard was not only a highly renowned bat researcher but also a very gifted administrator and organizer of large research groups, for which he was equally successful at obtaining research funds. He headed the *Sonderforschungsbereich* (special research area) "Neurobiology of Behavior" in Frankfurt and the *Sonderforschungsbereich* "Audition" in Munich, which were supported by the German Science Foundation. From 1978–1985, he was head of the Indo-German Research Project on Animal Behaviour at Madurai University, India. Besides his scientific work, Gerhard had a deep interest in science administration and politics. He was a member of the senate of the German Research Foundation (1991–1997) and member (1988–1994) and head (1994) of the Science Advisory Board for Germany. From 2001–2002 he was president of the German Zoological Society. Additionally, he was a member of the advisory boards of many research institutions.

The importance of Gerhard's work is documented by numerous honors, including membership in the Bavarian Academy of Sciences, Munich, Germany; the Academia Europaea, Cambridge, United Kingdom; the German Science Academy "Leopoldina," Halle, Germany; and the Academy of Sciences Nordrhein-Westfalen, Düsseldorf, Germany. He also received the Karl Ritter von Frisch Prize of the Zoological Society and the Felix-Santschi Prize of the University of Zürich, and he was an honorary professor of the Department of Animal Behaviour and Neurobiology at Madurai University.

Gerhard had an enormous, positive impact on many students and colleagues and on German science administration. He touched many peoples' lives for the better. We remember him with appreciation and affection, and we miss him a great deal.

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Frank Clements Kallen: 1928–2004

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Frank Clements Kallen was born in Colonie, New York, on 27 May 1928. After he graduated from Nott Terrace High School in 1945, he was a theater manager from 1945 to 1951, when he enlisted in the United States Air Force. While in the military, Frank was an orderly, aviation cadet, duty pilot, and research and development officer. He performed overseas service in Japan and combat duty in Korea, before leaving the Air Force with the rank of captain. After his military service, Frank earned a bachelor's degree in Zoology at Cornell University in 1957 and a doctorate from Cornell in 1960 in the field of histology and embryology, studying circulating blood volumes in the little brown bat (*Myotis lucifugus*). His mentor was the acclaimed chiropterologist William A. Wimsatt.

After a short stint at the University of Rochester (1960–1964), Frank became assistant professor of anatomy at the State University of New York at Buffalo (SUNY Buffalo). Rising through the ranks, he eventually became professor of anatomical sciences in 1975 and retired as emeritus in 1992, the same year in which he received an award for teaching excellence. During his tenure as professor, he guided the doctoral research of R. M. Webster (1970), N. D. Mohl (1971), K. P. Bhatnagar (1972), G. Gorniak (1976), D. R. Fish (1982), and M. J Cukierski (1986), as well as five master's theses, including those of R. Czarnecki and J. Kokoros.

Frank was an exceptionally talented person, who constantly displayed curiosity and creativity and performed everything with extreme finesse. He was a precise dissector and meticulous both in the laboratory and in creating manuscripts. Frank published many original articles, one of which was 194 pages long. He also was an artist who rendered many detailed figures for his own publications, and he teamed with Melford Diedrick to produce masterful drawings of the circulatory system in his chapter on the cardiovascular system in Wimsatt's *Biology of Bats*. The subjects that he investigated always pertained to bats, including manuscripts on hibernation, reproductive anatomy and physiology, blood circulation, the autonomic nervous system, water balance, renal histophysiology, olfaction, phonation, vision, and transmembrane potentials of the bat heart and wing veins.

For a few years after retirement, he continued to teach anatomy, succumbing to fatal illness on 25 February 2004. He is survived by his wife Marcie, whom he married in 1968, and daughters Judith Eleanor DelSorbo and Diane Kallen Breen.

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RECENT LITERATURE

Authors are requested to send reprints or PDF files of their published papers to the Editor for Recent Literature, Dr. Jacques P. Veilleux (Department of Biology, Franklin Pierce University, Rindge, NH 03461, U.S.A., e-mail: **veilleuxj@franklinpierce.edu**) for inclusion in this section. Receipt of reprints is preferred, as it will facilitate complete and correct citation. However, if reprints and/or PDF files are 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 and appreciated.

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BOOK REVIEWS

Bats of Michigan. Allen Kurta. Indiana State University, Center for North American Bat Research and Conservation, Terre Haute, Indiana.
72 pp., 2008. ISBN 13 978-0-9817096-1-1. ($10 United States)

Bats of Michigan represents an authoritative and interesting reference to the nine species of bats that reside in the state. The book is well written and organized with lively, compelling prose, mixed with whimsical comments that will surely appeal to a wide readership, from wildlife biologists to naturalists. For chiroptologists, *Bats of Michigan* also contains up-to-date information on the biology of bats living in the state. The book is well illustrated, containing 59 color images and 9 range maps. Bats have long suffered from a substandard public relations program that depicts these animals as sinister and evil creatures that readily become tangled in people's hair and spread a plethora of diseases; fortunately, this treatise dispels such ideas and effectively leads the reader to appreciate bats as fascinating and complex mammals that play a crucial role in the structure and function of ecosystems.

Allen Kurta is preeminently qualified to write this book. He has devoted much of his professional life to the study of mammals, especially bats, and is quite familiar with the mammalian fauna of Michigan and its varied ecosystems. Kurta previously has been involved in writing and editing numerous texts, guides, and symposia, such as *Mammals of the Great Lakes Region* and the *Indiana Bat: Biology and Management of an Endangered Species*.

Bats of Michigan is organized into four major parts: Basic Facts about Bats, Understanding Bats in Michigan, Identifying the Bats of Michigan, and Species Accounts. Within the first section, Kurta discusses bats, in general. A mention of bats and their roles in various cultures is followed by a description of structural diversity, in which the suborders Megachiroptera and Microchiroptera are briefly discussed. Next, a summary of diet includes effective photographs that compliment the narrative on insectivory, nectarivory, frugivory, sanguinivory, and piscivory. Echolocation is presented in a clear and concise fashion that helps the layperson visualize the complex concepts.

The second part, Understanding Bats in Michigan, focuses on the chiropteran fauna of the state. Here the author clearly defines torpor and hibernation, takes the reader on a "bat tour" of Michigan (including crucial characteristics of major hibernacula), and highlights details of reproduction, swarming, migration, and longevity. He also points out threats to local bats, such as predation, pesticides, loss of habitat, and the increasing number of wind turbines in Michigan. Furthermore, Kurta enlightens the public on proper techniques of evicting bats from buildings, as well as design and construction of bat houses.

A discussion of bats and public health provides the who, what, and where associated with external parasites and diseases, such as histoplasmosis and rabies. Understanding Bats in Michigan closes with a brief section on techniques for studying bats, in which the lucid text is augmented by high-quality color images of harp traps, mist nets, an eastern pipistrelle sporting a band, and a northern bat equipped with a radio transmitter.

The last half of the book is dedicated to a short tutorial on identifying bats, followed by species accounts. This section begins with a dichotomous key to adult bats of Michigan, which is easy to use and augmented by excellent images of characteristic structures. For example, Kurta photographically illustrates variation in morphology of the tragus needed to identify the evening bat, northern bat, and little brown bat. He also presents a clear picture of the keeled calcar of the Indiana bat, plus a close-up of hairs extending beyond the claws of a little brown bat. As in other portions of the book, measurements are presented in English units followed by metric units in parentheses.

The species accounts are comprehensive, up-to-date, and well-tailored to the Michigan environment. Color photographs are high in quality. Each account begins with the vernacular name and etymology of the scientific name, followed by a description of the animal, which highlights salient measurements and external characters that differentiate between potentially confusing species.

Range maps are provided for Michigan, with an inset of North America. They are well drawn, with accurate distributional data derived from the literature, unpublished data from Kurta and his students, and specimens housed in the Michigan State University Museum and University of Michigan Museum of Zoology. Within Michigan, individual capture localities are indicated by dots and associated counties are shaded.

A section on habits includes information concerning roosting strategies, reproductive and foraging behavior, diet, and hibernation biology. The information is tracked employing a phenological approach, which greatly enhances understanding of the biology of these bats. Much of each account is derived from the primary literature, although many previously unpublished observations specific to Michigan also are included. This part ends with a brief discussion of longevity specific to each species, both within the state and throughout the range.

Bats of Michigan contains a bibliography of over 100 references. Fifty-five percent of the references are dated later than 2000, and 32 % of the citations reflect studies that were conducted in Michigan. A glossary includes 35 terms that are helpful to the layperson. Although I favor expanded glossaries for textbooks, the glossary provided by Kurta seems appropriate for the audience.

This book has teaching as its premise and successfully bridges the gap between science and education by promoting to the layperson and scientist alike a strong conservation ethic and appreciation for bats. The book is a valuable reference for naturalists, mammalogists, and bat enthusiasts; I strongly recommend this book for chiroptologists interested in bats residing in Michigan. The book is a gem and well worth its very modest price.

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Dark Banquet. Bill Schutt (Illustrated by Patricia J. Wynne). Harmony Books, New York.
325 pp., 2008. ($25.95 United States, $30.00 Canada)

Noseleaf stilettos, urethra-seeking catfish, interspecific mounting behavior, and the death of George Washington are but a few of the stories that unfold between the covers of *Dark Banquet*, the story of blood and the beasties that partake of its bounty. *Dark Banquet* skillfully introduces readers of all kinds to the sordid lifestyles of blood-feeders, nature's bona fide vampires. Along the way, author Bill Schutt not only describes these much maligned and misunderstood organisms, but also recounts a vast menagerie of history, folklore, and fear—all of which are enhanced by Patricia Wynne's wonderful illustrations. Dr. Schutt begins the book with what he knows best, exploring the ways and means of all three species of vampire bats (Part 1: No Country for Old Chickens). Along the way he leads an in-depth discussion of a variety of topics including evolution of vampirism in bats, vampire mythology from the 15^{th} century forward, and the anatomical and physiological adaptations of vampire bats. He then becomes equal parts historian and investigative reporter to convey the intertwined stories of leeches and medicinal bloodletting (Part 2: Let It Bleed) and to take on an entire slew of sanguivores, including bedbugs, ticks, and candirus (Part 3: Bed Bugs and Beyond). As the epithets indicate, the author approaches his subject with a splendid sense of humor and in the end delivers an enjoyable and very informative read.

My own chiropterophily aside, I believe that the early chapters on vampire bats represent *Dark Banquet* at its best. Dr. Schutt draws upon a great deal of laboratory and field experience with vampire bats and is able to paint an intriguing portrait of this triumvirate of species—*Diphylla*, the primitive vampire with an extra finger; *Diaemus*, the wily but tame arboreal vampire; and *Desmodus*, the jumping, evil mastermind of the bunch. Another major advantage of these chapters is that they provide a vivid description of the ambience and romance of tropical fieldwork. The treks through the jungle, the vagabond existence, and the people and cultures all come alive. He also admirably portrays the bizarre situations that field biologists often find themselves, agitating barrels full of cow blood or searching abandoned buildings in Trinidad for vampires. Schutt describes one particularly eerie encounter with an elevator shaft of doom—a blood, urine, and feces-filled passageway to death. Although these experiences may cause revulsion in some, to me they brought back fond memories of the windy road of discovery that is scientific research.

Dark Banquet moves from vampire bats to leeches, the golden child of the vampire world. My only encounter with leeches came in the Ozarks of Missouri while mist-netting bats. The leeches, several inches long, at least in memory, seemed to come alive, writhing at the surface, as my colleague and I waded across a pond to set the nets. When I climbed out of the muck, I pulled a few leeches off my leg and observed the blood flow down my calf unimpeded by clots of any kind. In reading *Dark Banquet*, you realize this unsavory encounter was a very small price to pay for all the benefits that leeches provide. Leeches quite literally save life and limb on a regular basis. For the rest of the book, Dr. Schutt describes a dizzying array of blood-feeders including bedbugs, ticks, and candirus (bloodsucking catfish), a veritable coven of hematophagous critters. Field work in Missouri, Costa Rica, and the Bahamas has brought me face to face with hoards of blood-feeders, mosquitoes and ticks a-plenty and batflies by the dozen. The author takes on each new vampire in a similar way, by interviewing experts and relying upon extensive research to provide a broad historical, biological, and taxonomic perspective of each. My only real criticism of the book is that at times this perspective is too broad. In a few instances, the author flirts with the line between integral knowledge and unnecessary detail.

My favorite parts of *Dark Banquet* were the descriptions of the specialized adaptations sanguivores have developed for finding their prey and for exploiting blood as a food resource. We learn that vampire bats use thermoreceptors in their reduced noseleafs to find an ideal place to cozy up to their intended victims. Chapter after chapter show that the saliva of blood-feeders is truly magnificent. Ticks use saliva to cement themselves to their hosts. Vampire bats couple saliva, teeming with vasodilators and anticoagulants, with razor-sharp incisors to ensure a painless bite and a steady stream of blood. The saliva of leeches is all inclusive with vasodilators, anticoagulants (hirudin), anesthetics, and hyaluronidase, which facilitates the infiltration of this chemical cocktail into the wound. The pages of *Dark Banquet* are engorged with the fascinating biology of vampires and leave readers with an excellent understanding of how these organisms cope with the rigors of blood-feeding lifestyle.

The public reputation of blood-feeding creatures has never been good. Leeches, ticks, mosquitoes, and vampire bats are not going to make anyone's top ten lists. But *Dark Banquet* may be the perfect antidote to the poor image of blood-feeders the world over. The author has fun with the bloodsucking stereotypes and delights in the fear that he knows his audience is experiencing. Between bed bugs and candirus, it is hard not to wince at least a time or two, even for the stoic, battle-tested bat biologist. The truth is that blood-feeders can have negative effects, perhaps the worst being the spread of disease, such as rabies, malaria, and Rocky Mountain spotted fever, just to name a few. However, the author makes sure that we realize that blood-feeders seldom live-up to their fearsome reputation. They usually do no harm and often have a tremendous upside. For instance, leeches are critical to a variety of medical procedures and the saliva of blood-feeders continues to be a cornucopia of anesthetic and anticoagulant chemical compounds. Bill Schutt effectively defangs the mythology surrounding these amazing animals and gives a thorough, accurate, and entertaining account of the blood-feeding lifestyle. Blood, it's what's for dinner! I strongly recommend that you sink your teeth into *Dark Banquet*, the fascinating story of the beasts that dine at this grisly table.

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Australian Bats, Second Edition. Sue Churchill. Allen & Unwin Publishers, Sydney, New South Wales, Australia.
255 pp., 2008. ($45.00 Australia)

Ten years after the initial publication, Sue Churchill has produced a second edition of her highly regarded and widely used book, "Australian bats." We reviewed the first edition for *Bat Research News* in 2000 (BRN 41(3): 72–73) and both of us have used the book extensively and were therefore keen to see and read the new edition. The key question that we address in this review is whether owners of the first edition should also buy this one.

The new edition is only slightly longer (255 vs. 230 pages) and has the same dimensions, making it suitable for use in the field. The new edition has considerable updated content in the species accounts. The line spacing in the body of the text appears more compressed whereas the keys have more space, both of which are positive changes. The book has undergone a significant redesign with many more color plates than the previous edition. An exceedingly useful addition is the inclusion of sonographs for all echolocating species (except ghost bat).

The structure of the book has changed between editions. The first edition consisted of three parts: an introduction to bats (which is little changed), a list of species with keys to their identification, and species accounts; whereas the second edition has two parts: the introductory section and the species accounts. Rather than the keys all appearing together, there is now a key to families that directs the reader to the relevant pages where the accounts of a particular family begin. The header of each page in the species accounts section is color-coded by family (e.g., dark green for Rhinolophidae) to allow ease of separating families when rapidly flicking through the book. Each family account opens with a key to the species in that family. In the case of the Vespertilionidae (by far the most speciose of Australian families), there is first a key to separating genera and then each genus has its own key. Although the range maps are slightly reduced in size, better contrast actually makes them easier to read. These changes to the book's structure are significant improvements and, in particular, will aid in the ease of use in the field. One structural change that is not for the better is that after the pteropodids, species accounts are not restricted to the two facing pages. This excellent feature of the first edition no doubt generated a bit of unused space on some pages, but we are sorry it has been changed.

Some of the personalized touches that Sue Churchill has included in the text continue to be highlights. These include her account of echolocation and the description of her interactions with Indigenous Western Desert people in search of the ghost bat, *Macroderma gigas*. The quality of images in the book is vastly improved from the generally high quality of the first edition and notable for the inclusion of some stunning images by Bruce Thomson. It is good to see quality illustrations of little known species such as *Saccolaimus saccolaimus* (on page 211, photo by Bruce Taubert). The images on pages 75 and 97, however, are poor quality holdovers from Edition One.

Despite the useful changes, we have a number of criticisms of the second edition. Minor ones include an increased amount of anthropomorphic, overly qualitative or unsubstantiated information, especially in the "notes" section of species accounts (although this section does not occur for all species). References are made to various species being "pretty helpless on the ground," "delightful companions in areas with high numbers of mosquitoes," "Australia's cutest bat," "abandon roost caves if disturbed unreasonably," "a tenacious nature," "a species that is impatient in the mist net," and "aerial dogfights," etc. We think these could be pruned. The term weight is still used incorrectly, the author means mass. It is unclear the precise rationale for putting certain parts of species descriptions in bold. The descriptions must be read in their entirety for context so the bold typeface could easily have been deleted. There is still an apparent aversion to speaking about the "evolution" of characteristics especially in the introduction and instead a propensity to use the term design.

Our most serious misgivings are about taxonomic changes in this edition. We are not alone in these misgivings and refer readers to a recent article in *The Australasian Bat Society Newsletter* by Terry Reardon (April 2009, Number 32: 52–53), which details concerns about the taxonomic treatment in the second edition. Our review of the previous edition prompted a colleague to comment to us on the number of "naked names" in the text, i.e., species that have not been formally described such as the seven forms referred to as "*Mormopterus* species (undescribed)" on pages 203–211 of Edition One. This was not a criticism of Churchill but a reflection of the state of Australian bat taxonomy in the late 1990s. The new edition has tried to fix this by incorporating unpublished work. However, in a number of cases, we argue that changes have been made prematurely and, it seems, without adequate discussion with the relevant taxonomists undertaking revisions. These issues are covered in detail in Reardon's review. Reardon specifically asks readers to disregard the changes to the Molossidae Churchill incorporates in the new edition and to instead to follow the taxonomy of Van Dyck and Strahan (*The Mammals of Australia. Third edition.* 2008. Reed New Holland, Sydney.). We go further and recommend that readers disregard a raft of other changes such as those relating to the two forms of *Rhinolophus philippinensis*. Currently, Van Dyck and Strahan (2008) most accurately portrays the published state of knowledge of Australian bat taxonomy. This treatment should be used until the relevant unpublished work finds its way into the literature following critical peer-review.

In his review, Reardon noted that some changes to molossid taxonomy in the new edition are "…attributed to a revision of mine that simply does not exist,…" One of us (Pavey) had a different experience with his central involvement in a dietary study of Top End microbats not being acknowledged and a non-existent report (Mile and Burwell) on "Diet of Top End bats" being included in the Bibliography. A component of this work was published in *Canadian Journal of Zoology* (Pavey et al., 2006, 84: 425–433) but is not cited. Although this is assuredly just an oversight, evidence of sloppiness like this is a concern and it occurs elsewhere in the new edition. Overall, this suggests a rush to meet publication deadlines. Better communication with contributors of information and some more judicious proofreading were required.

As with the first edition, this is by and large an excellent book for anyone with an interest in Australian bats. It is a useful resource and invaluable in the field but frankly for those who already have the first edition, we suggest you save your money and wait until some of the issues we have pointed out are addressed in Edition Three. If you don't have Edition One, then by all means buy this one but beware of the issues we raise.

Reviewed by Chris R. Pavey, Biodiversity Unit, Division of Environment, Heritage & The Arts, NRETAS, Northern Territory Government, PO Box 1120, Alice Springs 0871 Australia, E-mail: Chris.Pavey@nt.gov.au; and
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ANNOUNCEMENTS

New Distance Learning Course on Bat Biology

In September 2009, the University of Western Ontario (London, ON) will offer a one-semester distance learning course on bat biology, which includes both lecture and laboratory components. The course, Biology 32222z, "Biology of Bats," uses bats to explore biodiversity, from form and function, behavior and ecology to evolution and adaptive radiation. The course will cover details of flight and echolocation, the origin and evolution of bats and how the latter has been influenced by zoogeography, and there will be interactions between bats and people and bat conservation issues. The goal of the course is to use bats as a model for exploring biological systems. For more information about the course and registration, contact Dr. Brock Fenton (bfenton@uwo.ca).

Request for Manuscripts — *Bat Research News*

Original research/speculative review articles, short to moderate length, on a bat-related topic would be most welcomed. Please submit manuscripts as MSWord documents to Allen Kurta, Editor for Feature Articles (akurta@emich.edu). If you have questions, contact either Al (akurta@emich.edu) or Margaret Griffiths (griffm@lycoming.edu). Thank you for considering submitting some of your work to *BRN*.

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FUTURE MEETINGS and EVENTS

19–26 July 2009

The 15th International Congress of Speleology will be held in Kerrville, Texas. Call for Papers and other information about the Congress can be found at: http://www.ics2009.us/papers.html

9–14 August 2009

The 10th International Mammalogical Congress will be held in Mendoza, Argentina. Proposals for symposia are welcome, and preliminary registration can be made at this time. For more information please see: http://www.cricyt.edu.ar/imc10/

28–29 August 2009

The 8th Annual Great Lakes Bat Festival will be held at the Milwaukee County Zoo (Wisconsin). A special "Bat Encounter" program will kick off the Bat Festival on August 28th at 7 p.m. On Saturday, August 29th, the Festival will feature presentations by Great Lakes region bat experts, environmental exhibits, kids activities, and an evening bat research demonstration. For all ages and free with Zoo admission. Sponsored in part by Batcone. More information and directions available at: http://www.batconservation.org and http://www.milwaukeezoo.org , respectively.

19–23 October 2009
The 20th Annual Rabies in the Americas (RITA XX) meeting will take place in beautiful Quebec City, Canada. This conference brings together rabies scientists from around the world, and is an opportunity to share your experiences and to enhance your knowledge of rabies and its control. Abstract submission begins in June, and registration continues until August 14th. Information is available at: http://www.RITA2009.org

4–7 November 2009
The 39th Annual NASBR will be held in Portland, Oregon. Please see http://www.nasbr.org/ for information.

12–14 July 2010
The 14th Australasian Bat Society (ABS) Conference will be held in Darwin, Northern Territory, Australia. For more information, please see: http://batcall.csu.edu.au/abs/absmain.htm

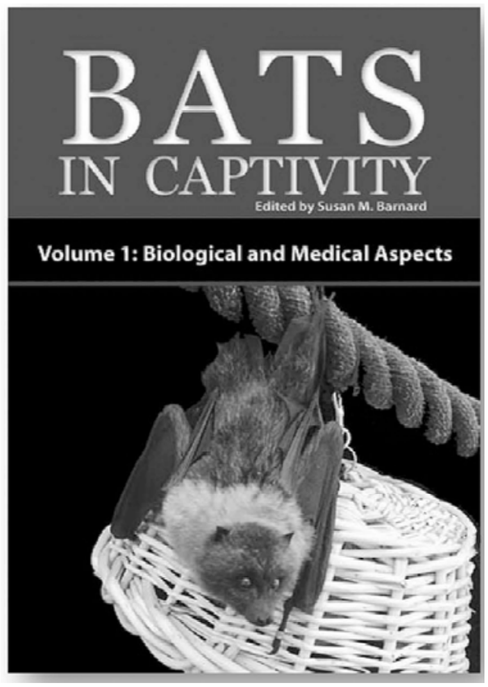
2010
The XVth International Bat Research Conference (IBRC) will be held in Czech Republic, dates to be announced.

2010
The 40th Annual NASBR will be held in Denver, Colorado. Please see http://www.nasbr.org/ for information.

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

BATS IN CAPTIVITY

Volume 1: Biological and Medical Aspects



Susan M. Barnard, Editor

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About the Editor

Susan M. Barnard holds a Bachelor of Science degree from the University of the State of New York. She founded Basically Bats – Wildlife Conservation Society, Inc. in 1993, and served as Executive Director until 2008. Currently retired from her position as Assistant Curator of Herpetology at Zoo Atlanta, Ms. Barnard has authored over 25 scientific papers in refereed journals and 2 book chapters. She also coauthored books on reptilian parasites and reptilian husbandry, and has appeared in numerous magazines and on television, including the National Geographic special, "Keepers of the Wild."

A comprehensive book intended for anyone maintaining bats in captivity. It comprises 44 papers by 22 contributing authors. *Bats in Captivity* is the only book of its kind, detailing the care of captive bats worldwide. This volume, Biological and Medical Aspects, includes a drug formulary, information on public health, anatomy and physiology, controlling reproduction, parasitology, and veterinary medicine and surgery, plus many other related subjects.

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BAT RESEARCH NEWS

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Front Cover

Gravid *Pteropus poliocephalus* with twins. Radiograph by Harmony Frazier, Woodland Park Zoo, Seattle, Washington. Copyright 2009.

Update of White Nose Syndrome in Bats, September 2009

Gregory G. Turner[1] and DeeAnn M. Reeder[2]

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Background

Just west of Albany, New York, a strange fungus and 18 dead bats were first photographed in Howe Cave in February 2006 (Blehert et al., 2009). However, this isolated incident was not odd enough to spark serious concern at the time and was not reported until 2008, as the problem became more widespread and publicly recognized. During routine counts of hibernating bats conducted from January through March 2007, mortality and bats with odd clinical signs and behaviors were documented by biologists from the New York Department of Environmental Conservation at four sites close to Howe Cave. Three different species of *Myotis* (*M. lucifugus, M. septentrionalis,* and *M. sodalis*) and *Perimyotis subflavus* were affected. The magnitude of the problem became apparent during winter 2008, as the newly described White Nose Syndrome (WNS) spread to three adjacent states: Connecticut, Massachusetts, and Vermont. No causative agent was known, but estimates of mortality at four sites in New York previously confirmed as infected and housing wintering populations of over 1,000 animals revealed an alarming 90% reduction in total number of bats when compared to pre-WNS counts (A. Hicks, pers. comm.). By the time that a meeting was convened in Albany, New York, to discuss the phenomenon (Reeder and Turner, 2008), a suite of clinical signs had been described and WNS had spread to all 28 sites checked within 130 km of the epicenter and 5 of 19 sites that were 130–200 km away (A. Hicks, pers. comm.).

Researchers scrambled to pull resources together and establish new collaborative studies in the short time between the meeting in June and the start of the 2008–2009 hibernating season. As reported at Albany, laboratory investigations did not point definitively towards any specific causative agent but did consistently show evidence of the fungus (Figure 1), and most dead animals were in poor body condition with little-to-no body fat. Using this as a starting point and based upon hypotheses generated at the meeting in June 2008 (Reeder and Turner, 2008), researchers conducted multiple studies on a regional scale during winter 2008–2009, which included examination of bats from both affected and unaffected sites. Studies included investigation of patterns of arousal and torpor, measurement of metabolic rates, examination of body condition and types of fat across the hibernating season, bacterial flora of digestive systems, and immune response.

Continued Spread

While these studies were being conducted, WNS continued to spread. As of August 2009, two more species (*Eptesicus fuscus* and *M. leibii*) were confirmed as affected, which meant that all six species of hibernating cave bats in the northeastern United States were susceptible. Total mortality at closely monitored sites with multiple years of infection in New York, Massachusetts, and Vermont averaged 95% (A. Hicks, pers. comm.). In 2009, WNS spread over 800 km from the epicenter and was confirmed in New Jersey,

Figure 1. Little brown bat (*Myotis lucifugus*) afflicted with white nose syndrome. The bat was found in an abandoned mine in Lackawanna County, Pennsylvania. Photograph courtesy of Greg Turner, Pennsylvania Game Commission.

Pennsylvania, West Virginia, and Virginia (Figure 2).

Anthropogenic transmission?—Concern over anthropogenic transmission was raised initially in 2008, after discovery that all but two or three new WNS sites found that year had been visited by either biologists or recreational users who had been in at least one of the original four sites noted in 2007. This concern highlighted the need for establishing decontamination protocols, as well as the need to verify that they were effective. Large-scale movements (jumps) of WNS occurred in 2009 into areas where WNS was not thought to exist, leaving sites in-between unaffected. These jumps occurred in central Pennsylvania, West Virginia, and Virginia, and several factors pointed toward a human connection. First, most sites had small hibernating populations. Although the possibility existed for spread by an infected bat that had migrated a long distance to a small hibernating population in the new area, it was unlikely that this would have occurred multiple times, particularly when hibernacula with much larger populations existed nearby, as was the case at several of these newly infected sites. Second, most new sites had very high recreational use, and third, several sites were confirmed to have visitation by people or mud-covered gear that had been in affected sites in New York, prior to establishment of decontamination protocols. Due to this suspicion that anthropogenic movements were likely, that no causal agent had been identified, and that decontamination protocols were not thoroughly tested, some states reduced or halted population surveys during hibernation and the U.S. Fish and Wildlife Service requested a voluntary moratorium on caving until more was learned (http://www.fws.gov/northeast/wnscaveadvisory.html).

Bat-to-bat transmission?—In addition to anthropogenic spread, bat-to-bat transmission surely also occurred and may have been the primary mechanism of spread. This mode of transmission was supported by a wave-like pattern of spread away from the epicenter (in addition to long-distance jumps) and the fact that in both 2008 and 2009 some newly affected sites had not been visited by

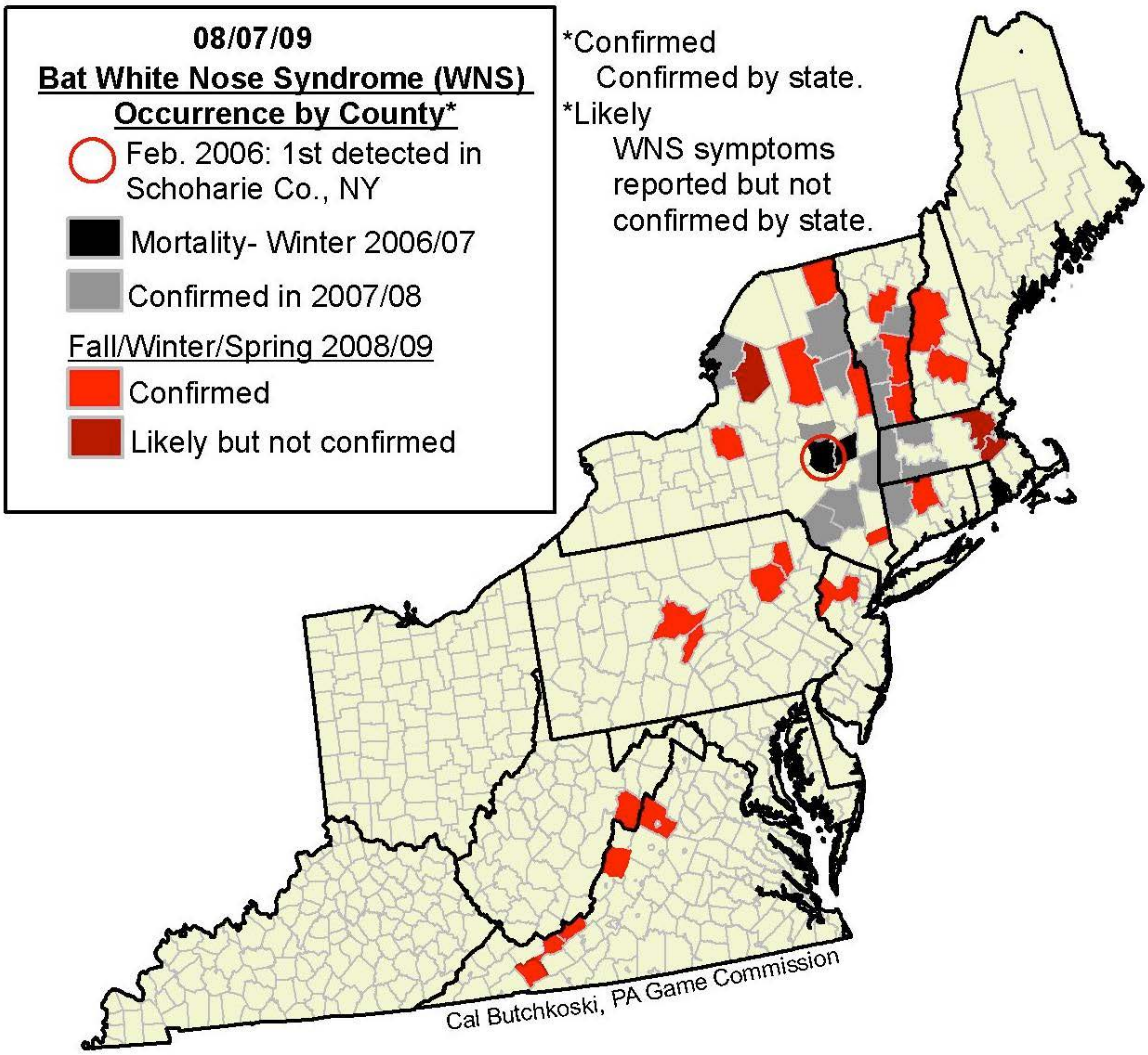

Figure 2. Map depicting the spread of white nose syndrome by county across hibernating seasons. Courtesy of Cal Butchkoski, Pennsylvania Game Commission.

researchers or recreational users for several years prior to infection by WNS.

New Results

Most studies conducted in winter 2009 are still in the data-analysis or manuscript-preparation phase and thus not available for reporting. However, several publications have recently appeared, and preliminary data have been generously provided by many researchers, allowing us to highlight recent findings. For example, the study investigating the thermoregulatory patterns of hibernating bats documented that bats with WNS display atypical patterns of torpor that could explain the significant decrease in body condition experienced by WNS-affected bats (D. M. Reeder et al., pers. comm.). An investigation of metabolic rates of hibernating bats showed that the rates of bats in New York at affected sites were two-to-three times higher than the rates of bats in Pennsylvania (A. Janicki and T. Tomasi, pers. comm.). According to these authors, the higher metabolic rates during torpor (assuming no changes in arousal patterns/metabolism) in affected bats would require an additional 0.7 grams of fat over the winter. An analysis of the digestive tracks revealed that WNS-affected bats have a reduced bacterial flora in their digestive tracts, especially a reduction in those species that produce the enzyme chitinase (J. Whitaker, Jr., and K. Dannelly, pers. comm.).

Data examining the body fat of healthy and affected bats across the hibernating season are too preliminary to provide any insight at this time (J. Reichard and T. Kunz, pers. comm.). However the same researchers showed that *M. lucifugus* at maternity colonies near affected hibernacula began the summer with poorer body condition but achieved typical post-reproductive body mass when compared to bats studied at these sites prior to WNS; at one site, the bats also remained active later into fall and declined in body mass before entering hibernation (Reichard and Kunz, in press). Another study, comparing a small group of bats from an affected hibernaculum with those from a clean hibernaculum noted a dramatic difference in the body mass index. While field necropsy of these specimens suggested reduced brown adipose tissue in the affected bats, the investigator did not consider this reduction sufficient to explain mortality (J. Fallon, pers. comm.).

Fallon also noted that preliminary data suggested decreased circulating leukocytes in bats with WNS, which may indicate immunosuppression. This is supported by a different study that found alterations in B-cell mediated immune function in affected bats independent of differences in body mass (R. Jacob, D. M. Reeder, and K. A. Field, pers. comm.). Additionally, M. Moore and T. Kunz reported that differences existed between the innate immune response of bats from affected and unaffected sites, as well as between bats with and without visible signs of the syndrome at affected sites.

In addition to exploring how WNS affects physiology and behavior, other research focused on culturing and characterizing the fungus suspected to be the causative agent. Following up on the first study of the WNS-associated fungus (Blehert et al., 2009), Gargas et al. (2009) named the species and further characterized its biology. The newly described *Geomyces destructans* was described as the causative agent of the skin infection that is hallmark of WNS-affected bats, and the unique morphology of this fungus was unlike that of any previously described species of *Geomyces*. Preliminary analyses of infection trials also demonstrated that *G. destructans* is transmissible from affected to clean bats (D. Blehert, pers. comm.).

Another study investigated the prevalence of *G. destructans* among bat hibernacula east of the Mississippi River. To examine this question, sediment samples were collected from hibernacula within and outside the WNS-affected region in winter 2009, and preliminary analyses indicated a diversity of fungi related to, but distinct from *G. destructans* (D. Blehert, pers. comm.). The presence of these closely related species made analyzing samples for *G. destructans* labor intensive. Nonetheless, Blehert noted that *G. destructans* was found in sediments from a number of hibernacula within the WNS-infected region.

Scientific studies supporting the fungus as the sole causative agent of mortality are on-going but not conclusive at this time. Many researchers within the WNS community currently believe that the fungus is the most likely culprit. Additionally, anecdotal evidence of the likely role of *G. destructans* in causing WNS continues to grow. Consider first, that if humans are capable of spreading this fungus from site to site via caving equipment, the odds of transmission would appear greater with a resistant fungal spore than with other pathogens. Although fungi are common inhabitants of caves and mines and are occasionally documented on live bats, the unique morphological characteristics of this fungus had never been seen and/or reported in the United States until 2006, and the fungus continues to be found only in sites confirmed to be affected and displaying high mortality. In one central Pennsylvania site, the fungus was noted and confirmed prior to the observation of the clinical signs of roost shifting, distortions of typical arousal patterns, lethargy, and early emergence or death. Further, these clinical signs increased as growth of the fungus on individual bats progressed and as a greater number of bats became affected. Finally, evidence that the *G. destructans* can be found in sediments in affected sites supports the hypothesis that humans may represent a potential vector.

Research investigating the efficacy of fungicides for decontaminating affected gear and compounds for potential use as treatment for affected bats is also underway. Preliminary results indicate that the vegetative structures of a similar, but non-pathogenic fungus are rather easy to kill but the spores are quite resistant (H. Barton, pers. comm.). Thus far, over 80 compounds have been tested by Barton and the efficacies of these treatments are being analyzed. The combining of different compounds to achieve synergistic decontamination and/or treatment, while causing minimal damage to either the unique cave biota or the performance of technical gear is a major challenge but is showing promise. Barton preliminarily notes that washing caving equipment in Woolite (Reckitt Benckiser, Inc., Parsippany, New Jersey) prior to decontamination is critical, because it removes mud, clay, and other sediments that contain charged surfaces that attract disinfectants, decreasing their efficacy. These studies and their widespread application hinge on confirmation of the fungus as a causative agent of mortality.

If the fungus is eventually documented as the causative agent of WNS, the immediate question that follows is: where did this fungus come from? It is possible that this pathogenic fungus evolved from one of the naturally occurring and closely related species found in nearly all hibernacula investigated so far, but the fungus could also be an introduced species to which North American bats have no resistance. On this front, several European scientists, upon hearing about WNS, have noted that a fungus with similar morphological traits can be found on their hibernating bats but with no signs of mass mortality at this time. The arrival of an exotic cold-loving fungus is a "perfect storm" for killing hibernating bats, because bats have extremely high rates of contact, the fungus attacks them at a time when their capability for mounting any immune response is minimized to save energy, and this period of inactivity and immune suppression is lengthy. Regardless of the causative agent(s), the levels of mortality are unprecedented in the known history of bats, and the potential loss of millions of bats across this region gives everyone reason to be greatly concerned.

Hope for the Future?

Despite all this, there may be hope for North American bats. If the fungus is actually the causative agent, then what we know suggests that non-hibernating bats should largely not be affected as the fungi will not have the ability to grow for prolonged periods. Evidence from Pennsylvania suggests a single year's natural spread may be only around 15–20 miles per year without anthropogenic transmission. Therefore, if we can determine the mechanisms and timing by which natural transmission is occurring, we may be able to slow the spread and allow for containment or treatments to be developed. Progress is also being made on testing procedures to decontaminate all gear used underground. Compounds that have anti-fungal capabilities are now being tested to determine whether there are impacts to bats or the many unique and globally rare creatures that live among them and will hopefully lead to some management options. These compounds may help delay or break the cycle of transmission, or even better, they may increase the survival rate at affected sites until even more can be learned.

There are also things people can do in both affected and not-yet-affected areas. In those parts of the continent not currently affected, intense surveillance can provide estimates of pre-WNS population size and allow for better tracking and potential mitigation of WNS. One excellent example of this type of activity is the Appalachian bat count (http://www.pgc.state.pa.us/pgc/cwp/view.asp?a=458&Q=176676&PM=1).

People can also install bat boxes to provide alternate roosts for bats. Although this would not affect the fungus directly, installing bat boxes could provide fungus-free environments over the summer months and also reduce migratory distances between winter hibernacula and summer sites by providing suitable roosts, both of which could enhance the survival of as many bats as possible. Examples of boxes that work well in the eastern United States can be found by visiting the websites of the Pennsylvania State Game Commission (http://www.pgc.state.pa.us/pgc/lib/pgc/wildlife/woodcrafting/plan11.pdf) or Bat Conservation International (http://www.batcon.org). As the disease moves through new areas, locating resistant individuals and those few remaining summer and winter colonies will be of critical importance to the future recovery efforts of our night-flying friends. We hope and expect that some bats will survive, but even survivors will face tremendous challenges, because they can be expected to have limited fat reserves for migration and winter survival. Minimal winter disturbance will be critical for these bats to give them a fighting chance. Even so, with their low reproductive rates, it will be decades before bat populations in WNS-affected areas are restored. Finally, people can inform their state and federal representatives that significant governmental funding is desperately needed, as WNS is clearly an issue for all of North America—not just the Northeast. Lastly, several mechanisms for collecting personal donations to assist WNS-related research have been established (http://www.indstate.edu/ecology/centers/bat.htm, http://www.batcon.org/, or http://www.caves.org/WNS/).

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Additional Observations of the Eastern Pipistrelle (*Perimyotis subflavus*) in Colorado

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The eastern pipistrelle (*Perimyotis subflavus*) is an uncommon member of the mammalian fauna of Colorado. Until recently, it was known from a single specimen found on the side of a building in Greeley, Weld Co., in September 1987 (Fitzgerald et al., 1989). The lack of additional specimens led to speculation that this individual was a "disoriented wanderer" (Armstrong et al., 1994:34). Armstrong et al. (2006), however, reported two additional pipistrelles from northern Colorado—one collected near Boulder, Boulder Co., in March 2004, and another specimen, currently housed at the Denver Museum of Nature and Science, that was collected in Arapahoe Co., in September 1996. Herein, we report two new individuals, both from the southeastern part of the state.

On 17 September 2007, E. Wostl captured an adult female eastern pipistrelle in a mist net strung over a small pool of water in Cottonwood Canyon, near the boundary between Baca and Las Animas counties (UTM 13S 0670302E 4112389N; datum: WGS 84). Body mass was 7.2 g, and length of the right forearm was 35.1 mm. The animal was photographed and released; the photograph was submitted to the University of Colorado Natural History Museum Ancillary Collection (UCM-AC 168). This individual is the first eastern pipistrelle known from Baca Co., and the nearest record of an eastern pipistrelle is from New Mexico, near the New Mexico-Oklahoma border, 57 km to the south (Geluso, 2005).

On 2 April 2008, E. Wostl and N. LaMantia-Olsen observed an adult male eastern pipistrelle roosting in the entrance of an abandoned mine on the southern portion of the Fort Carson Military Reservation, Pueblo Co. (UTM 13S 0513371E 4255485N; datum: NAD 83; elevation: 1,758 m). The specimen also was examined and photographed (UCM-AC 169) before being released. Fresh guano on the ceiling where the bat was roosting and the fact that it defecated as the individual was handled indicated that it was already active and foraging for the season. This animal is the first eastern pipistrelle from Pueblo Co. The nearest record of an eastern pipistrelle is the previously mentioned animal from Boulder Co., 178 km to the north (Armstrong et al., 2006).

The eastern pipistrelle is most abundant in eastern North America, but it occurs westward to north-central Kansas, eastern Nebraska, and the Panhandle of Texas (Adams, 2003). Using records from Colorado, Kansas, and Nebraska, which were considered accidental occurrences, and new records from New Mexico, South Dakota, and Texas, Geluso et al. (2005) suggested that the eastern pipistrelle was expanding its range westward. To support their contention, they cited the time of year and condition of the animals upon capture, the short-distance migrations typical of eastern pipistrelles, and the sudden appearance of these bats at sites that had been well sampled in the past. The circumstances surrounding the recent observations in Colorado match many of Geluso's reasons for postulating residency of eastern pipistrelles at novel localities at the western edge of their distribution. All specimens were in apparently good health, found early or late in the warm season (i.e., near hibernation sites), and occurred large distances from known populations. These factors suggest that the eastern pipistrelle is a resident of eastern Colorado, although it is unknown whether these new observations reflect insufficient sampling effort in the past or a recent colonization from the east.

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Letters to the Editor

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

A Tale of Two Deniers: Nylon versus Polyester Mist Nets

For many years, all mist nets manufactured in North America (Avinet, Dryden, New York) were made from nylon, and the finest nets (i.e., those with the thinnest threads) were fabricated with 50-denier, two-ply threads. Recently, Avinet ceased production of 50-denier nylon nets and substituted nets made with 75-denier, two-ply polyester. Nylon and polyester are both synthetic polymers with varying composition. Although nylon thread is slightly stronger than polyester, polyester is more resistant to shrinking and stretching (http://www.sternandstern.com/polyesterfibersandfabrics.asp; accessed 8 September 2009).

We were concerned, though, that 75-denier polyester nets might be made from thicker threads that could be detected more easily by bats and result in lower capture success. However, denier is defined as the mass of a continuous thread that is 9,000 m in length, and denier alone cannot be used to judge the thickness of different materials. In this report, we compare the thickness of threads used by Avinet to make 50-denier nylon nets and 75-denier polyester nets.

We first cut a small piece (ca. 12-mm long) of thread from a number of nylon (n = 12) and polyester (20) nets. The threads that we selected extended from the sides of each net and were free at the distal end; consequently, they were not under tension prior to being cut. We placed each two-ply thread on the stage of a dissecting microscope and measured its maximum diameter, near the midpoint, using an ocular micrometer that had been calibrated with a plastic ruler. Average (± *SE*) diameter of 50-denier nylon threads was 0.180 ± 0.005 mm, whereas mean diameter of 75-denier polyester threads was 0.178 ± 0.004 mm. Nylon and polyester threads did not statistically differ in thickness ($t = 0.72$; *d.f.* = 30; $P < 0.25$).

In terms of diameter of threads, mist nets made from 75-denier polyester and 50-denier nylon should be equally effective for capturing bats. The threads are similar in thickness, and the difference in denier simply indicates that the specific type of polyester that is used is 50% more dense (heavier) than the type of nylon that is used. Whether this difference in density will lead to differences in detectability by echolocating bats is unknown. However, differential detectability could be tested in the field by placing nets of both types at multiple sites and comparing capture rates.

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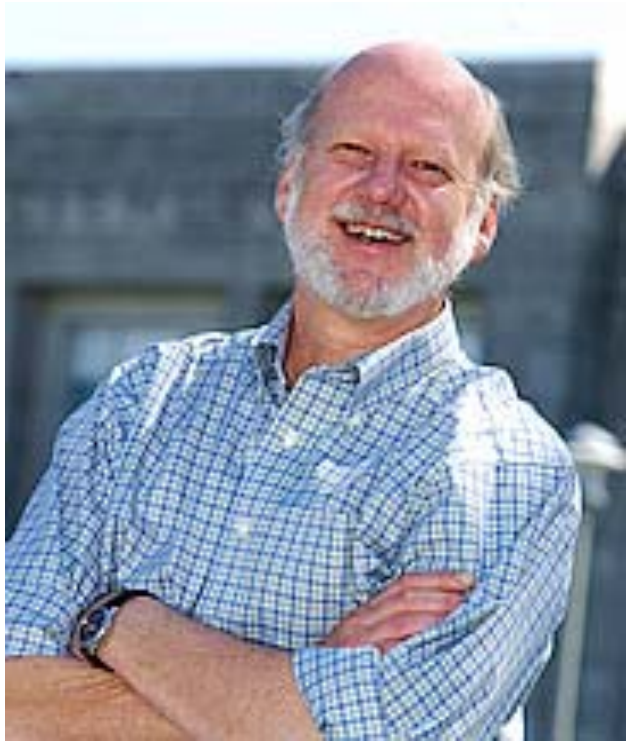
IN MEMORIAM



Donald William Thomas: (1953–2009)

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Donald W. Thomas died on 30 May 2009 at the age of 55, at his field site in Corsica—"l'île de la beauté"—while hiking a mountain trail leading to a scenic overview. His sudden death is an immense shock to friends and colleagues. He is survived by his beloved partner Marie-Hélène Poulin and sons Alexis and Patrick.

We will try to tell Don's academic story, highlight the importance of his contributions to eco-physiology, and describe his personality both as a young scientist (Brock's point of view) as well as an accomplished researcher and experienced supervisor (Vincent's point of view).

Don completed his high school education at Lower Canada College and received his Honours B.Sc. from the University of New Brunswick (Fredericton) in 1975. He completed his M.Sc. at Carleton University in 1978, and his Ph.D. at the University of Aberdeen in 1982. He performed post-doctoral work at Carleton University and at the University of Washington.

I (Brock) first met Don in 1976 when he joined my laboratory at Carleton University. Although it was common knowledge that little brown bats (*Myotis lucifugus*) mated in the fall, usually in underground sites where they would later hibernate, nobody had looked closely at the details—until Don took this on as a topic for his master's thesis and opened our eyes to some of the details of what was happening. But in true form, Don also worked with others in the lab to expand the scope of the overall work.

Whether the setting was a mine in southeastern Ontario, the bush in Zimbabwe, or a panel discussion in Montreal, Don's enthusiasm and love of life was entirely obvious. However, there was more to Don than bonhomie. No doubt it was this combination of talents that made Don a success—as a colleague and as an administrator.

In 1985, Don obtained a University Research Fellowship from the Natural Sciences and Engineering Research Council of Canada, which he held in the Département de Biologie at Université de Sherbrooke. He took only 8 years to reach the rank of full professor, a status usually awarded around mid-career. His rapid progression through academia was facilitated by the great diversity of research experience that he had gained as a student and postdoctoral fellow. These experiences gave Don a broad vision of ecology and allowed him to put his research into perspective. Don became Dean of Science at the Université de Sherbrooke in 2005 and, at the time of his death, had just been appointed to an additional term as Dean.

Don wrote over 20 book chapters and more than 100 scientific papers that appeared in numerous journals including *Functional Ecology*, *Ecology*, *Journal of Animal Ecology*, *Journal of Experimental Biology*, *Nature*, *Oecologia*, *Oikos*, and *Science*. He also served as editor of *Écoscience* from 2004 to 2008. During 24 years at Université de Sherbrooke, Don supervised 2 postdoctoral fellows, 9 doctoral students, and 13 master's students. Many of them now occupy academic research positions, testifying to his important scientific legacy.

Don was a question-driven scientist. He rightly thought that the marriage between precise laboratory-based measures and the reality of field-based studies allowed better understanding of the strategies that animals used to resolve energetic challenges. Don worked on many different animals—mainly mammals (multiple species of bats, eastern chipmunks, voles, and porcupines) and birds (blue tits, juncos, broad-winged hawks) but also on reptiles (turtles). He undertook projects all over the world, including Canada, the United States, Costa Rica, Venezuela, Great Britain, France, French Polynesia, the Cook Islands, Australia, Côte d'Ivoire, and Zimbabwe.

Don's research pursuits were eclectic. His main interests were torpor and hibernation, digestive function and nutritional requirements, metabolic rates, body condition, temperature regulation, and the energetics of breeding and overwintering. Don also published papers on raptor migration, eco-physiology of personality, and heat flux (radiation and bovid horns). The essence of his scientific contribution was his ability to address diverse questions through technically challenging methods.

Don was proactive. He was a proud and imposing man, whose presence in any room was never unnoticed. He was talkative and particularly skilled at expressing himself with clarity and at listening. These characteristics made him an imposing colleague. His honesty and direct criticism—though potentially shocking for the least confident ones—consistently made scientific discussions more productive. He was renowned for asking remarkably pertinent questions during departmental seminars and doctoral defenses, even on subjects that were far from his domain of expertise.

Don was also a great teacher. He received the teaching award from the Faculté des Sciences of Université de Sherbrooke during four consecutive academic years (1994–1998). His energetic style of teaching kept the sleepiest of us awake, and his passion for animal eco-physiology connected many of us to this field. In 1999, he also received the national Roy C. Hill award from the Canadian Teachers Federation for production of a scientific manual for young scientists (*Les Mains à la science: éveil de l'esprit scientifique*), which he co-authored with his wife Marie-Hélène Poulin.

Don was famous for his strong English accent when speaking French. It seemed that throughout his whole career in a French-speaking university he never worked on improving pronunciation. To Don, content mattered more than form. Even though we joked about his accent, he still expressed himself clearly while lecturing in French. His accent was definitely part of his charm, and we will continue to imitate his intonations when quoting his numerous down-to-earth lines.

I (Vincent) first met Don during an undergraduate field course. He was demonstrating use of telemetry instruments and saying that if we were able to find all the hidden transmitters rapidly, some time would remain for a beer "*à la plage*." Don was a great advisor, providing his students with the means they needed to develop their potential while pushing them to gain the autonomy required to be an independent researcher. After important academic events, such as pre-doctoral exams and dissertation defenses, he regularly invited his students, families, and members of the committee to his house for a warm-hearted Mediterranean dinner prepared by Marie-Hélène.

Most important of all, besides being a true leader, Professor Donald William Thomas was one of the most enthusiastic and passionate individuals we have known. Everyone who had the unique privilege of knowing him personally and working with him knows that. We could not afford to lose Don—as a friend, colleague, dean, and mentor. His scientific legacy will continue to have a profound impact in the field of eco-physiology.

Note: A fund in Don's name is being established to help teaching and research at the Faculté des Sciences of Université de Sherbrooke, and can be addressed to La foundation de L'Université de Sherbrooke.

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IN MEMORIAM

Arkalgud Gopalakrishna: 1922–2008

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Arkalgud Gopalakrishna, the former Director of the Institute of Science, Nagpur, India, was a well-known bat researcher and educator. A living legend of his times, AG was born in Chamrajnagar, Karnataka, India, on 20 October 1922, passing away at Nagpur on 19 September 2008. His early schooling was at Malleswaram High School, in Bangalore. He was awarded the Bachelor of Science (honors) and Doctor of Science degrees in Zoology by the University of Mysore. He began his career at Central College, in Bangalore, and came to the then College of Science at Nagpur in 1946. His first paper in a long series on the embryology of bats was published in 1947 when he was only 25. He was initiated into bat research by P. A. Ramakrishna and M. A. Moghe, and his studies bloomed at Birla Science College in Pilani and at Nagpur, the latter becoming the cradle of bat research in India for the 60 years of AG's productive life. He became the "Batman of India," pioneering in the field of reproductive biology of bats. He retired in 1981 to continue as professor emeritus.

India is represented by eight families of bats that AG and his coworkers explored in every possible manner. His intensive research focused on the study of breeding cycles, breeding behavior, implantation and early development, fetal membranes, placentation, and female genital anatomy. Together with A. Madhavan, he reported the survival of spermatozoa in the female genital tract of *Pipistrellus ceylonicus chrysothrix* (1971) and *Scotophilus heathii* (1978). His contributions in top-level journals numbered over 100, and the ISI Web of Science reported 45 articles to his credit between 1970 and 2009. He guided the research of numerous students, including S. Bhide, D. A. Bhiwgade, P. N. Choudhari, K. B. Karim, M. S. Khaparde, A. Madhavan, D. R. Patil, K. V. Ramamurthy, K. R. Ramaswami, and V. M. Sapkal.

He won a Population Council scholarship in 1955 for 2 years of research in the United States, where AG worked with W. A. Wimsatt at Cornell University and visited other centers of scholarship. Because of his high-impacting research, the College of Science at Nagpur was upgraded to a center of excellence as the Institute of Science. He received the Maharashtra State award for best teacher. A Gold Medal with scholarship was instituted in his name. AG was an accomplished player of the sitar and Rudra veena, and he represented his state in football. Tall, handsome and impressive, he was very friendly, loved to correspond, and eagerly helped students and colleagues alike. In retirement, he not only continued to pursue research but also delved into Vedic philosophy and astrology. He is survived by his wife Venkamma and children and grandchildren, including daughter Uma Anant and sons Eshwar Gopalakrishna, Shiva Gopalakrishna, Shankar Gopalakrishna, and Viswa Gopalakrishna Vasistha.

The sheer volume of his research on bat reproduction is mind boggling, and his findings need careful analysis and compilation into a single volume. Until that occurs, his discoveries are likely to remain poorly appreciated. Dr. Gopalakrishna was an unparalleled scholar, a multi-gifted person, an artist, and above all a generous human being. He will ever be missed. We bow in reverence to his great self.

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RECENT LITERATURE

Authors are requested to send reprints or PDF files of their published papers to the Editor for Recent Literature, Dr. Jacques P. Veilleux (Department of Biology, Franklin Pierce University, Rindge, NH 03461, U.S.A., e-mail: **veilleuxj@franklinpierce.edu**) for inclusion in this section. Receipt of reprints is preferred, as it will facilitate complete and correct citation. However, if reprints and/or PDF files are 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 and appreciated.

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BOOK REVIEWS

Bats in Captivity: Volume 1: Biological and Medical Aspects. Edited by Susan M. Barnard. Logos Press, Washington, D.C.
587 pp., 2009. Hardcover: ISBN 978-1-934899-02-1 ($99.95 United States). Softcover: ISBN 978-1-934899-03-8 ($74.95 United States).

Disclaimer—this reviewer contributed several photos to this book, but was neither involved in the development of nor read the book prior to publication.

Although not clearly stated, *Bats in Captivity: Biological and Medical Aspects* appears directed primarily at bat rehabilitators in North America, Europe, and Australia. It does, however, contain valuable information for veterinarians who have limited experience with bats. It could also serve as an introduction for biologists to the diseases that might develop while these mammals are in captivity.

This 587-page book is divided into 16 chapters and two appendices that cover biology, physical examination, common medical problems, diagnostic evaluation, and clinical management. The format tends towards large print, especially for paragraph and section titles, and there are areas of the book that could be condensed to reduce its size. Although there are often multiple authors for each chapter, the many small sections in some of the chapters could also be combined. Some chapters have useful tables summarizing essential information, but this format is not consistent throughout.

Although a valuable source of information, there are several issues this reviewer believes the book should have addressed. Because the volume appears directed to those interested in the captive management and treatment of injured and ill bats, the book should have an introductory chapter discussing the philosophy and goals of rehabilitating bats. Clearly defining the foundations, goals, and implications of rehabilitation is very important, especially in light of recent public health concerns regarding bats and the possible zoonotic diseases they may harbor. Although the first chapter does cover health precautions for those working with bats, it is not clear how to work safely with bats to minimize risk. Table 1.1 lists 10 general considerations for anyone working with bats, but I found the last issue quite ominous: “consider a provision in your Will dedicating your remains to medical science for a full pathological inquiry upon death.” The chapter on pathology, covering necropsy and collection of tissue for rehabilitators, is well written. It emphasizes that bats should be necropsied preferably by veterinarians, but then goes on to describe how rehabilitators can necropsy a bat. I believe that a lay person performing a necropsy on a bat is an unacceptable health risk, given the known and unknown zoonotic risks and the difficulty in setting up an appropriate safe facility for this purpose. Similarly, the chapter on euthanasia does not include a discussion on the triage of injured bats. Which animals are likely to survive and where will they go after they are healed? Which animals should be euthanatized and when? What are the legal implications of working with injured and ill wildlife? What is the cost and who pays for rehabilitation?

As indicated earlier, the book appropriately begins with a chapter on health precautions, written by Cathleen Hanlon from the Kansas State Veterinary Diagnostic Laboratory. Although the chapter primarily covers lyssaviruses, there is also a subsection on paramyxovirus and histoplasmosis. The chapters dealing with anatomy and physiology are adequate for the purposes of the book, highlighting the relevant information for the clinical management of these animals. The two chapters on reproductive management of captive bats discuss the available and potential options. The chapter on clinical environment and physical examination is brief. The chapters on common health problems and their management are comprehensive, covering most, if not all the problems likely to be encountered in a rehabilitation facility. Similarly, the remaining chapters on anesthesia, surgery, radiography, and collection of blood are adequate. The chapters on pathology and euthanasia are well written and appropriate. The parasite chapter is a good introduction to parasites of bats, as well as their detection and classification. The last chapter on calculating drug dosages will be useful for lay persons not familiar with this procedure, and finally the drug formulary is valuable for veterinarians working with bats.

Overall, this book is a good source of information for those who choose to work with injured and ill bats. A clear condensed format with well-defined goals and audience would have improved its usefulness.

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Do Bats Drink Blood?: Fascinating Answers to Questions about Bat. Barbara Schmidt-French and Carol A. Butler. Rutgers University Press, Piscataway, New Jersey.
176 pp., 2009. ISBN 978-0-8135-4588-2. ($21.95 United States)

Do Bats Drink Blood? is a fact-filled and interesting, general readership book about bats for non-scientists. The book is divided into seven major sections (Bat Basics, Bat Bodies, Bat Life, Bat Behavior, Bat Love, Dangers and Defenses, and Bats and People). Each, in turn, is presented as a series of 7–14 questions, followed by answers that are often quite informative.

Ultimately, the authors provide plenty of useful information, and they are at their best when incorporating recent research into their answers. Typical is their discussion of a study in which the researchers determined that barotrauma was a significant cause of bat mortality from wind turbines. Similarly, there is intriguing new information that bats stricken with white-nose syndrome “lack chitinase-producing enzymes normally present in bats, which may be another clue to causation.”

Unfortunately, I often found myself thinking that more information was needed. Few non-scientists, for example, will be able to figure out just what a lack of chitinase means to an insect-eating bat. And although mosquitoes are later mentioned as a food source, there’s no discussion of the controversy over just how many mosquitoes bats actually do consume. Similarly, the authors mention that bats have “specialized tendons in the toes” for roosting upside-down, but there is no explanation as to how these tendons function. Because providing understanding was a major theme of their book, I feel that the authors often tripped up short of their goal.

Although many of my problems with *Do Bats Drink Blood?* are related to missed opportunities, others concern choices that the authors have made. For example, the short section on Bat Bodies spends far more space (three pages) on a list of the words used for “bat” in different languages than it does in discussing unique aspects of bat anatomy. Similarly, the section on “Bat Behavior” inexplicably contains a three-page insert on Batman—with nearly a half page spent on the distinction between Batman and Man-Bat. This space could have been put to better use by expanding on other answers or perhaps by including additional topics. The common question of “why doesn’t blood rush into a hanging bat’s head?” is one that I would like to have seen answered.

In addition to problems with content, errors of an editorial nature also occur, including occasional inconsistencies, such as referring to *Noctilio* as the “fisherman bat” and “fisherman’s bat” in successive sentences. My final and strongest criticism concerns the list of references. In the list, only the first author of multi-authored papers is typically listed—unless one of the authors of *Do Bats Drink Blood?* happens to be a coauthor. Perhaps this omission was corrected in the final version of the manuscript (I did review an uncorrected proof), but if that is not the case, I find it somewhat inexcusable that the authors of this book took the time to cite completely their *own* multi-authored works but not those of others.

In conclusion, the intentions of the authors are noble, and they have provided “a trove of fascinating facts” across a range of topics in *Do Bats Drink Blood?* However, better choice of content and better editing would have resulted in a more powerful addition to the general-readership literature on bats.

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ANNOUNCEMENTS

M.S. Research Assistantships, University of Maryland and Frostburg State University

M.S. Research Assistantships are available in Wildlife and Fisheries Biology or Applied Ecology and Conservation Biology at the University of Maryland Center for Environmental Science, Appalachian Laboratory, and Department of Biology, Frostburg State University. Search will continue until openings are filled. To apply (electronic submission preferred), send a cover letter indicating availability, résumé, copies of transcripts and GRE scores, and names and addresses (including email) of three references to J. Edward Gates (egates@al.umces.edu). Please write "Bat Assistantship" in the subject line of your email.

2010 Bat Conservation International Student Research Scholarships

Bat Conservation International is accepting applications for its 2010 BCI Student Research Scholarships. Grants of up to $5,000 each will be awarded for the 2010–2011 academic year. Grants will be awarded for research that is directly related to bat conservation, with an emphasis on research that documents roosting and feeding habitat requirements of bats, their ecological and economic roles or their conservation needs. Ten of these scholarships are supported by the U.S. Forest Service International Programs specifically for research conducted in developing countries. Students enrolled in any college or university worldwide are eligible to apply for BCI scholarships. Applications are competitive and will be reviewed by bat scientists outside BCI. The **application deadline** for 2010 scholarships is **15 December 2009**. Information and the online application form are available at http://www.batcon.org/scholarships

New Book: *Bat Rabies and Other Lyssavirus Infections*

Bat Rabies and Other Lyssavirus Infections (by Dr. Denny G. Constantine) is intended for scientists and the general public. presents the material in a simple, straightforward manner that serves both audiences. The book, written and prepared by the U.S. Geological Survey National Wildlife Health Center, was published with the goal of increasing public understanding of rabies and the often misunderstood bat, and providing a balanced perspective on the risk of bat rabies to people. The publication is available online (USGS Circular 1329) and printed copies are available from the USGS Store (Product #213560). For details, more information, and links, please see: http://www.nwhc.usgs.gov/publications/other/batrabies.jsp

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FUTURE MEETINGS and EVENTS

19–23 October 2009
The 20th Annual Rabies in the Americas (RITA XX) meeting will take place in beautiful Quebec City, Canada. This conference brings together rabies scientists from around the world, and is an opportunity to share your experiences and to enhance your knowledge of rabies and its control. Abstract submission begins in June, and registration continues until August 14th. Information is available at: http://www.RITA2009.org

4–7 November 2009
The 39th Annual NASBR will be held in Portland, Oregon. Please see http://www.nasbr.org/ for information.

19–21 February 2010
The 2nd International Berlin Bat Meeting: Bat Biology and Infectious Diseases will be held in Berlin, Germany. More information is available at : http://www.izw-berlin.de/

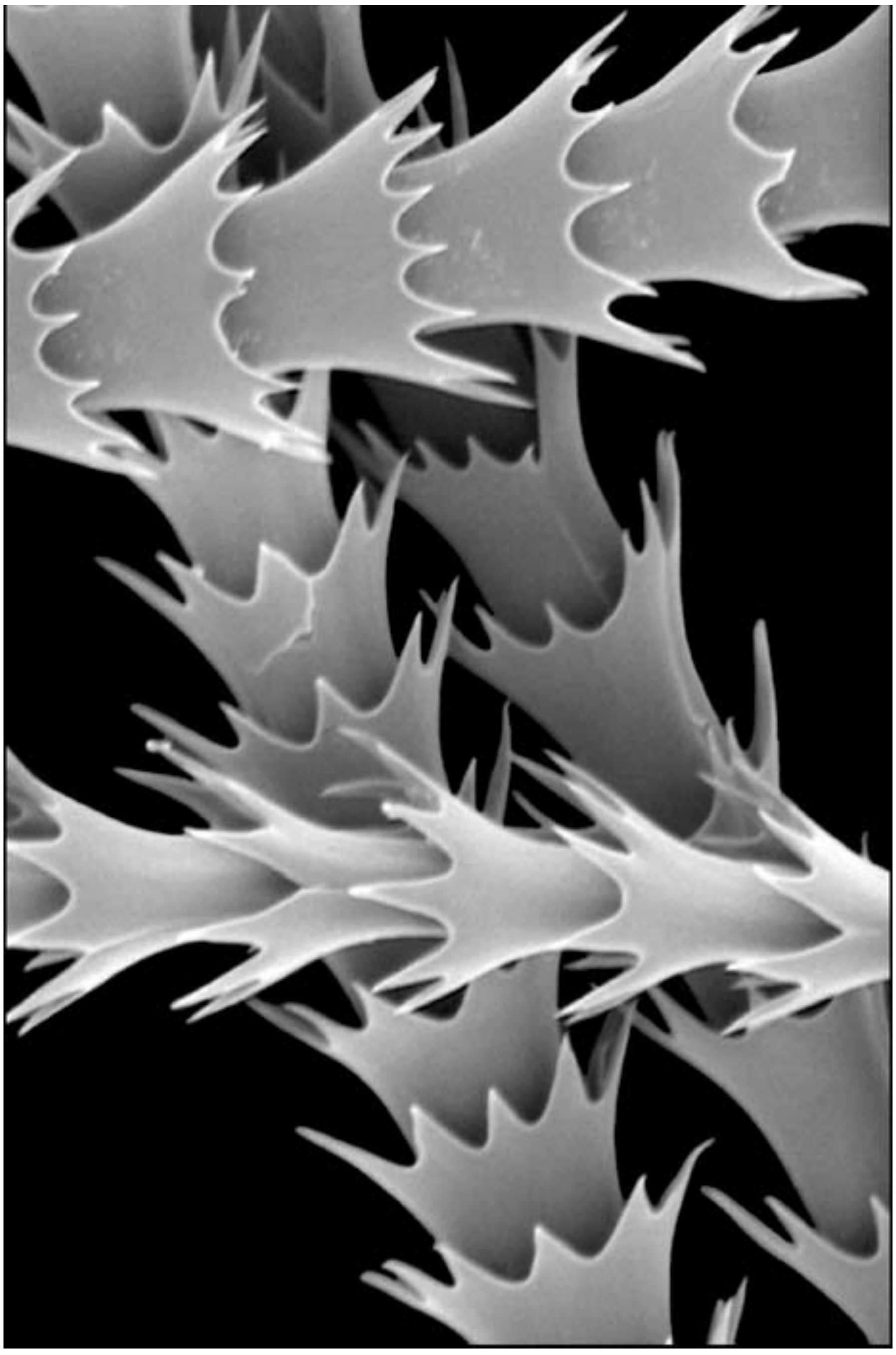
12–14 July 2010
The 14th Australasian Bat Society (ABS) Conference will be held in Darwin, Northern Territory, Australia. For more information, please see: http://batcall.csu.edu.au/abs/absmain.htm

2010
The XVth International Bat Research Conference (IBRC) will be held in Czech Republic, dates to be announced.

2010
The 40th Annual NASBR will be held in Denver, Colorado. Please see http://www.nasbr.org/ for information.

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

BAT RESEARCH NEWS



VOLUME 50: NO. 4 **WINTER 2009**

BAT RESEARCH NEWS

Volume 50: Number 4 Winter 2009

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

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BAT RESEARCH NEWS

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Front Cover

Hairs of *Tadarida brasiliensis* from Puerto Rico magnified 2,300 times. Photo by Brian A. Schaetz, Eastern Michigan University.

A Field- and Laboratory-based Comparison of Adhesives for Attaching Radiotransmitters to Small Insectivorous Bats

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Introduction

Radiotransmitters are a valuable tool for studying numerous aspects of chiropteran behavior (Campbell et al., 2006; Chruszcz and Barclay, 2004; Willis and Brigham, 2004), physiology (Park et al., 2000; Turbill et al., 2003; Willis and Brigham, 2003), and ecology (Heithaus and Fleming, 1978; Murray and Kurta, 2004; Neubaum et al., 2006; Nicholls and Racey, 2006; Perry et al., 2007). There are various methods for attaching transmitters, but rubber-based surgical adhesives (e.g., Skin-Bond, Smith & Nephew, Inc., Largo, Florida) frequently are used to glue the transmitter to the skin between the scapulae (Aldridge and Brigham, 1988; Brigham, 2008). Although some aspects of applying transmitters to bats are unique, the manufacturer's general directions for using these adhesives are similar for most brands and apply for use with bats. After trimming the fur close to the skin, the biologist applies a thin layer of adhesive to both the bat and the transmitter. When the adhesive is tacky, the transmitter is positioned on the bat, and the fur often is folded over the transmitter to finish the application (Brigham, 2008; Carter, 2009).

The original formula of Skin-Bond (hereafter referred to as old Skin-Bond) was the most popular and widely used adhesive for bats (Brigham, 2008), but since its discontinuation, an alternative adhesive is needed. The replacement formula of Skin-Bond (hereafter referred to as new Skin-Bond) was not considered acceptable by all workers, and this new formulation also was discontinued within a year of its release. Some researchers recommended Torbot Bonding Cement (Torbot Group, Inc., Cranston, Rhode Island), which is a latex-based surgical adhesive, as a replacement. We tested characteristics of these and other adhesives to evaluate their performance compared to the benchmark set by old Skin-Bond. Specifically, we assessed performance with four metrics: transmitter retention time, adhesive waiting time, adhesion strength, and re-adhesion strength.

Materials and Methods

Field test.—Three types of surgical adhesives (old Skin-Bond, new Skin-Bond, and Torbot) were tested in the field by placing transmitters on three species of *Myotis* (*M. sodalis*, *M. lucifugus*, and *M. septentrionalis*) at sites in southern Indiana, Illinois, and northern Kentucky and tracking each bat using telemetric equipment. We documented how many days each transmitter remained attached to the animals. Transmitters were considered attached if we located the bat in a new roost tree each day or if we documented that the bat was flying (variable versus constant signal during the night). If we failed to locate the animal, the transmitter still may have remained attached. Therefore, our estimate represents the minimum number of days that a transmitter remained on an animal. Although conservative, any bias should be equal among treatments (types of adhesive).

Laboratory tests.—In addition to old Skin-Bond, new Skin-Bond, and Torbot, three other brands—Osto-Bond (Montreal Ostomy Products, Vaudreuil, Quebec, Canada), Perma-Type Surgical Cement (Perma-Type Company, Inc., Plainville, Connecticut), and LashGrip Eyelash Adhesive (American International Industries, Los Angeles, California)—were tested in a controlled laboratory environment. Each adhesive underwent tests to assess waiting time, adhesion strength, and re-adhesion strength. First, each adhesive was applied to a clean glass slide in the same manner as it would be applied to a bat. The time it took for the adhesive to become tacky was recorded. This represented the time that a biologist should wait before applying a transmitter (Brigham, 2008). The transmitter was deemed tacky after visual confirmation of bubbles and tactile confirmation of a sticky surface that did not transfer any glue to a finger when lightly touched.

To measure adhesion strength, each adhesive was applied to both the flat side of a transmitter and to a clean glass slide. The slide and transmitter were left apart until the adhesive became tacky. Then, the adhesive-coated transmitter was applied to the adhesive on the slide, and the adhesive was allowed to cure. After 24 h, the transmitters were pulled parallel from the glass-slide by gripping the antennae with a spring-scale (Pesola AG, Baar, Switzerland). Adhesion strength was defined as the loading (g) at which the bond failed. Each adhesive was tested on 10 slides with 10 different transmitters.

The test for re-adhesion strength occurred immediately after the initial 24-h strength test. After a transmitter became detached, it was immediately reapplied to the same slide, without any modifications, and adhesion strength was immediately remeasured with the spring scale. This procedure tested the ability of the adhesive to re-adhere (re-adhesion strength) and simulated re-attaching a transmitter to a bat after the transmitter had been subjected to some stressing force or partial removal. In the field, this rebonding ability presumably helped prevent loss of transmitters and increase retention time.

Statistics.—Retention time, adhesion, and re-adhesion strength were compared using one-way analyses of variance and Tukey's multiple comparison tests. Because tackiness is based on a person's judgment and there is no good way to quantify tackiness, we report our observations for this measure but do not statistically analyze them. All means are presented ± 1 sd.

Results

Field test.—New Skin-Bond, old Skin-Bond, and Torbot were applied to 5, 30, and 17 bats, respectively. There was a significant difference in length of time that a transmitter was retained ($F = 5.57$; d.f. = 2, 46; $p = 0.007$). Although number of days of attachment for new Skin-Bond (17.6 ± 7.6 days) was not significantly different from that of old Skin-Bond (16.9 ± 6.1 days), both formulations of Skin-Bond held significantly longer than Torbot (10.9 ± 4.5 days).

Laboratory tests.—Old Skin-Bond needed 5–10 min to become tacky. After curing for 24 h, old Skin-Bond required a load of 330 ± 76 g to pull the transmitter from the slide (Table 1). With immediate reapplication and testing, a load of 318 ± 98 g resulted in adhesive failure. After 24 h, the adhesive was still tacky.

New Skin-Bond had a waiting time of less than 5 min. After curing for 24 h, new Skin-Bond required a load of 565 ± 63 g to pull transmitters free from the slides. When the transmitters were retested, a load of 496 ± 63 g was needed for adhesive failure. After 24 h, new Skin-Bond also was still slightly tacky.

Torbot dried to a tacky state in 2–2.5 min. After curing for 24 h, a load of 270 ± 144 g was required to cause adhesive failure. After immediate reapplication, Torbot failed under

Table 1. Range of time to tackiness and mean (± sd) adhesion strength and re-adhesion strength of different adhesives used for attaching radiotransmitters to bats.

Adhesive	Time to tackiness (min)	Adhesion strength (g)	Re-adhesion strength (g)
New Skin-Bond	<5	565 ± 63	496 ± 63
Perma-Type Surgical Cement	3–4	465 ± 102	392 ± 94
Old Skin-Bond	5–10	330 ± 76	318 ± 98
LashGrip Eyelash Adhesive	>20	276 ± 74	0
Torbot Bonding Cement	2–2.5	270 ± 144	154 ± 88
Osto-bond	<2	254 ± 171	153 ± 69

a load of 154 ± 88 g. After 24 h, the adhesive was not tacky.

Time to tackiness for Osto-Bond was less than 2 min. Adhesion strength at 24 h was 254 ± 171 g, and re-adhesion strength was 153 ± 69 g. Osto-Bond was not tacky after 24 h.

Perma-Type Surgical Cement became tacky in 3–4 min. This cement had an adhesion strength of 465 ± 32 g at 24 h and a re-adhesion strength of 393 ± 94 g. The cement was slightly tacky after 24 h.

LashGrip Eyelash Adhesive took more than 20 min to become tacky. The 24 h adhesion strength was 276 ± 74 g, and the adhesive had no ability to re-adhere after 24 h and was not tacky.

There was a statistical difference in adhesion strength among the adhesives ($F = 12.73$; d.f. = 5; 54, $p < 0.001$). New Skin-Bond was stronger than all other adhesives, except Perma-Type. Perma-Type, in turn, was stronger than Osto-Bond, Torbot, and LashGrip. Results were similar for re-adhesion strength ($F = 54.87$; d.f. = 5, 53; $p < 0.001$). New Skin-Bond had a stronger re-adhesion strength than all other adhesives except Perma-Type. Perma-Type and old Skin-Bond were stronger than Osto-Bond, Torbot, and LashGrip. LashGrip had no re-adhesion ability and was significantly weaker than all other adhesives.

Discussion

Although laboratory tests are no substitute for real-world field tests, they can eliminate many confounding factors likely to influence the performance of adhesives used to affix transmitters to bats. Laboratory tests are useful for eliminating the variability caused by numerous biotic and abiotic factors (e.g., animal behavior and weather) and also factors likely to influence probability of detection (e.g., topography, road density, and property access), which can affect measures of retention time. Using field and laboratory tests and the worldwide-accepted use of old Skin-Bond as a benchmark, we evaluated the other adhesives.

Although initial strength of an adhesive is certainly important, it is not the only consideration. Our tests and field observations also identified a large disparity in waiting time (time to tackiness) among brands of adhesives. Although amount of time an adhesive takes to reach the tacky state does not appear related to its ultimate adhesion strength (e.g., Old and New Skin-Bond have very different time to tackiness but have similar strength; Table 1), it is an important factor affecting how long bats must be held while transmitters are applied.

Additionally, age and consistency of the adhesive are factors that contribute to waiting time and, therefore, length of time that bats are held. We observed in preliminary tests that, within a brand, the more viscous the adhesive (generally older bottles), the greater the amount of adhesive that must be applied, which results in added weight, longer drying times, and weaker bonds. Most adhesives that we tested use a hexane-based solvent as a thinning ingredient. As that solvent volatilizes, the adhesive thickens and eventually dries. Old bottles of Skin-Bond, Torbot, and similar adhesives can be returned to original consistency by mixing with small amounts of hexane. This procedure allows less adhesive to be used with each application, thus improving performance and maximizing number of applications per bottle.

Even with these similar patterns of drying time versus consistency across adhesives, some brands apparently reach the tacky state more quickly than others (Table 1). Although not analyzed statistically, our observations indicate that the time required for old Skin-Bond to become tacky is much longer than for the other adhesives. Researchers who are accustomed to old Skin-Bond will have to change their current time-management and work-flow patterns due to the shorter waiting times of many alternative adhesives. A benefit, however, is that these new adhesives allow for faster processing of animals and greatly reduced holding times. We were able to release bats in 10 min or less after using new Skin-Bond and Torbot, compared to a typical 20–30 min with an older bottle of old Skin-Bond. However, some adhesives, such as Torbot, dry so fast that steps to expedite the process of applying transmitters may be needed. Occasionally, by the time that we were ready to apply a transmitter, the Torbot had almost completely dried, rendering it considerably less effective. In these cases, a new, thin layer of Torbot was applied, and the process was restarted.

We noticed a seeming disparity in the performance of old Skin-Bond between field and laboratory tests. Although retention time and adhesion strength should have some correlation, the performance of old Skin-Bond seemed much better in the field than in the laboratory. We believed that this is a consequence of old Skin-Bond having a better ability to re-adhere than alternative products. New and old Skin-Bond and Perma-Type had re-adhesion strengths that equaled 90% or more of their initial values. Re-adhesion strengths of Torbot and Osto-Bond averaged ca. 70% of initial adhesion strengths.

We advocate that re-adhesion strength is important, because it allows both Skin-Bond formulations and presumably Perma-Type to maintain a stronger hold over time, as bats actively work to remove transmitters or the bond is exposed to passive stressors. These adhesives can essentially reattach after partial removal, which should increase length of time a transmitter stays attached. The differences in re-adhesion strength may be related to the ingredients used. Both formulations of Skin-Bond and Perma-Type are rubber-based adhesives, whereas Torbot and Osto-Bond are latex-based cements.

During early stages of this work, we intended to suggest new Skin-Bond as a replacement for old Skin-Bond, because the newer formulation is generally superior to other alternatives (Table 1). However, because new Skin-Bond is no longer sold, we now recommend Perma-Type Surgical Cement. It is similar in characteristics to both formulations of Skin-Bond and is the best available adhesive based on our laboratory tests (Table 1). Torbot and Osto-bond are also acceptable for applications where maximum time of transmitter retention is not needed. Additionally, we believe that Osto-bond is the same product as Torbot, just relabeled. The packaging and ingredients are identical, and results of our laboratory tests are virtually identical for all metrics (Table 1).

Lastly, woodworking contact cement (e.g., Weldwood Contact Cement, DAP, Inc., Baltimore, Maryland) has been used in some countries to affix transmitters to bats

(Brigham, 2008). It has been described as performing well in wet conditions (F. Anderka, pers. comm.), and our preliminary tests suggest that strength and re-adhesion may be greater than other adhesives. However, even though contact cement has ingredients and material safety data sheets (MSDS) similar to those of Skin-Bond, the U.S. Fish and Wildlife Service (Field Office, Bloomington, Indiana) has rejected it for use with endangered bats because, unlike the adhesives described in this paper, woodworking products are not designed for direct contact with skin.

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Of Darwin and Bats

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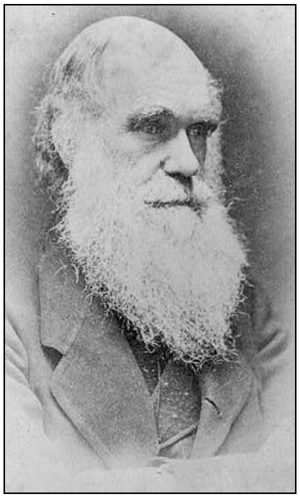

Figure 1. Darwin as an older man. Library of Congress, Prints & Photographs Division, [Reproduction Number, LC-USZ61-104].

This year marks the 200th birthday of Charles Darwin (1809) and the 150-year anniversary of his seminal work "*On the Origin of Species by Means of Natural Selection and the Preservation of Favored Races in the Struggle for Life*" (1859). Darwin and his influential writings are being celebrated across the globe in various ways, from school events to museum displays and lectures. With publication of the *Origin*, Darwin connected all life through space and time, an idea that has rippled across all fields of science. Today, scientists continue to test many of the concepts that have rested peacefully among thousands of pages of his life's work, awaiting technology to catch up to his 19th-century mind.

But Darwin's staggering intellectual impact goes far beyond this one book. Indeed, he wrote many other influential publications that impacted diverse fields of science such as, *Geological Observations on South America* (1844), *Volcanic Islands* (1844), *Fertilisation of Orchids* (1862), *The Movements and Habits of Climbing Plants* (1865), *Variation of Animals and Plants Under Domestication* (1868), *Descent of Man* (1871), *Insectivorous Plants* (1875), *Effects of Cross and Self Fertilisation in the Vegetable Kingdom* (1876), *The Different Forms of Flowers on Plants of the Same Species* (1877), *The Formation of Vegetable Mould, through the Action of Worms, with Observations on their Habits* (1881). He even wrote a book on "*The Expression of the Emotions in Man and Animals*," which is interesting because only recently have scientists begun to accept that some nonhuman animals experience emotional states very similar to our own. Thus, Darwin's contribution to the world was impressively comprehensive and visionary, despite the relative paucity of, and gaps in, knowledge at that time.

Despite his eventual fame, Darwin, as a person, was humble and reclusive and his personality did not mesh well with the attention his discoveries drew. Certainly, nothing was further from Darwin's imagination than fame when, at the tender age of 23, he boarded the H.M.S. Beagle as the ship's naturalist, leaving Plymouth, England on 27 December 1831 on a 5-year expedition to circumnavigate the globe. He suffered severely from motion sickness and nearly left the expedition within the first year. But instead he pushed onward, collecting specimen after specimen, many of them previously unseen by the world from which he ventured. Throughout his journey, Darwin slowly began to realize that the patterns of life he was witnessing conflicted in almost every way with the theological explanations he knew and cherished. He became so distraught over his own findings and the clear and obvious conclusions demanded by rational thought that he was reticent to discuss his evidence with anyone except close confidants for more than 22 years after the Beagle expedition.

Figure 2. Drawing of a common vampire bat *(Desmodus rotundus)* caught at the back of Darwin's house in Chile. Drawing by R. T. Pritchett. Reprinted with permission of The University of Adelaide Library, University of Adelaide, South Australia.

So how do bats play into all this? Although Darwin is best known for his use of the Galapagos finches to illustrate how natural selection works, he often refers to bats in the *Origin*, using them as illustration for many aspects of his argument. For example, in reference to how islands isolate populations, he states: "Although terrestrial mammals do not occur on oceanic islands, aerial mammals do occur on almost every island. New Zealand possesses two bats found nowhere else in the world." However, his most powerful evidence for the interrelatedness and evolution of life through what he termed "decent with modification," was the fact that structures do not appear *de novo*; instead, so-called new structures, such as wings in birds and bats, are only new functions built upon the recycled anatomy of ancestors. He expressed this as follows: "What can be more curious than that the hand of a man, formed for grasping, that of a mole for digging, the leg of the horse, the paddle of the porpoise, and the wing of the bat, should all be constructed on the same patterns, and should include similar bones, in the same relative positions?" Darwin also integrated the work of Haeckel on developmental biology and bats in his evolutionary scheme by stating, "It is notorious that the wings of birds and bats, and the legs of horses or other quadrupeds, are indistinguishable at an early embryonic period, and they become differentiated by insensibly fine steps." Despite his 19th-century insights, it was only in 2006 that a researcher isolated the proteins produced by a mutated regulatory gene in bats that, when injected into mouse embryos, proceeded to produce, in late development, bat-like, elongated fingers.

These insights are foundational to our understanding that all life is fundamentally related, descending through time from a single common ancestor, thus sharing many basic attributes across all taxa. We call this homology today, indicating shared evolutionary history, and it is in this way that we are all related to Darwin, to each other, and to the rest of life. So in celebrating Darwin's bicentennial, we are celebrating the long history of life on Earth and all its descendants, including ourselves.

Happy Birthday, Chuck!

Abstracts of Papers Presented at the
39th Annual North American Symposium on Bat Research
Portland, Oregon
4–7 November 2009

The following abstracts are from papers presented at the 39th Annual North American Symposium on Bat Research (NASBR). They were compiled and submitted by G. Roy Horst, and edited for publication by Margaret Griffiths. Any omissions or errors are inadvertent.

Abstracts are listed alphabetically by first author. Student awards recipients are indicated by an asterisk (*****) next to the title of the paper. Contact information for authors who attended the 39th Annual NASBR follows the abstracts.

Linking Food Resources with Male Calling Sites of Walberg's Epauletted Fruit Bat (*Epomophorus wahlbergi*) in Kruger National Park, South Africa
Adams, R. A., and Emily Snode, University of Northern Colorado, Greeley, CO

On 19 June 2009 we located a relatively large number (n = 23) of calling male *Epomophorus wahlbergi* along the upper Sabie River, at the western boundary of Kruger National Park (KNP), South Africa. Unlike years previous, there was a paucity of ripe figs throughout KNP, making this particular area along the Sabie River unique in concentrating female and male *E. wahlbergi* within a 10 km stretch of river corridor. On the nights of 20 and 21 June 2009, we returned to the site and recorded UTM localities of each calling male from our position on the road. We also recorded audible mating calls of each male using a Pettersson D240x bat detector. We used SonoBat and Raven sound analysis software to analyze male calls and used decibel levels of calls to calculate approximate distances of each male from our position on the road (i.e., intensity of sound varies inversely with the square of the distance from the source). During the day we located and mapped each sycamore fig tree in the mating area, noting which were actively fruiting, and recorded each tree's distance from the road using a Nikon Range Finder. Results showed that males produce audible, constant frequency, moderate- to long-duration call pulses (49.92–343.05 ms) beginning with a high frequency between 7.80–7.93 kHz and ending at a slightly lower frequency between 7.63–7.79 kHz (range of total slopes = 0.0012–0.0015). Highest intensity readings taken from an individual within 3 m of the detector was 98.1 decibels. Using this decibel level to map out the approximate distribution of calling males from the road resulted in a clumped distribution of males in proximity to those sycamore fig trees that were fruiting (5 of 16), presumably because females were feeding at those sites. Males did not apparently roost in fruiting fig trees, instead roosting peripherally to, but in proximity of, fig trees. Each fruiting fig tree had an associated male that was located closest, with other males located at varying distances from the food source and in some cases nearer to nonfruiting fig trees. This may suggest a dominance hierarchy among males for access to prime calling roosts nearest to trees that are actively fruiting and attracting females. Thus, males apparently take advantage of fruiting sycamore fig trees to set up call stations for mating purposes.

Tale of the TAIL: A New Dimension in Bat Flight Dynamics
Adams, Rick A., and Emily Snode, University of Northern Colorado, Greeley, CO

Although the uropatagium of vespertilionid bats is well known for its use as an insect catchment during foraging, the inter-femoral membrane has been largely ignored as an active contributor to flight mechanics. Indeed, the uropatagium is often referred to as a morphological feature to be overcome due to its tendency to increase drag during flight. With the use of high-speed video (Casio EX-F1), we put forth a new interpretation of the uropatagium and its participation in flight dynamics by showing how this membrane may contribute lift and acceleration during takeoff. We define this contribution to be Tail-Assisted-Inertial-Lift or TAIL. The employment of this technique is manifested fully during more difficult takeoffs, but the timely use of this skill during foraging is readily conceivable.

Spatio-temporal Variation in Bat Activity in Ontario and How Sampling Method Impacts its Depiction
Adams, Amanda M., University of Western Ontario, London, ON

Effective management and conservation strategies for biological communities require a thorough understanding of structure and function. The structure of a community, the number of species, and the distribution of those individuals can vary dramatically both temporally and spatially. When attempting to characterize the structure of a community it is important to consider the advantages and limitations of various sampling techniques. When and how to sample is a question that is typically decided by time availability, manpower, and equipment limitations. The majority of bat surveys occur during the initial peak in activity (within 3 h of sunset). The degree of temporal variability will determine if sampling in the beginning of the night is adequate and, if so, for which species. My research addresses how much sampling and what techniques are most effective for representing bat activity levels in temperate locations and to what extent different practices can give different representations of the same community.

"Being a Bat's Friend": A Spread of Knowledge and Research Project by the Museum of Natural History, University of Florence (Italy)

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In 2006 the Museum of Natural History at the University of Florence launched the campaign "BAT-BOX: Being a Bat's Friend" whose aim is to address and spread the knowledge and the role of bats and their ecology in urban environments, to raise their appreciation within the general public, and to enable the conservation of bats to be available to anyone through the use of bat boxes. Whilst we recognized that bat boxes are well used in wooded and rural environments, their use in urban areas has been limited and with modest results. Thanks to the sponsorship from COOP, a large Italian retail outlet, we have been able to distribute, at cost price, 6600 bat boxes (200 in 2007, 2000 in 2008, and 4400 in 2009, until August) to a great number of people and city governments who have had them installed and agreed to monitor them. It is a cheap, wooden bat box with one compartment. The testing is still going on; the regular collection of data through a card delivered at the same time with each bat box allows the volunteers to send information concerning installation and monitoring. The main communication tool has been the brochure "*Un Pipistrello per Amico*" ("Being a Bat's Friend") and the e-mail batbox@unifi.it, fully dedicated to the correspondence about the project. Bat boxes placed during 2007 have shown a colonization success of 18.7% at the end of the same year, and the 31.9% at the end of 2008. Those located during 2008 have recorded a success of colonization of 13.9% after one season of monitoring only. The permanence time is therefore a decisive element for the colonization of these artificial roosts. The best success of colonization can be performed with the higher elevation above the ground and the limited sunshine. The growing number of participants enhances the chances to achieve further development; the latter can lead to the identification of better skills of construction and specific bat-box position in anthropic areas, by supporting a very important work of public awareness, which is essential to any project of faunistic conservation.

Assessing the Fight-or-Flight Response in the Brazilian Free-tailed Bat (*Tadarida brasiliensis*) Using Heart Rate Telemetry

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As human populations expand, increased encroachment on natural landscapes and wildlife habitats is inevitable. It is likely that organisms that are able to adapt or acclimate to human-altered habitats will have a selective advantage over those unable to do so. One example of a human-altered landscape condition is the increasing availability and use of highway bridges by bats. Evidence from previous research, based on measured levels of the hormone cortisol, suggests that bridge-roosting Brazilian free-tailed (BFT) bats (*Tadarida brasiliensis*) experience lower levels of stress and are in better overall health than their cave-roosting counterparts. This unexpected result suggests that this species is able to acclimate to the potential stressors commonly observed at highway bridges. Heart rate telemetry (HRT) allows direct and continuous monitoring of a response to an acute stressor and, thus is ideal for assessing acclimation to repeated stimuli in free-ranging organisms. HRT has been used in several avian and mammalian species; however, to date use of this technology on small, free-ranging bats has not been tested. In this study we assessed the suitability of HRT for evaluating physiological responses to disturbance in *T. brasiliensis*. Furthermore, we evaluated the ability of BFT bats living in a large highway bridge to acclimate to repeated environmental stressors. We subjected lactating females (n = 4) to several novel, but repetitive, disturbance events (simulated predator) over the course of 12–36 h experiments. We also correlated the response of bats to other notably disturbing events: sound and vibrations from trains, vehicles, and human presence. To measure heart rate, we attached a small (0.06 g) custom-made HR transmitter to each bat (~12 g). Signals were recorded on an MP3 recorder, while each bat was in the roost and during the onset of nightly emergence. Preliminary results show that when subjected to acute stressors lactating females reacted by reducing their heart rate, an uncommon response in the animal kingdom. Results are discussed in the context of the conservation implications of this physiological response.

Analyzing Anabat Detection Distance of Eastern U.S. Bats Using a Zip-Line
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The proliferation of industrial wind farms has led to the widespread use of Anabat detectors for both pre- and post-construction bat surveys. Detectors are often used passively and the data are used to ascertain local bat fauna. The assumption is that the detector is sampling equal amounts of airspace for all species of bats. If this is false, many species may be under- or over-represented when using bat passes to obtain a relative abundance of species or species groups present. We have conducted trials to obtain a linear detection distance among species. Additionally, future trials will attempt to create a three dimensional view of the sampled airspace. A 35-m wire zip-line was constructed in an open field to avoid clutter. Bats were attached to the zip-line using a 30-cm elastic sewing thread, with a small non-constraining noose around their neck and a wire loop attached to the zip-line. The trials were conducted after sunrise, eliminating the possibility of other bats flying in the area. Bats from five species (*Eptesicus fuscus, Nycticeius humeralis, Lasiurus borealis, Myotis septentrionalis,* and *Perimyotis subflavus*) were used, representing different sizes and frequencies. An Anabat SD1 detector with sensitivity set to 4.5, was placed at a 90° angle from the center of the zip-line, initially at a distance of 5 m. It was incrementally moved until the bat was no longer detectable and the data light was not blinking. Preliminary results show a general trend indicating that the lower frequency the bat uses, the farther away it is able to be detected. Additionally, there is a steep degradation of both the quality of the call and the number of identifiable pulses within a call sequence as distance is increased. These results are supported by physics, as higher frequency sounds are attenuated faster than lower frequencies. Unfortunately, calls obtained from the zip-line were not representative of search phase calls from free-flying specimens. They were higher in frequency and shorter in duration. Zip-lined call files should not be used in known call libraries and we are currently considering other options for future trials such as the use of a flight cage.

How Solitary Is Solitary? Is there Social Structure in Eastern Red Bats (*Lasiurus borealis*)?
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Eastern red bats (*Lasiurus borealis*) are insectivorous bats that roost solitarily in tree canopies. Radiotelemetry studies, conducted in the Ozark region of Missouri, evaluating both roosting and foraging habitat of adult females frequently revealed two or more individuals roosting in the same forest patch. These same individuals consistently foraged in the same areas at the same time, suggesting these individuals may represent a social structure consisting of mothers and their female offspring. Control region sequences of mtDNA were amplified and the resulting haplotypes were evaluated using ARLEQUIN 2.0 to determine relatedness of these individuals. Our results indicate a higher than expected level of similar haplotypes between these individuals. We are currently evaluating pairs of individuals with shared haplotypes using microsatellite DNA to further evaluate the relationships between these individuals.

Molecular Phylogeny of the Family Molossidae
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Our current understanding of the relationships among genera of bats in the family Molossidae (100 species, 16 genera) is based largely on morphological data. Relationships among the genera of free-tailed bats have not been tested with molecular data and thus, the objective of this study was to construct a phylogeny of representative members of this family using DNA sequence data. We collected sequence data from one mitochondrial locus (*ND1*) and 3 nuclear loci (*DMP1*, *FibI7*, and *RAG2*) from members of the family Molossidae (subfamily Molossinae) and outgroups from the family Vespertilionidae (*Myotis* and *Antrozous*). Taxonomic sampling was greatest for the *ND1* data set (12 genera, 32 species) and lowest in the Fibrinogen intron 7 data set (10 genera, 21 species). Sequence from the 4 genes totaled 3028 base pairs. Each data set was analyzed separately using maximum likelihood and Bayesian methods. Nuclear divergence values (uncorrected ‘p’) averaged 5% among molossid genera, while mitochondrial divergence in the *ND1* data set averaged 15%. Few intergeneric relationships were significantly supported by the mitochondrial data; however monophyly of most genera was supported. Nuclear results supported a “New World” clade consisting of *Eumops*, *Molossus*, *Promops*, *Molossops* (including *Neoplatymops*), *Cynomops*, and *Nyctinomops*. Our analysis also showed significant support for a *Promops*-*Molossus* clade and a *Chaerephon*-

Mops clade although the position of these clades in relation to the others is not well supported. Based on the taxa included in our analysis, we will discuss our evaluation of specific hypotheses of relationship that have been proposed for *Nyctinomops*, *Otomops*, *Sauromys*, *Cheiromeles*, and *Tadarida*. We conclude that although additional data and taxonomic sampling will be necessary to completely understand relationships within the family Molossidae, the hypotheses of relationship supported by this analysis are inconsistent with published morphological phenograms.

Reducing Bat Fatalities at Wind Energy Facilities by Changing Turbine Cut-in Speed

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We implemented the first U.S.-based experiment on the effectiveness of changing turbine cut-in speed on reducing bat fatality at wind turbines at the Casselman Wind Project in Somerset County, Pennsylvania. Our objectives were to 1) determine the difference in bat fatalities at turbines with different cut-in-speeds relative to fully operational turbines, and 2) determine the economic costs of the experiment and estimated costs for the entire project area under different curtailment prescriptions and timeframes. We employed three treatments at each turbine with four replicates (n = 12 turbines) on each night of the experiment: 1) fully operational, 2) cut-in speed at 5.0 m/s (C5 turbines), and 3) cut-in speed at 6.5 m/s (C6 turbines). We used a completely randomized design and treatments were randomly assigned to turbines each night of the experiment, with the night when treatments were applied being the experimental unit. We conducted daily searches at the 12 turbines from 26 July to 10 October 2008. There was strong evidence that the estimated number of fatalities over 25 nights differed among turbine treatments ($F_{2,33} = 8.99$, $p = 0.008$). There was no difference between the number of fatalities for C5 and C6 turbines ($\chi_1^2 = 0.83$, $p = 0.3625$, 95% CI: 0.11, 2.22). Total fatalities at fully operational turbines were estimated to be 5.4 times greater on average than at curtailed turbines (C5 and C6 combined; $\chi_1^2 = 14.63$, $p = 0.001$, 95% CI: 2.28, 12.89); in other words, 73% (95% CI: 53–87%) of all fatalities at curtailment turbines likely occurred when the turbines were fully operational. The lost power output was only 0.3 to 1% of total annual output. Given the magnitude and extent of bat fatalities worldwide, the conservation implications of our findings are critically important.

Power of Genetic Data in Understanding Speciation in Bats

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Robert J. Baker was awarded the Gerrit S. Miller Award

It is generally acknowledged that speciation is a seminal event relative to biodiversity, evolution, conservation, distribution, niche partitioning, etc. However, resolution of these speciation linked phenomena has been limited by the difficulty associated with identification of species and species boundaries, statistically supported monophyly, understanding of inter- and intraspecific variation, extent of introgression and hybridization, etc. We provide examples using bats of how genetic data can resolve different speciation mechanisms (ecological speciation, Bateson Dobzhansky Muller speciation through allopatry, speciation by hybridization, chromosomal speciation by monobrachial fusions, and species boundaries that require redefinition to achieve monophyly). We hypothesize that variations in the process of speciation will leave a genetically defined footprint (oops, I mean wingprint) that will permit the testing of alternative speciation mechanisms. Additionally, genetics can be used to more clearly define "species" in a way more easily applied to the variation observed in bats. We use genetically defined monophyletic clades of nectar feeding bats (Choeronycterini, Glossophagini and Lonchophyllinae) and geographic information system based computer modeling to demonstrate geographic areas of speciation that are ecologically defined for these phylogroups. The geographic ranges representing the niche amplitude of defined monophyletic groups identified in our work are different from traditional geographic ranges, typically defined by connecting lines between geographic adjacent localities where the species have been collected, opening the possibility of a better reconstruction of potential evolutionary scenarios for the origin of nectivory among Neotropical bats. We hypothesize that the combination of bioinformatics, genomics, and computer based ecological definitions will have a considerably more powerful resolution of the evolutionary and ecological forces that are producing patterns of Chiropteran biodiversity.

Selection of Day Roosts by Keen's Myotis (*Myotis keenii*) at Multiple Spatial Scales
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Keen's myotis (*Myotis keenii*) has one of the most limited geographic distributions of any species of bat in North America. Because there is little knowledge of its roosting ecology, we examined selection of day roosts in trees by male and female Keen's myotis at three spatial scales (tree, tree plot, and landscape) on Prince of Wales Island, southeastern Alaska, from May to September 2006. We selected variables known to influence roost selection by other tree-roosting bats for logistic regression models. We used Akaike's Information Criterion to rank all models within and between scales according to their ability to differentiate between characteristics of used and available roosts and we determined the effect of each variable with model-averaged coefficient estimates and associated odds ratios. We tracked 13 females and 6 males to 62 and 24 roosts in trees, respectively. Selection of day roosts by males and females was most strongly influenced by characteristics of trees. The odds a tree was used for roosting by female Keen's myotis increased with the presence of defects, increasing diameter, and decreasing bark; increasing quadratic mean diameter in the tree plot; and decreasing distance to the nearest stream and increasing proportion of old growth in the landscape. Male Keen's myotis exhibited flexibility in types of roosts chosen, but the odds of a tree being used increased with decreasing bark, the presence of defects, and increasing slope-height. The odds a tree was used as a roost by males also increased with the increasing proportion of trees in early to late decay stages in the tree plot. Some habitat features differed between males and females at each spatial scale and differences are likely a reflection of the energetic demands associated with reproduction. We suggest that maintaining structural components characteristic of old-growth rainforest will promote conservation of Keen's myotis in southeastern Alaska.

Count Methods and a New Population Estimate for a Hunted Population of Mariana Fruit Bats (*Pteropus mariannus*)
Boland, Julia L., Commonwealth of the Northern Mariana Islands Division of Fish and Wildlife, Rota, MP

The Mariana fruit bat (*Pteropus mariannus*) is listed as Threatened under the Endangered Species Act (ESA) and Endangered on the IUCN Red List. Populations of Mariana fruit bats have been declining throughout the Mariana archipelago for the last several decades. The island of Rota contains the last viable population of this species in the southern Marianas and illegal hunting is a constant threat to its persistence. From 1999–2008, island-wide population estimates on Rota were based on departure counts of bats at seven sites that were historically occupied by maternity colonies. However, poaching has led to an unpredictable and relatively frequent turnover of roost sites used by bats on Rota, and therefore we proposed that departure counts at seven static stations were underestimating the population. We conducted an island-wide search for existing maternity colonies and determined current population estimates using direct and picture counts of maternity colonies at day roosts, and dawn and dusk counts of extra-colonial bats. To assess differences in results of each count method, we performed departure, direct, and picture counts at maternity colony roost sites on the same day; analyses of these differences were still in progress at the time this abstract was submitted. In March 2008, before revised count methods were implemented, the minimum population estimate was 107 fruit bats on Rota. In January 2009, after implementation of revised methods, the minimum population estimate was 1301 fruit bats. From June–November 2008, four maternity colonies were hit by poachers, killing an estimated 100–200 bats. Therefore, the increase in the population estimate likely reflects a change in survey methods rather than an actual increase in the population. Despite a higher population estimate, it is unlikely that the naturally low reproductive rate of this species can sustain the level of hunting pressure observed on Rota, and continued population declines are expected without adequate enforcement of the ESA.

Why Do Hawaiian Hoary Bats Migrate to High Elevations in Winter?
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Effective conservation management for highly mobile bat species must include understanding of migratory movements and seasonal habitat shifts. Seasonal movements, particularly the winter range requirements, of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) are incompletely understood. To test the hypothesis that hoary bats annually migrate through gradients of elevation and habitat on the island of Hawaiʻi, we deployed automated ultrasound detectors coupled to memory storage devices at 20 sites from near sea level to 2000-m

elevation. We recorded ultrasonic bat calls for one-week periods bimonthly and applied occupancy analysis to quantitatively estimate bat occurrence. Recorded bat calls were examined with Analook software and "detectability" of bat presence was estimated with Presence 2. At our 100- and 1000-m rainforest sites on the eastern (windward) side of Hawai‘i, bat occurrence was low January through April and dramatically increased between May and December. The bimonthly presence of bats at Pua Akala, a 1843-m moist forest site, was complex with multiple peaks of occupancy. Autumn peaks in bat detectability over several years at Pua Akala correspond to annual irruptions of palatable geometrid moths (*Scotorythra* spp.). Bat presence peaked at a 2000-m dry forest site in October–November. Hawaiian hoary bats may migrate to higher elevations possibly to 1) couple the use of daily torpor during winter (non-reproductive season) with cold temperatures at times when the highest rains occur in the lowland rainforests; and 2) feed on seasonal moth irruptions at elevations above the cloud inversion layer and thus in relatively dry, cool weather. Our ultrasound detection monitoring is continuing for a third annual cycle at an increased number of locations to provide wildlife managers with additional information about movement patterns displayed by *L. cinereus semotus*.

Bat Activity at Caves and Ponds in the Ozark National Scenic Riverways

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Mist netting, in conjunction with acoustic detection, was utilized to make an assessment of weekly and monthly habitat use by bat species at the Ozark National Scenic Riverways (ONSR) in South Central Missouri. Pre- and post-hibernation activity (April–October) shows bat species composition and numbers fluctuating near caves and ponds. Nine species were captured, including the endangered gray bat (*Myotis grisescens*) and Indiana bat (*Myotis sodalis*). Six mist-net surveys conducted over this period at one cave location, using a 2.6 x 4-m net near the cave entrance, showed total species present changing from 6, 3, 3, 6, 4, and 3 consecutively. Seven species were captured at this site. The abundance of all individuals captured also changed from 86, 90, 12, 79, 14, and 52. In June, 80 male northern bats (*Myotis septentrionalis*) and 9 male Indiana bats were captured emerging from the cave, with estimated population sizes greater than 1000 and greater than 100 respectively. This is an undocumented occurrence for that time of year. Three mist-net surveys conducted at a pond near this cave also showed variable bat activity. Species present changed from 5, 2, and 4, while total number of individuals went from 37, 7, and 39. A total of seven species were captured at the pond site. Activity from September through October will be included in this data set. These data show that one-time sampling does not adequately describe species diversity and/or relative abundance at a survey site, especially in and around hibernacula during the summer.

Could "Hot-Boxes" Enhance Survival of Bats with White Nose Syndrome?

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Since 2006, white nose syndrome (WNS) has killed hundreds of thousands of hibernating bats, presumably because the *Geomyces destructans* fungus causes affected individuals to starve during hibernation. Although new data are emerging, lack of field data on normal hibernation energetics has limited efforts to understand WNS. We used an individual-based population model to examine potential proximate causes of mortality and found that increasing the duration or frequency of periodic arousals during hibernation closely replicated the pattern of mortality observed in 2006/2007. However, reducing pre-hibernation fat stores could not replicate the observed mortality pattern. Although bats may prefer stable, cold temperatures during their long, hibernation torpor bouts, healthy little brown bats appear to travel to warmer microclimates inside hibernacula during periodic arousals, presumably to reduce thermoregulatory costs. Therefore, we used the model to test the potential of localized thermal refuge sites (i.e., small areas of warm microclimate) to improve survival and found that survival increased by up to 75%. We report data on field tests of prototype, artificial thermal refuge sites deployed in a hibernaculum outside the WNS-zone in Manitoba, Canada. Each prototype consisted of a wooden bat box equipped with exterior insulation and a small, thermostat-controlled heating cable that was powered by solar panels. Despite maintaining internal temperatures as high as 28° C, "hot-boxes" had no effect on overall hibernaculum microclimate, even in a very small, cold cave. Although an unusual idea, hot-boxes could provide a realistic option for mitigation of WNS but only under certain, specific scenarios. Clearly, hot-boxes should not be tested within the affected area unless it can be confirmed that increasing over-winter survival would not increase the rate that WNS spreads.

Habitat Selection and Diversity of Bats in a Pecan Agroecosystem in Texas
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Insectivorous bats have been postulated to play vital, yet largely unexplored, roles in ecosystem function by suppressing certain agricultural pests. Knowledge of bat activity and diversity in human-altered landscapes is crucial for understanding this expected ecosystem service. In Texas, agriculture has significantly modified native oak woodland savanna, and pecan cultivation has replaced diverse riparian woodlands. In our study, we documented habitat use by bats within the pecan agroecosystem to evaluate: 1) the role of pecan orchards as a source of riparian woodland habitat for bats, and 2) the influence of management intensity on bat activity and diversity. In 2008 and 2009, fieldwork was conducted in San Saba, Texas, a county dominated by pecan orchards. Sites were divided into three habitat types: 1) organic native pecan orchards, 2) conventionally managed planted orchards, and 3) unmanaged mesquite/juniper woodlands. Bat diversity and activity were monitored with mist nets and Anabat II detectors in June–August. During this period, six bat species were captured: *Tadarida brasiliensis*, *Myotis velifer*, *Nycticeius humeralis*, *Lasiurus borealis*, *Perimyotis subflavus*, and *Lasionycteris noctivagans*. We found a significant association between bat species and habitat type, with three of the four most abundant taxa showing clear habitat preferences in both years. Relative abundance, alpha diversity, and evenness of bats, based on mist netting, was significantly higher in organic native orchards in 2008 but not in 2009; however, mesquite/juniper woodlands consistently showed lower bat activity and diversity than both orchard types in the two years. In 2008, bat activity, as defined by number of call sequences per hour, was significantly higher in organic native orchards and this difference was most pronounced in early June; acoustic data from 2009 have not yet been analyzed. Bat activity increased with proximity to the river, but only significantly within 100 m. Our findings indicate that both organic native and conventional planted pecan orchards are important sources of habitat for bats in a semi-arid landscape, and that there are species-specific differences, as well as seasonal variation, in habitat use between management types. This study of habitat use by bats directly compliments other work we are conducting to examine bat-mediated trophic interactions within pecan orchards and their cumulative ecological and economic impact on specific pests of pecans.

Social Behavior among Individual Tree-roosting Big Brown Bats (*Eptesicus fuscus*)
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Since 2000 we have used radiotelemetry, PIT-tagging, and roost captures to document roosting associations by individual big brown bats in Cypress Hills, Saskatchewan, Canada. Individuals switched roosts about every two days on average and mid-way during the study began to shift to a new roosting area. Bats do not select or switch roost trees based on differences in microclimate or the amount of solar radiation falling on roosts, but most likely select roost trees with large cavity volumes that can hold many individuals, so they can socially thermoregulate. We assessed association frequency using a ratio index compared to expected values to show that associations between pairs of bats were non-random, consistent with the fission-fusion model of social interaction. Associations were strongest during pregnancy and weakest after lactation, suggesting that within the fission-fusion system, reproductive constraints affect social cohesion. Furthermore, mean dyadic associations of reproductive bats were significantly higher than between non-reproductive or mixed-status pairs. Based on nine microsatellite loci and a mitochondrial DNA control region segment, we found that roosting associations were not based on relatedness or matrilineal relationships. Female-mediated gene flow was restricted between roosting areas ($F_{st} = 0.145$) but male-mediated gene flow was not (0.015). Despite female philopatry and preferred roost mates roosting associations are not based on genetic relationships within roosting groups. However, we found evidence that during establishment of a new roosting area, females who moved to the new area had higher average relatedness than those that remained, suggesting that the establishing cohort were closely related maternal kin. We suggest that fission-fusion is maintained by individual benefits gained through associations with preferred roost mates (e.g., information transfer, dominance status) and membership in the group (information about roost sites, thermoregulation).

Do Edges Act as Conduits or Filters For Foraging Bats?
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Research on managed forest landscapes in the southeastern U.S. has shown that six bat species (*Lasiurus borealis*, *L. cinereus*, *Eptesicus fuscus*, *Nycticeius humeralis*, *Tadarida brasiliensis*, and *Perimyotis subflavus*) have substantially higher activity along hard edges (older forested stands adjacent to young open-canopy stands) than in forest interiors, consistent with studies that show high bat species richness and abundance along hard forest edges. Hard edges may create a semi-permeable barrier to movements of bats into the forest, causing an accumulation of bat activity along edges (a *filtering* effect). Alternatively, forest edges may improve connectivity between foraging areas (a *conduit* effect), or serve as both a filter and a conduit. To investigate this, we used a microphone array and thermal imagery during summer 2009, along hard forest edges (older forest stands adjacent to young, open canopy stands), to examine how individual bats use edges and to test the hypotheses that edges act as filters (fly perpendicular to edge) and/or conduits (fly parallel to edge). We used a 4-channel microphone array (Avisoft USG) to determine position of the incoming echolocation call, relative to the edge, based on time of arrival of the call at each microphone in the array. In addition, we used a thermal imaging camera (Photon 320; Flir/Core By Indigo) with the microphone array to visualize individual bat flight at the edge. We sampled 10 different edge sites, each for 3 continuous nights, within an intensively managed forest landscape owned and managed by Weyerhaeuser Company in eastern North Carolina. Data analyses are ongoing and we are currently examining both flight (imagery) and echolocation (microphone array) data. We are also analyzing echolocation calls to species so that we can determine species-specific use of edges as conduits or filters. Preliminary results suggest both filtering and conduit effects of edges may be species-specific.

Using Acoustic Transects to Monitor Bat Population Trends in the Eastern United States
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Bats are difficult to survey and except for a few species that congregate in large numbers in caves during hibernation, researchers have no idea of their population levels. Bat populations may be impacted by two relatively recent sources of mortality: white nose syndrome and wind energy development. While it is often easy for us to document the mortality of these two factors at a particular site, we lack the context needed to evaluate potential changes in bat populations. Therefore, conservation efforts could benefit from a method to enable population monitoring of multiple bat species on a broad geographic scale. Recording bat echolocation calls along a transect has been used in Europe to monitor bat populations. We applied this technique to sample with ultrasonic detectors as a vehicle drove a pre-determined route. Transects were typically ~48 km long, were traveled at 32 km/ h, and were sampled just after sunset on nights with suitable weather conditions, although there was flexibility in the design of transects to account for specific site requirements. Sampling was conducted 1–5 times per transect with most effort focused on the summer maternity season. Transects were sampled in 17 states, with the number of transects ranging from 1–50 per state. Thus far over 20,000 bat echolocation calls have been collected. This project will establish a baseline measure to which future surveys can be compared to assess population-level impacts that cannot be assessed in other ways.

Genetic Analysis of the Taxonomic Status of Populations of the Threatened Fruit Bat *Pteropus mariannus*
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The Mariana fruit bat (*Pteropus mariannus*) is found on islands in the South Pacific Ocean and is currently listed as Threatened under the U.S. Endangered Species Act. *P. mariannus* is thought to once have been abundant on these islands, but the species has suffered substantial decline in numbers due to illegal hunting, habitat loss, forest degradation by feral pigs, and introduced species. Taxonomic classification of *P. mariannus* has been inconsistent, with subspecies designation based mainly on geography. In this study, we examine the phylogeny of *P. mariannus* across several islands potentially constituting separate northern and southern populations. Mitochondrial sequences from D-loop, cytochrome oxidase I, and cytochrome b suggest that the southern population on the island of Palau is genetically isolated from the northern populations. Microsatellite data support this isolation. Gene flow appears to occur among the northern populations of Guam, Rota, and the Commonwealth of the Northern Mariannus Islands

(CNMI). Our data suggest that the southern population may warrant separate species or subspecies designation and that separate conservation efforts should be considered for these populations.

Comparative Bat-use between Native Cottonwood Galleries and Non-native Saltcedar Forests along a Riparian Corridor in Arizona
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Invasive non-native species are often implicated in habitat alteration, degradation and loss of biodiversity. Saltcedar (*Tamarix* spp.) was introduced from Asia to the U.S. during the mid-1800s for erosion control but now dominates many western riparian landscapes. It is estimated that saltcedar occupies almost 1.6 million acres between northern Mexico and central Montana and from central Kansas to central California. Given its dominance along streamside habitats, it is important to understand its possible impact on bats. We monitored foraging bats using Anabat II (frequency division) ultrasonic bat detectors to evaluate and compare bat-use between native cottonwood-willow galleries and monotypic saltcedar groves near Winkelman, Arizona during summers 2005–2007. We also conducted limited active acoustic sampling using Pettersson D240x (time-expansion) detectors coordinated with Anabat detectors using AnaPocket software. We deployed four bat detectors during each sampling period, two in each biotic community, and quantified bat-use as the average number of foraging calls/hr between the two habitats. We sampled bat calls for eight months (842 detector hours), recording >35,000 bat calls. Although our data showed some year-to-year variation in bat-use on a landscape level, there was a strong correlation between bat foraging (i.e., average number of foraging calls/hr) and native (e.g., cottonwood/willow) vegetation ($R^2 = 0.20$, $F_{7,53} = 1.92$, $p = 0.01$) across three years. However, evaluation of how species used the two vegetation types showed differential use of the two landscapes by species guilds. This evaluation of impacts from the spread of non-native species, particularly along riparian corridors, is critical. These habitats are already at risk due to numerous anthropogenic impacts and once exotic species gain a toehold, it may be difficult, if not impossible, to adequately mitigate the situation. Despite the complex nature of many landscapes, our data gave us insight into how bats use the two biotic communities in southern Arizona and our study confirmed a strong correlation between bat foraging and native vegetation.

Movement Dynamics and Population Structure of *Myotis* Bats among Hibernacula in Atlantic Canada
Burns, Lynne E., and Hugh G. Broders, Dalhousie University, Halifax, NS; Saint Mary's University, Halifax, NS

Temperate year-round resident bats make regional migrations from summering areas to wintering sites, at which mating is believed to occur. Anecdotal evidence suggests that bat movements in the late summer are irregular with transient roosting that is separate from their summer roost locations. In the early autumn regionally migrating bats engage in swarming behavior at hibernacula entrances, and bat-band recoveries demonstrate that large movements can be made by bats among swarming sites during this time. Recaptures at swarming sites are typically very low with few individuals roosting within hibernacula at this time. This suggests that bats may remain dispersed on the landscape, visiting multiple swarming sites prior to arriving at their ultimate hibernation site. If this is true then autumn swarming may mean that within a regional context, hibernacula are interconnected with a larger breeding bat population split among these sites in the winter. To gain insight into the autumn movements and population genetic structure of regionally migrating bats we initiated a 3-year study of *Myotis lucifugus* and *M. septentrionalis* at hibernacula in Atlantic Canada. To investigate the movements made by bats during autumn swarming and to determine hibernacula selection made by individuals, we PIT-tagged bats during the spring and fall of 2009 at six hibernation sites in Nova Scotia. This presentation will discuss preliminary recapture results from the first year of our study.

Three Years of Intensive Mist Netting at Riparian Restoration Sites along the Lower Colorado River
Calvert, Allen W., U.S. Bureau of Reclamation, Boulder City, NV

Bats are being monitored as part of the Lower Colorado River Multi-species Conservation Program (LCR MSCP). The LCR MSCP is a 50-year cooperative federal-state-tribal-county-private effort that will provide habitat for 26 covered and 5 evaluation species that are either listed under the Endangered Species Act or have the potential to become listed during the 50 years of the program. The western red bat (*Lasiurus blossevillii*) and western yellow bat (*Lasiurus xanthinus*) are listed as covered species and the Townsend's big-eared bat (*Corynorhinus townsendii*) and California leaf-nosed bat (*Macrotus californicus*) are listed as evaluation species under the LCR MSCP. Listed species are monitored using roost out-flight counts, acoustic surveys, and capture methods. Site-specific acoustic and capture surveys are conducted within riparian restoration areas created under the LCR MSCP. Capture methods are being utilized to gather information on age, sex, and reproductive status of bats using the restoration sites as well as to obtain reference acoustic calls. The capture surveys also have aided restoration site project managers to better understand how bats utilize these sites, which may aid in the design of future sites. Surveys have been conducted at a total of six sites, with three of those sites being surveyed at least once during each of the last three years. A pilot year was first conducted to determine the feasibility of capturing covered bat species within restoration sites. The use of triple stacked net sets was found to adequately capture the majority of the species of interest. Surveys were conducted between April–October each year, and opportunistically at other times of the year due to potential wintering red bats that had been recorded acoustically. A survey conducted in February 2009 was successful in providing the first capture of a western red bat on the mainstem Colorado River. From April 2007–September 2009, a total of 789 bats of 12 species have been captured. All LCR MSCP species have been captured with the exception of the Townsend's big-eared bat. Surveys will continue for at least two more years.

Both the Flower Bat *Glossophaga soricina* and the Fruit Bat *Carollia perspicillata* Use Spatial Memory over Associated Sensory Cues to Relocate Food

Carter, Gerald, University of Maryland, College Park, MD

Aspects of cognition, such as which environmental cues animals perceive as salient, can be adaptively specialized for the particular challenges faced by different species. Accordingly, previous research found that the nectivorous bat *Glossophaga soricina*, relies overwhelmingly on spatial cues over shape cues for relocating food. After all, flowers do not move. However, two important questions remain. First, is *G. soricina* more likely to use spatial cues than frugivorous or insectivorous bats? Fruit and insects do move. Second, would *G. soricina* also use spatial cues over olfactory cues? *G. soricina* has a strong innate attraction to dimethyl disulfide, a major scent component of many Neotropical bat-pollinated flowers. Would *G. soricina* use dimethyl disulfide, or novel smells, over spatial memory? To address these questions, I tested whether *G. soricina* and the fruit-eating bat *Carollia perspicillata* use different strategies for relocating food. I presented captive bats with four food dishes, each associated with a unique location, shape, and smell. The reward dish contained unadulterated food, while the others contained food made unpalatable with quinine. After each bat learned to feed from only the reward dish, I used conflicting cues to test which of the cues bats were using to relocate food. First, bats chose between correct location or correct shape ($n = 10$), then between correct location or correct smell ($n = 10$), and finally, between correct shape or correct smell ($n = 10$). I presented this test to 30 *G. soricina* and 30 *C. perspicillata*. I also repeated the test with 30 more *G. soricina* using dimethyl disulfide as the smell associated with the reward dish. To relocate food, both *G. soricina* and *C. perspicillata* used spatial memory over associated shapes and smells. I found no significant differences in cue use between species. *G. soricina* even used spatial cues over the scent of dimethyl disulfide to relocate food. Along with past experimenters, I found it extremely difficult to condition *G. soricina* to use associated shapes at all. In contrast, others have reported that insectivorous bats easily learn to ignore location and associate shapes with food. Further research may indicate whether insect-eating bats differ from fruit and flower bats in their cue salience hierarchy during associative learning.

Comparative Ontogeny of Echolocation Between Two New World Fruit Bats: Preliminary Analysis

Carter, Richard, and Rick Adams, University of Northern Colorado, Greeley, CO

The ontogeny of echolocation is fairly well studied in some oral emitters; however, little is known about nasal emitters. We are investigating comparative ontogeny of echolocation between two species, *Artibeus jamaicensis* (less precocial young) and *Carollia perspicillata* (more precocial young). We hypothesize that there are at least two distinct forms of call and the occurrence of either is based on age. We predict that development will differ between these two species due to different levels of development at birth. Young were captive raised and calls were recorded as individuals were released from a 1-m high perch onto a foam pad beginning on Day 1 postpartum. Calls were recorded on Pettersson D240X detectors and analyzed with Sonobat V2.9.2. *A. jamaicensis* isolation calls consisted of three or more harmonics of medium to long duration (8–36 ms), with the latter often sinusoidal. Directives were present at Day 1 and displayed up to three harmonics with a mean fundamental maximum frequency of 21.69 kHz (SD = 2.9), mean minimum frequency of 13.39 kHz (SD = 2.1), and average duration of 3.72 ms (SD = 1.4). Frequency of maximum amplitude appeared in the 1st harmonic for most calls but was also present in the 2nd and 3rd harmonics in a few calls. By 21 days the calls were adult-like with the 3rd harmonic containing the most energy. The average maximum frequency of the adult calls is 78.8 kHz (SD = 4.0), minimum average frequency of 55.46 kHz

(SD = 8.1), and average duration of 0.73 ms (SD = 0.37). *C. perspicillata* isolation calls had three or more harmonics. Most energy was for the 1^{st} harmonic for most directive calls, with high energy 2nd harmonics present by day 11 and no high energy 1^{st} harmonics present by day 26. The average maximum frequency of the 1^{st} harmonic was 40.4 kHz (SD = 5.35), with mean minimum frequency of 25.2 kHz (SD = 3.2), and average duration of 5.0 ms (SD = 3.3). Adult calls had an average maximum frequency of 74.34 kHz (SD = 7.1), average minimum frequency of 51.9 kHz (SD = 6.0), and average duration of 1.07 ms (SD = 0.49). Echolocation calls developed at different rates (*C. perspicillata* being faster) and in different ways (harmonics utilized) between species.

Don't Forget the Legs: Hindlimb Movement of *Cynopterus brachyotis* During Flight

Cheney, Jorn A., Daniel Ton, Daniel K. Riskin, and Sharon M. Swartz, Brown University, Providence, RI

Many discussions of bat wing morphology focus primarily on the forelimb, but because the wings of bats include the entire hindlimb, the hindlimbs may also influence aerodynamics. We examined the kinematics of the hindlimbs of flying bats to determine whether or not leg motions are consistent with the hypothesis that hindlimbs play an active role in wing shape modulation during flapping flight. For example, the movement of the tibia could modulate angle of attack or camber by moving independently from the rest of the wing. If this occurs, we expect that the movement of the tibia in the dorsoventral and mediolateral axes would not passively follow the motion of the trailing edge of the wing. If the hindlimb does exert an influence on wing shape, we would predict that the dorsal orientation of the ankle would primarily explain changes in angle of attack. We also looked for an influence of hindlimb motion on wing camber, given that movement of the ankle toward the midline of the body, away from the fifth digit, will result in lengthening of the wing's trailing edge and an increase in tension in the plagiopatagium. We flew five *Cynopterus brachyotis* (Pteropodidae) five times each in a wind tunnel over a range of speeds (3.2–7.8 m/s). We recorded the motions of several markers on the body, hindlimb, propatagium, and plagiopatagium using three phase-locked high-speed cameras, and reconstructed their 3D motions using the direct linear transformation method. As predicted, we found that the position of the ankle marker moved toward the midline, away from digit V, at some parts of the wing beat cycle, and that movement of the ankle in the dorsoventral direction preceded movement of the trailing edge. This suggests that the hindlimb plays an important role in flight, actively shaping the membrane during flight. Thus, while both insects and birds can modulate angle of attack and camber at the leading edge of the wing only, bats appear to be able to modify these parameters at the trailing edge. Human-engineered aircrafts appear to have converged on more bat-like system of control in this regard.

Genetic Identification of Prey Species in Guano: Spatial and Temporal Variation in Food Webs

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In nature, predator-prey interactions can be difficult to observe. This is particularly true of insectivorous bats, which hunt at night and are rarely visible. When direct observations are impossible, morphological investigation of digested insect fragments can be used to identify prey types, but identifications below order or family are challenging at best. We recently used molecular techniques to provide far greater taxonomic resolution and we are now regularly able to identify digested prey to species. We used insect mtDNA in bat fecal pellets to generate "DNA barcodes," molecular markers we compared to standardized genetic libraries to retrieve species level identification of prey. We have used DNA barcoding to identify prey of *Myotis lucifugus*, *M. leibii*, *M. septentrionalis*, *Lasiurus borealis*, *L. cinereus*, *Lasionycteris noctivagans*, *Eptesicus fuscus*, and *Perimyotis subflavus* from sites in Ontario (Canada). The resulting community food web currently includes more than 300 genetically confirmed species of arthropods and spiders, providing insights into resource partitioning, predator-prey interactions, and temporal and spatial variations in prey choice. We now present preliminary results on resource partitioning between all eight species of bats living sympatrically in Ontario and discuss the problematic definitions of "generalist" and "specialist" when referring to insectivorous bats. In particular we present and contrast data collected from five months of intensive dietary monitoring of *L. borealis* and *M. lucifugus*. Colonies of *M. lucifugus* show temporal patterns in predator-prey interactions coinciding with physiological demands associated with the bats' periods of parturition, mating, and preparation for hibernation. Analyses of spatially separated collecting sites also demonstrate shifts in diet associated with colonies in urban versus natural habitats. Similar patterns were not observed in *L. borealis*.

White Nose Syndrome Update for 2009

Coleman, Jeremy T. H., Alan C. Hicks, Anne E. Ballmann, David S. Blehert, and Noelle L. Rayman, U.S. Fish & Wildlife Service, Cortland, NY; NY State Department of Environmental Conservation, Albany, NY; USGS-National Wildlife Health Center, Madison, WI

White nose syndrome (WNS) continued to spread in 2009, and signs of the disease were observed at hibernacula over 900 km from the point of origin near Albany, NY. Newly affected hibernacula were confirmed in New Hampshire, New Jersey, Pennsylvania, Virginia, and West Virginia in 2009, while population declines continued at previously infected sites in Connecticut, Massachusetts, New York, and Vermont. Numbers of bats at the 12 most closely monitored sites in the Northeast have declined roughly 95% in the 2 or 3 years since the sites were known to be infected. Thus far there has been no indication of resistance to the disease, although no winter colonies have yet been known to have been extirpated. Mortality rates continue to vary between species and between sites, with *Myotis lucifugus* being the species most notably affected and drier hibernacula appearing to be least affected sites. Of the six hibernating species in the region, the only two not known to be affected by WNS in 2008, *Myotis leibii* and *Eptesicus fuscus*, were both confirmed in 2009. The presence of a newly identified fungus, *Geomyces destructans*, continues to be the common link between affected sites, and the implication that the fungus is the cause of WNS continues to provide the most parsimonious explanation despite the fact that Koch's postulates have yet to be definitively satisfied. The need to understand the etiology of WNS and identify the mode of transmission drives much of the WNS research currently underway. The coordination of the investigation has presented several challenges, and general awareness of the disease has been increasing. WNS was the focus of both Congressional and Senate Hearings in recent months. Approximately $800,000 in research grants and $940,000 in multi-state SWG grants will be available in coming months to support research and surveillance. Projects planned for this winter include: video monitoring to further analyze winter behavior, an assessment of the role of hibernacula in WNS transmission, and initial efforts to develop chemical and biological controls.

Abundance, Diversity, Foraging Activity, Body Condition, and Reproduction of Urban and Non-urban Prairie Bats: Is the City a Bat Population Sink?

Coleman, Joanna, University of Calgary, Calgary, AB

Since 2006, I have been addressing three key gaps in urban ecology research, which lacks sufficient attention to 1) grassland biomes, 2) individual- and population-level effects, and 3) non-avian vertebrates. I hypothesized that increased urban availability of roosts and insects, combined with the urban heat island would benefit Prairie bats, leading to increased bat abundance, diversity, body condition, reproductive rates, and production of juveniles in the city. I acoustically monitored bat activity on 184 nights and captured more than 2000 bats on 161 nights in urban, transition, and rural riparian sites in and around Calgary, Alberta. My data do not support most of the predictions I generated to test my original hypothesis. Although urban bats are more abundant, they are not more diverse; *Myotis lucifugus* dominates bat communities throughout my study area, but nowhere more so than in the city. However, increased numbers of *M. lucifugus* in Calgary do not seem linked to greater prey availability; insect abundance is unaffected by urbanization and insect diversity is greatest in rural areas, although I am still analyzing foraging activity data. Nor do greater urban *M. lucifugus* numbers reflect urbanization-related benefits such as greater body condition, reproductive rates, or successful production of juveniles, all of which are maximized in the transition zone. Ultimately, I reject my hypothesis and am currently exploring one scenario that might explain why: perhaps transition zone bats hunt less selectively than their urban and rural counterparts. To investigate this possibility, I am comparing bat diets based on fecal pellet analysis. It is also possible that *M. lucifugus* in urban and rural areas exhibit increased use of anthropogenic, as opposed to natural, roosts, favoring larger colonies and higher population densities and, in turn, increasing food competition. Additional possibilities include increased stress, disease transmission, and/or impacts of noise on urban bats. Whatever the proximate cause, the combination of greater *M. lucifugus* population density with decreased body condition and production of juveniles is a fairly strong indication that Calgary may represent a Prairie bat population sink. However, a proper investigation of source-sink dynamics in Calgary (or in any city) requires knowledge of bat mortality rates, which are difficult to measure given bats' remarkable longevity and low recapture rates.

***Tiger Moth Jams Bat Sonar**

Corcoran, Aaron J.[1], Jesse R. Barber[2], and William E. Conner[1], [1]Wake Forest University, Winston Salem, NC; [2]Colorado State University, Fort Collins, CO

*** Aaron Corcoran** received the **Bat Conservation International Award**

Sonar jamming, or corruption of the audio stream interpreted by an animal's sonar receiver, has long been suspected as a defensive function of arctiid moth clicks. However, demonstrating defense through sonar jamming has been complicated by the fact that moth clicks can also function as aposematic and startling signals. Here, for the first time, we show that moths effectively defend against attacking bats by jamming their sonar. Using high-speed infrared videography and ultrasonic recording in a flight room, we observed interactions over seven nights between the palatable, Neotropical tiger moth *Bertholdia trigona* and the sympatric big brown bat (*Eptesicus fuscus*). Bat attack success decreased from 93% on novelty controls to 19% on clicking moths, and was restored to control levels after the moths' sound-producing organs were ablated. The bats did not require previous experience with the moths for the defense to be effective (as is the case with moths using aposematic signals); nor did the defense's effectiveness decrease over time (as occurs with startle due to habituation). Ultrasonic recordings provide further evidence that moth sounds interfere with bat sonar. Sonar jamming is a new level of escalation in the evolutionary arms race between bats and moths.

Stable Isotope Inferred Geographic Constraints on Origins of Hoary Bats (*Lasiurus cinereus*) Killed at Wind Turbine Facilities

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Hoary bats (*Lasiurus cinereus*) are consistently found dead beneath wind turbines during late summer and autumn across North America—approximately half of all documented bat fatalities at turbines are hoary bats. Deaths of hoary bats at wind turbines are predicted to range into the tens of thousands per year by 2020, raising serious questions regarding the long-term viability of their populations. Hoary bats are highly migratory and fatalities coincide temporally with the timing of autumn migration, indicating that turbines probably impact migrants rather than residents of nearby habitats. Stable isotope analysis is a viable way of inferring the pre-migration origins of hoary bats because hoary bats molt into new fur during summer, and because known geographic patterns of stable hydrogen isotope ratios in precipitation are reflected in newly grown fur. We analyzed the stable hydrogen isotope values of hair (dD_h) from hoary bats killed at wind turbines for evidence of migration and to determine probable summer origins. We sampled 165 individual bats from 9 wind energy facilities in 6 states, spanning 10º of latitude. Stable hydrogen isotope ratios indicated that many bats grew their fur at locations away from turbine sites where carcasses were found. There were no consistent trends in dD_h with date of collection or sex, and site differences were subtle. We derived relative probability density surfaces for the geographic origins of individual bats using a modeling approach that incorporated known sources of variation estimated from bat fur of known origin. Interpreted in the context of previous information on the seasonal distribution of this species, results indicate that hoary bats often die at wind turbines during migration and that most of the hoary bats sampled originated from a surprisingly limited range of northern latitudes. Many of the hoary bats we sampled that died at wind facilities in the United States may have originated in Canada.

Island Area Change, Not Species Range, Explains Bat Extinction in the West Indies

Dávalos, Liliana M., and Amy L. Russell, SUNY-Stony Brook, NY; Grand Valley State University, Allendale MI

Bats are among the last surviving land mammals in the West Indies, a fauna that suffered widespread extinction and extirpation in the Holocene. Despite the survival of many species, at least 17 different bat lineages were extirpated from individual islands, and 9 went extinct from the region. Why certain species went extinct while others survive remains one of the most vexing questions in Caribbean biogeography. Multiple studies have suggested that climate change—by changing local habitats from predominantly xerophytic to mesic or humid, and/or by increasing sea level leading to smaller area across many low-relief islands—was the leading cause of bat extinction. To explore the role of climate change as a driver of bat extinction we designed a null model of regional extinction accounting only for island area loss—but not habitat change—resulting from post-glacial ice melt. This model was the basis for three hypotheses: 1) bats went extinct because of island area loss linked to post-glacial climate change, 2) bats confined to smaller ranges lost proportionally more of their range and were therefore more prone to extinction, and 3) certain lineages were more prone to extinction than others. We compiled a database of West Indian bat extinction, compared current and Last Glacial Maximum (LGM) island areas, and used dated phylogenies of phyllostomids and mormoopids to both investigate and correct for phylogenetic correlation in range/range loss analyses. Our results show that 44% of the variance in species loss across islands can be explained by area loss since the LGM. Range loss was positively correlated with LGM range size, but this correlation disappeared (p = 0.999) when the effect of phylogeny was discounted. Range loss, but not range size, was correlated with phylogeny. Taken together these results indicate that: 1) area loss alone can explain much of the variance in extinction without considering the effects of habitat change, 2) small ranges do not necessarily entail greater extinction risk, but 3) species traits, as summarized by phylogeny, are associated with greater range loss perhaps because of correlations between phylogeny and biogeographic history.

Resource Partitioning in a Forest-dwelling Bat Community in Eastern Texas: Preliminary Findings
Debelica, Anica, and Kenneth T. Wilkins, Baylor University, Waco, TX

Sam Houston National Forest (SHNF), located 80 km north of Houston, comprises 65,978 ha of southeastern Texas “pineywoods.” Because of the presence of old tall trees, and relatively mild climate, SHNF offers suitable habitat for multiple bat species throughout the year. A community of many species present is expected to exhibit complex interactions, which likely are further complicated by the presence of individuals of different sexes, reproductive states, and ages because members of these various subgroups have different energetic needs and may behave differently. For these bats to avoid direct competition within such a complex community, I expect to see evidence of resource partitioning in diet, foraging, and roosting areas. During summer 2009, we conducted a pilot study to explore complexity of the forest-dwelling bat community and to investigate resource partitioning. We sampled at a pond, using a triple-high net. Captured bats were identified to species, sexed, measured, and examined for reproductive state. Feces were collected for detailed dietary study. We collected insects with a black light trap as reference for the dietary study and bat activity. We captured more than 120 individuals belonging to 8 species: 20 eastern red bats (*Lasiurus borealis)*, 1 hoary bat (*L. cinereus*), 47 Seminole bats (*L. seminolus*), 12 big brown bats (*Eptesicus fuscus*), 29 evening bats (*Nycticeius humeralis*), 6 eastern pipistrelle bats (*Pipistrellus subflavus*), 3 southeastern myotis bats (*Myotis austroriparius*), and 4 Mexican free-tailed bats (*Tadarida brasiliensis*). We noticed variation in demographics of the bat community during the summer. For example, there was a shift between community dominated by pregnant/lactating females and community dominated by males and non-reproductive subadults of both sexes through the summer. In addition, we noticed the differences in emergence times between subadults and adults as well as among the present species. Differences in community structure and emergence times suggest that even though the bats are feeding at the same area, they are partitioning their resource temporally. We anticipate that the insect data will shed light on this phenomenon—presence of certain subgroups might be directly related to the insect community structure at various times.

Roost Tree Selection and Roost Fidelity of the Female Indiana Bat (*Myotis sodalis*) in Northern Missouri
Dey, Shelly N., and Lynn W. Robbins, Missouri State University, Springfield, MO

Several threats exist for the endangered Indiana bat (*Myotis sodalis*) including habitat destruction, wind energy development, and the rapid spread of white nose syndrome. It is extremely important to study endangered bat species in areas not yet exposed or potentially exposed to these threats. Beginning in mid-April and continuing until early October, Indiana bats utilize woodlands throughout northern Missouri especially for establishing maternity colonies. One particular goal of this study was to study roost tree characteristics and roost fidelity of female Indiana bats during the maternity season as well as pre- and post-lactation periods. During the summers of 2007, 2008, and 2009, 23 reproductively active and 1 non-reproductively active female Indiana bats from 3 northern Missouri counties were fitted with a 0.47 g (Holohil) transmitter and tracked throughout the life of the transmitter (± 2 wks). Circumference, DBH, height, and tree species were recorded at each new roost tree. Percent canopy cover, basal area, snag density, and distance to nearest snag (all within a 0.1-ha circular plot) were analyzed at new roost trees in 2009. Exit counts were conducted when a roost was found and roosts that yielded >1 bat were counted throughout the remaining season. Some bats remained in the same tree throughout the season, while others switched roosts as often as every day. Excessive heat, rain, and other weather aspects seemed to affect many of the bats’ roosting locations. Roost selection was highly variable, but most roost sites were in dead trees with peeling bark—2007 and 2008: 26.7% elm, 20% oak, 40% shagbark hickory, 6.6% maple with an average height of 13.4 m, and 6.6% other (an old barn); 2009: 18% oak, 59% shagbark hickory, 12% elm, and 12% cottonwood with an average height of 14.26 m.

Effects of Immune System Diversity and Physical Variation of Immunotypic Mixing on the Dynamics of Rabies in Bats

Dimitrov, Dobromir, and Thomas Hallam, Fred Hutchinson Cancer Research Center, Seattle, WA; University of Tennessee, Knoxville, TN

The ecology and life history of rabies viruses in bats suggest a need for an integrated modeling treatment that extends beyond traditional epidemiological approaches. We modify our adaptive modeling approach to investigate the effects of immune system structure and immunological mixing events on the disease profile of the bat colony and subsequently, on the dynamics of rabies viruses in bats. Our theoretical framework, which is based on individual (intra-host) models of the response of the host to a viral challenge and virus-specific disease mechanisms, integrates the individual components to provide information about the disease structure and the demographic composition of the bat colony. We focus on the changes in dynamics at the population level due to two processes: 1) immunological diversity in a biological process—reproduction, and 2) immunological diversity in a physical-physiological process—migration. The results suggest that immunotypic mixing plays a critical role in the disease progression within populations and it is an important factor in determining persistence of rabies in exposed bat colonies.

***Bat Activity in the Urban Savanna of the Upper Midwest**

Dixon, Michael D., University of Minnesota - Twin Cities, St. Paul, MN

*** Michael Dixon** received the **Basically Bats Wildlife Conservation Society Award**

Despite all the attention that has been paid to conservation in working landscapes, relatively few studies have investigated the role of cities as bat habitat, and fewer still have attempted to determine what about urban landscapes promotes or limits bat activity. During the spring and summer of 2008, I visited 47 sites in habitats that ranged from forest, to agriculture, to dense urban residential in the Twin Cities metropolitan area of Minnesota. Each site was visited on three occasions, each time in a different time window, resulting in three hours of active recording per site. This was used to generate an acoustic activity index (AI) for each of the seven species of bats found in this region. I then extracted land cover data at 100 m, 500 m, and 1 km radii from each of the sampling points and used stepwise regression with AIC to help determine which combination of land cover variables best predicted bat activity. These models had a range of success. The best model for *Myotis lucifugus* explained over 50% of the variance in their activity, while models for *Lasiurus borealis* explained barely 20%. Clearly some other unaccounted for factors are more significant than gross land cover for lasiurine bats. This underscores the fact that a one-size-fits-all approach to bat conservation is inappropriate and further knowledge of roost and microhabitat requirements may be required for some species. However, this study does demonstrate that preexisting land cover data and acoustic surveys can help managers predict which areas are likely to be important bat foraging areas or commuting corridors with minimal effort and cost.

What's Sex Got To Do With It? The Effects of Reproductive Status on Torpor and Foraging Behavior in the Little Brown Myotis

Dzal, Yvonne, University of Regina, Regina, SK

Mammalian reproduction is energetically demanding so individuals should adjust foraging behavior and thermoregulatory patterns to suit reproductive status and minimize energetic costs. This is especially true for small mammals, such as bats, which have high metabolic rates and a large surface area-to-volume ratio over which they dissipate heat and water. Torpor is one likely energy-saving strategy as it decreases physiological processes, and results in reduced metabolic activity. However, torpor may also delay the development of offspring, and therefore be used at a cost. Presumably, if reproductive individuals are not using torpor as often, or for the same duration as non-reproductive individuals, they could forage longer to meet the energetic demands of reproduction. The purpose of this study was to assess the influence of pregnancy and lactation on torpor use and foraging behavior of little brown myotis, *Myotis lucifugus*. Over two consecutive summers in upstate New York, I captured 38 female bats from building maternity colonies and identified reproductive status. I monitored thermoregulatory and foraging behavior by recording skin temperature and radio-tracking tagged bats. I found that bats, regardless of reproductive status, used torpor every day, but patterns of the use of torpor varied between reproductive and non-reproductive females. As expected, reproductive individuals used shorter and shallower torpor bouts than non-reproductive animals. In contrast, foraging behavior did not vary with reproductive condition, suggesting that even short, shallow torpor bouts may produce substantial energy-savings, without sacrificing offspring development. My results demonstrate that torpor use and reproduction are not mutually exclusive, but that variation in torpor use is influenced by reproductive stage.

The Correlated Evolution of Olfactory Ability and Sociality in Bats
Eiting, Thomas P., and Elizabeth R. Dumont, University of Massachusetts, Amherst, MA

Experimental work has shown that many species of bats use olfactory cues in communication. However, the role of olfaction in communication has rarely been examined in phylogenetic comparative studies. Such studies have the potential to uncover broad aspects of the evolutionary history of traits that have been experimentally investigated in only a few species. In this study we used an ecologically diverse sample of 160 species of bats to test the hypothesis that olfactory ability is correlated with sociality. We used relative olfactory bulb volume as a measure of olfactory ability and maximum colony size as a proxy for sociality. We predicted that species living in large groups would have relatively large olfactory bulbs compared to species living in smaller groups. After controlling for phylogenetic effects, we found that echolocating bats that live in large colonies have relatively larger olfactory bulbs than bats that live in smaller colonies. This relationship was not found in the non-echolocating pteropodids. These results suggest that olfaction may be an important mode of communication in echolocating bats generally, but that olfaction may play a lesser role in communication among pteropodids.

Resource Use of the Greater Long-nosed Bat, *Leptonycteris nivalis*, in Big Bend National Park, Texas
England, Angela E., University of New Mexico, Albuquerque, NM

The greater long-nosed bat, *Leptonycteris nivalis*, is federally listed as endangered in the United States and in Mexico. In the summer, adult females and their young migrate north from Mexico to Big Bend National Park in Texas. Migration is believed to be synchronized with the bloom cycle of agave plants, on which they rely for nectar and pollen. The recovery plan identified the need for locating the protecting roosts and foraging habitat, and determining nightly distances traveled. Our objective was to determine habitat use of these bats within the park. We hypothesized that bats focus activity in agave-rich areas. In 2003, we attached radiotransmitters to 25 *L. nivalis* and tracked nightly movement patterns in the vicinity of the Emory Cave, the only known roost it Texas. We used simultaneous bearing to estimate the location of bats through the night, and computed 95% and 50% fixed kernel utilization areas (“home range” and “core use areas”) for adults and juveniles. We also mapped the distribution of blooming *Agave havardiana* plants within the park. Home ranges included large areas of the park where no agaves or other known food sources have been reported. Home ranges of adults included proportionately more agave-rich areas than those of juveniles. Juveniles had larger home range and core use areas than adults. Reasons for bat excursions to areas with no agaves remain unknown, but bats may have been using undiscovered night roosts, previously undocumented food resources, or perhaps simply exploring the landscape.

Understanding the Dynamics of Nipah Virus in Pteropid Bats
Epstein, Jonathan H.[1], Sohayati Abdul Rahman[2], Shahneaz Ali Khan[1,3], Kevin Olival[1], Hume Field[5], Stephen Luby[4], and Peter Daszak[1], [1]Wildlife Trust, New York, NY; [2]Veterinary Research Institute, Ipoh, Malaysia; [3]Chittagong Veterinary and Animal Sciences University, Chittagong, Bangladesh; [4]International Centre for Diarrheal Disease Research, Dhaka, Bangladesh; [5]Queensland Primary Industries and Fisheries, Brisbane, Queensland, Australia

Nipah virus (NiV) emerged in Malaysia in 1998 as a respiratory and neurologic disease in pigs and caused a severe febrile encephalitis in humans associated with a 40% mortality rate (n = 265). Ten Nipah virus outbreaks and several sporadic cases in Bangladesh (case fatality rate ≈ 71%; n = 122) and one outbreak in India associated with Nipah virus (case fatality rate ≈ 74%; n = 66) have been reported since 2001, broadening the focus of zoonotic transmission studies to include the Indian subcontinent. There is serological evidence to suggest that several genera of bats may become infected with henipaviruses. Bats of the genus *Pteropus* are considered a primary natural reservoir for Nipah virus and other related henipaviruses throughout a large part of their range, including regions where human infections have occurred. *Pteropus vampyrus* and *P. hypomelanus* are native to Malaysia and *Pteropus giganteus* commonly occurs throughout the entire Indian subcontinent. As part of a large-scale study of Nipah virus ecology in Malaysia, we tested the hypothesis that Nipah virus is endemic and circulating in pteropid bats throughout Malaysia, including populations near the index pig farm, as opposed to having been introduced to Malaysia in 1997 via bat immigration. In Bangladesh, Nipah virus outbreaks in humans show a strong seasonal pattern. While domestic animal amplifying hosts may play a role in human infection, several outbreaks appear to involve direct bat-to-human transmission, in some cases via a food-borne route. We are currently studying the distribution and temporal dynamics of Nipah virus in *Pteropus giganteus* in Bangladesh, in conjunction with broad scale epidemiological studies of human outbreaks, in order to test the hypothesis that seasonal patterns (Jan.–Apr.) may be, in part, the result of seasonal viral shedding in bats. This report will discuss Nipah virus ecology in pteropid species in Malaysia, India, and Bangladesh.

Material Properties of *Glossophaga soricina* Wing Membrane

Evans, Andrew J., Jorn A. Cheney, and Sharon M. Swartz, Brown University, Providence, RI

Bat wing form and aerodynamic performance are tightly coupled. To understand how compliant wing membranes interact with airflows, we must first understand the properties of the membrane itself. To quantify the mechanical characteristics of the wing membrane in relation to hovering flight, we obtained frozen cadaveric specimens of *Glossophaga soricina*. We excised the plagiopatagium from thawed specimens and carried out a series of tests using a mechanical testing apparatus (MTS Systems, Eden, MN). Each membrane was axially strained through a series of sinusoidal tensile tests, with force and strain data recorded using a 10 N load cell and high-speed videography. The membranes were strained in the chordwise direction between 5–15% and in the spanwise direction 20–30%. The membranes displayed high levels of anisotropy, and in some regions of the stress-strain curve the skin also displayed a negative Poisson's ratio. These results will be important to future studies that will model the interactions between air flow and wing membranes during hovering flight.

Environmental Effects on the Emergence Time of Little Brown Bats (*Myotis lucifugus*) in Central Pennsylvania

Fidiam, Kathryn L., and Carlos A. Iudica, Susquehanna University, Selinsgrove, PA

Little brown bats (*Myotis lucifugus*) are crepuscular-night insect predators that leave their roosting sites nightly in the spring, summer, and fall to forage for their prey. Their main food sources are flying insects that show an activity peak in the late evening near sunset. A maternity colony of little brown bats in Central Pennsylvania, along the Susquehanna River, is being studied in the late summer and fall months to determine what factors trigger little brown bats to leave their roost at a specific time each night. Two HOBO pendants continuously record temperature and light intensities every ten minutes inside and outside of the barn. These data are being collected to see if we can find a correlation between temperature and light intensities that affects the emergence of bats at night. A Kestrel 4000 NV Pocket Weather Tracker is triggered manually at the time of emergence of the first bat to record time, barometric pressure, temperature, humidity, wet bulb, due point, heat index, and wind speed. Four separate readings are taken, the first as the first bat emerges, the second when 10 bats emerge, the third when 50 emerge, and the fourth when it appears that the bats are tapering off in the numbers of new emergences. Multiple readings are taken to ensure that there is an accurate description of emergence. The variables recorded on the Kestrel will be analyzed to look for values associated with emergence time. A light meter (SS 840006) is also manually triggered to record light intensity data outside the barn at the time of emergence. Additional observations of cloud cover, precipitation, and sunset and twilight times are also recorded daily. We anticipate having preliminary results and interpretations for discussion during the poster session. We expect to find a correlation between emergence and light intensity and temperature.

The Evolution of Bat Pollination: A Phylogenetic Perspective

Fleming, Theodore H.[1], Cullen Geiselman[2], and W. John Kress[3], [1]University of Miami, Coral Gables, FL; [2]New York Botanical Garden, Bronx, NY; [3]National Museum of Natural History, Smithsonian Institution, Washington, DC

Most tropical and subtropical plants are biotically pollinated, and insects are the major pollinators. A small but ecologically and economically important group of plants classified in 28 orders, 67 families, and about 528 species of angiosperms are pollinated by nectar-feeding bats. Bat pollination occurs in about twice as many genera and species in the New World as in the Old World. From a phylogenetic perspective this is a derived pollination mode involving a relatively large and energetically expensive pollinator. Here we examine this mode from a plant phylogenetic perspective. Adaptation to pollination by bats has evolved independently many times from a variety of ancestral conditions, including insect-, bird-, and non-volant mammal-pollination. Bat pollination predominates in very few families but is relatively common in certain angiosperm subfamilies and tribes. It is concentrated in advanced lineages in both the monocots (Zingiberales) and eudicots (rosids). We note that flower-visiting bats provide two important benefits to plants: they deposit large amounts of pollen and a variety of pollen genotypes on plant stigmas and, compared with many other pollinators, they are long-distance pollen dispersers. Bat pollination tends to occur in plants that occur in low densities and in lineages producing large flowers. In highly fragmented tropical habitats, nectar bats play an important role in maintaining the genetic continuity of plant populations and thus have considerable conservation value.

Variation in the Stable Hydrogen Isotope Values of Bat Fur across an Altitudinal Gradient
Fraser, Erin E., University of Western Ontario, London, ON

The stable hydrogen isotope values of precipitation vary predictably with several factors, including latitude and altitude. By eating and drinking local food and water, animals incorporate local stable hydrogen isotope values into their tissues. Analysis of these tissues can provide information about the location where the tissue was grown and insight into migratory patterns. This technique has been widely used with birds, but infrequently with migratory bats. In order to draw conclusions about migrant bat origin using stable hydrogen isotope analysis, it is first necessary to quantify local variation. Stable hydrogen isotope values of precipitation decrease with increasing altitude. However, foraging bats are mobile and are capable of foraging and drinking at different altitudes within their home ranges. It is not known whether the relatively fine-scale variation that has been observed in the stable hydrogen isotope values of precipitation can be observed in local bat tissues. I evaluated whether the stable hydrogen isotope values of fur taken from bats living on and around mountains differed based on capture site altitude. I collected fur samples from 40 resident bats (*Myotis lucifugus*, *Myotis evotis*, and *Eptesicus fuscus*) across an ~1000 m altitudinal range in the Kananaskis Valley, Alberta, Canada during July 2008. I also collected precipitation and surface water samples at several sites along the gradient. I conducted stable hydrogen isotope analysis on both fur and water samples and will present age, sex, and altitude-related variation in stable hydrogen isotope data.

Influence of Climate and Reproductive Timing on Demography of *Myotis lucifugus* and the Implications for Understanding Impacts of White Nose Syndrome on Regional Species Viability
Frick, Winifred F., D. Scott Reynolds, and Thomas H. Kunz, Boston University, Boston, MA; St. Paul's School, Concord, NH

Given that bat species in the eastern U.S. are facing an unprecedented population crash from mortality associated with white nose syndrome (WNS), it is of critical conservation concern to determine population dynamics of species affected by this devastating phenomenon. We used 16 years (1993–2008) of mark-recapture data to estimate age-specific survival and breeding probabilities of the little brown myotis (*Myotis lucifugus*) in southern New Hampshire. Using Kendall and Nichol's (1995) full-likelihood approach of the robust design to account for temporary emigration, we tested whether survival and breeding propensity is influenced by regional weather patterns and timing of reproduction. Our results demonstrate that adult female survival of *M. lucifugus* ranged from 0.63 (95% CL = 0.56, 0.68) to 0.90 (95% CL = 0.77, 0.94), and was highest in wet years with high cumulative summer precipitation. First-year survival [range: 0.23 (95% CL = 0.14, 0.35) to 0.46 (95% CL = 0.34, 0.57)] was considerably lower than adult survival and depended on pup date of birth, such that young born earlier in the summer (ca. late May) had a significantly higher probability of surviving their first year than young born later in the summer (ca. mid July). Similarly, the probability of young females returning to the maternity colony to breed in the summer following their birth year was higher for individuals born earlier in the summer. The positive influence of early parturition on 1st-year survival and breeding propensity demonstrates significant fitness benefits to reproductive timing in this temperate insectivorous bat. Climatic factors can have important consequences for population dynamics of temperate bats, which may be negatively affected by summer drying patterns associated with global climate change. Understanding long-term demographic trends are important for predicting regional extinction probabilities and determining appropriate management options to support species conservation and potential recovery from white nose syndrome.

Life without Bats: Auditory Degradation in Tahitian Populations of the Pacific Field Cricket
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The auditory thresholds of the AN2 interneuron and the behavioral thresholds of the anti-bat flight-steering responses that this cell evokes are higher in female Pacific field crickets that live where bats have never existed

(Moorea) compared to individuals subjected to intense levels of bat predation (Australia). In contrast, the sensitivity of the auditory interneuron, ON1, which participates in the processing of both social signals and bat calls, and the thresholds for flight orientation to a model of the calling song of male crickets show few differences between the two populations. Genetic analyses confirm that the two populations are significantly distinct and we conclude that the absence of bats has caused partial regression in the nervous control of a defensive behavior in this insect. This study represents the first examination of natural evolutionary regression in the neural basis of a behavior.

Identification and Protection of a Bat Colony on the Hanford Site, Richland, Washington

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In 2006, a colony of bats was discovered at a former underground water storage facility on the Hanford Site. This facility, the 183-F Clearwell, was scheduled for demolition as part of the Hanford cleanup mission. Further observation showed this facility housed a maternity colony of more than 2000 bats, making this the largest known colony in eastern Washington. A follow-up study was conducted (June 2007 to September 2008) to determine how the bats were using the facility, the impact that demolition might have on the colony, and the need for a successful mitigation project to protect the colony. From the results of this study, a decision was made to leave the facility intact. The 183-F Clearwell is a non-contaminated facility associated with the retired 105-F Reactor. The clearwell is 114 m long, 41 m wide, and approximately 5 m deep and covered with a 15-cm reinforced concrete slab roof supported by 98 concrete pillars. The roof has six access hatches (81 x 107 cm), one of which was removed in the past, providing easy access for bats to fly in and out. The mitigation study involved a combination of roost entries, acoustic analysis, video analysis, morphometric measurements, and DNA analysis. The study showed the bats are Yuma myotis (*Myotis yumanensis*) and that they use many portions of the complex facility at different times of the year. The large size of the clearwell and the unlimited roosting options make this an ideal maternity roost site. This colony is likely a “source” population, providing smaller “sink” populations in the region with immigrants (mostly males), facilitating the in-flow of new genetic material into those colonies. The study determined that demolition of 183-F Clearwell would undoubtedly affect the success of this large maternity colony. The ecological significance of the clearwell, the viability of the maternal roost contained therein, and the biological contribution of this colony to the regional bat populations all required that the decision to demolish the facility be re-evaluated. After reviewing recommendations from this study, the U.S. Department of Energy (Hanford Site manager) along with the U.S. Environmental Protection Agency (Hanford environmental cleanup regulator) agreed with trustees and numerous stakeholders that the roost site should be preserved.

Dietary Differences among Nectar-feeding Bats in a Lowland Forest in French Guiana

Geiselman, Cullen K., Columbia University, New York; The New York Botanical Garden, Bronx, NY

I studied the dietary differences among three glossophagine species (*Anoura geoffroyi*, *Lionycteris spurrelli*, *Lonchophylla thomasi*) coexisting in the lowland primary rainforest near the Nouragues research station in French Guiana. Over the course of one year I collected 325 fecal samples from 536 individuals captured in mist nets at dawn as they returned to their day roosts. Based on the pollen found in their feces, I identified 14 plant species from 7 families in the bats’ diets. All three bat species showed evidence of feeding on insects and visiting flowers throughout the year, though the dominant life form of plants visited changed seasonally with epiphytes and lianas predominating in the wet and canopy trees in the dry season. Overall *A. geoffroyi* and *L. spurrelli*, the glossophagines commonly captured at the site, visited 12 species each, with 10 in common, though the proportions in which these 10 were visited differed between the 2 bat species. For example, *A. geoffroyi* had significantly higher proportions of samples with pollen from *Eperua rubiginosa*, *Marcgravia coriacea*, *Souroubea guianensis*, and *Psittacanthus acinarius*, while *L. spurrelli* had significantly higher proportions with pollen from *Caryocar glabrum* and *Bauhinia outimouta*. The results of a canonical discriminant analysis and a logistic regression analysis confirmed that *A. geoffroyi* and *L. spurrelli* had distinct diets. In some cases, their differences could be attributed to a lack of fit between flower and pollinator, such as the case of the smaller *L. spurrelli* being excluded from the flowers of *P. acinarius*. However, neither flower morphology nor energetics can explain why the two bat species differed significantly in their visitation to accessible flowers with large nectar rewards. I propose that repetitive interactions with certain flowers may illicit flower constancy in nectar-feeding bats.

Marco! Polo! Social Calls Used by *Thyroptera tricolor* for Locating Roostmates
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Spix's disc-winged bats, *Thyroptera tricolor,* form small, long-term social groups in which bats are loyal to a patch of forest but move on a daily basis between highly ephemeral roosting sites (partly unfurled leaves of *Heliconia* and *Calathea* species). Individuals that become separated from their social group face the challenge of relocating groupmates in a habitat where vegetation is dense and often several optimal roosting leaves are available at the same time. Under such conditions, a system where both the separated individuals and the roosting bats signal to each other would facilitate rapid relocation of groupmates. In this study, we examined the social calls emitted by *T. tricolor* when individuals search for members of their social group. For each group captured, we placed some bats in an optimal roosting leaf and held the remaining bats for individual release. Upon release, we recorded any sounds produced and noted if the released bat relocated the group. We recorded two distinct signals: 1) "inquiry" calls, which were produced by the released bat, and 2) "response" calls, which were emitted by bats within the roost. Inquiry calls were always produced first, followed rapidly by response calls from groupmates. This calling system allowed bats to rapidly reform groups and provides a mechanism by which Spix's disk-winged bats maintain associations with particular conspecifics despite regular roost movements.

How to Store Mammalian Tissues for DNA-based Analyses in Tropical Field Conditions
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Determining the best non-cryogenic storage method of tissue for DNA extraction is critical in areas where freezers and liquid nitrogen are unavailable or impractical. Not only is DNA degradation a problem, but also the storage media may introduce mutations in the DNA leading to incorrect analyses of data. For example, DMSO produces higher yields of PCR products in tissues relative to storage in lysis buffer or ethanol, but it may be detrimental in DNA sequencing. Finding the best method can save researchers both time and money. However, little research has been performed in this area. In this study, we examined the effects of three preservation methods (silica beads, DMSO, and ethanol) and differences in time before freezing (4–18 days) on bat wing punctures in tropical conditions. The effects of these treatments were assessed through DNA extraction and sequencing of samples of multiple replicates from the same individuals. These samples were collected and field-preserved for variable lengths of time in Puerto Rico (average temp = 25.6°C; average relative humidity = 76.5%) and the Dominican Republic (average temp = 25.8°C; average relative humidity = 64.3%), conditions that normally lead to rapid nucleic acid degradation. DNA extraction (Qiagen DNeasy) and PCR amplifications (GE Biobeads) were performed using standard manufacturers' protocols. The amounts of DNA extracted were similar across field storage times and methods (single-classification ANOVA; $F = 0.603424$, $p = 0.553639$). Relatively low yields of DNA were extracted from the samples ($\mu = 12.3$ ng/μl). All PCRs were successful, however, illustrating the high sensitivity of amplification methods. These findings indicate that any of these methods used in the field can produce viable amounts of DNA.

Bat Activity in Northeastern Minnesota
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The North Shore of Lake Superior in Minnesota concentrates migrating birds and possibly bats along the lake's shoreline during the spring and fall migrations. Recent proposals to develop parts of the North Shore for wind power have spurred interest in potential effects on birds and bats. Migrating birds and bats could be affected by wind power facilities along the North Shore, and resident birds and bats could also be affected. We identified habitats that are important to bats on the North Shore using two Landsat-based satellite imagery land cover classification types in GIS. We then identified sampling locations based on stream and transportation GIS coverages. We used Anabat II acoustic detectors to measure bat presence and relative abundance at 75 sites along the North Shore. We placed detectors at 25 corridor, 25 forest, and 25 riparian sites for 3–4 consecutive nights during the summer and fall of 2009. We trapped nocturnal insects with black light traps at a comparable site an average of 120 m from the bat detector to estimate prey availability. Bat activity levels were greatest along linear features, with 51% of bat call files recorded along trails and pipelines, 46% of bat call files at riparian area sites, and 3% in contiguous forest. Bat activity was greatest in deciduous forest, with 55% of bat call files recorded, compared to 26% in coniferous forest, and 19% in mixed forest. Sites with the highest bat activity had high insect abundance. However, there was bat

activity at sites with low insect abundance. The results of this study provide baseline data for predicting bat activity along the North Shore, including at potential wind power development sites.

Habitat Occupancy and Detection of the Pacific Sheath-tailed Bat (*Emballonura semicaudata*) on Aguiguan, Mariana Islands
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The Pacific sheath-tailed bat (*Emballonura semicaudata*) was once common and widely distributed across the southwestern tropical Pacific, and the subspecies that occurred throughout the Mariana Islands (*E. s. rotensis*) now occurs only as a single remnant population on Aguiguan Island. Occupancy analysis is a fairly new technique only recently being applied to bat studies in which echolocation calls are used as a measure of occurrence and activity. We used the approach to quantify the species' foraging activity and its relationship to forest structure and proximity to cave roosts on Aguiguan. Bat occurrence was most closely associated with canopy cover, vegetation stature, and distance to known roosts. The metrics generated by this study can serve as a quantitative baseline for future assessments of status following changes in habitat due to management activities (e.g., feral goat control) or other factors (e.g., typhoon impacts). Additionally, we described the search-phase echolocation calls produced by *E. s. rotensis*, and found them to be characterized by a relatively narrow bandwidth and short pulse duration typical of insectivores that forage close to and among vegetative clutter. Given the island's very limited resource base and size (7 km^2), its vulnerability to typhoons, the extreme isolation of the population, and the species' narrow habitat preference and specialized foraging strategy, it is imperative that native limestone forest on Aguiguan be restored to ensure the long-term survival of the Pacific sheath-tailed bat in the Marianas.

Comparison of Bat Activity Recorded Using Different Acoustic Sampling Equipment: Implications for Study Design at Wind-Energy Facilities
Gruver, Jeffery C., Donald I. Solick, and Michelle K. Sonnenberg, Western EcoSystems Technology, Inc., Cheyenne, WY

Bat activity as measured by ultrasonic detectors is roughly correlated with bat mortality at wind-energy facilities, and passive acoustic monitoring has become a standard approach to assessing mortality risk at proposed wind developments. However, equipment used for deploying detectors is not standardized among bat researchers. We tested the effects of weatherproofing (plastic box with 45° PVC elbow vs. EME Systems Bat-Hat with reflector plate), audio cable length (2 m vs. 50 m), and microphone amplification device (Titley Scientific's Hi-Microphone™ vs. EME Systems preamplifier) on bat pass rates recorded by Anabat™ bat detectors. Trials were conducted at locations in Arizona, Wyoming, and Wisconsin to determine if these comparisons were consistent across different environments. Preliminary results indicate differences among treatments and regions. Contrary to previous research, Arizona detectors housed in Bat-Hats with reflector plates recorded significantly more bat passes than detectors housed in boxes with PVC elbows, whereas bat activity was unaffected by weatherproofing treatment in Wisconsin. Overall bat pass rates did not differ significantly between cable length treatments, although detectors with 2-m cables did record significantly more passes by high-frequency (>35 kHz) bats, suggesting that long audio cables may under-represent high-frequency species. However, while differences between some treatments are statistically significant, the differences between mean bat activity are quite small and would likely result in similar risk assessments at wind-energy facilities.

Bat Activity as it Relates to External Variables at a Proposed Wind Energy Site in Northeast Missouri
Hale, Benjamin T., C. Ryan Allen, and Lynn W. Robbins, Missouri State University, Springfield, MO

Investigating and quantifying how bat activity is influenced by weather and habitat would give a more accurate depiction of species presence or absence at a chosen site. Information on bat activity patterns would be beneficial to wind energy development, especially in determining turbine placement and curtailment. Three acoustic detector stations, utilizing the SD1 recording system (Titley Electronics, Ballina NSW, Australia), solar charged 12-volt batteries, and waterproof casings were set equidistant in a 1000 m transect across an agricultural field in northern Missouri. The stations were placed 10 m, 500 m, and 1000 m respectively from a riparian edge. Two Kestrel 4500 Weather systems were placed in the detector transect, one at the riparian edge station and another at the 1000 m station. Kestrel data collection began on June 20 and will continue until November 1. Graphical representations of hourly bat activity, over all surveyed nights, consistently showed peaks in activity occurring between 20 and 80 min after sunset. Another significant peak in activity consistently occurred approximately 8 h after sunset. Preliminary observations also suggest a positive correlation of bat activity and temperature. The effects of instantaneous wind speed, maximum wind gust, average wind speed, temperature, and relative humidity on bat activity will also be included in this study. Specifically, differences among species and species groups and how they respond to these variables will be explored to determine species preference or avoidance of certain environmental conditions. Patterns of bat activity based on habitat and weather variables would improve the quality of information currently used to determine wind turbine placement and operation in order to mitigate bat mortality.

White Nose Syndrome and Culling of Colonial Bats
Hallam, Thomas G., University of Tennessee, Knoxville, TN

Current evidence indicates that the white nose syndrome (WNS) pathogen is an exotic fungus, *Geomyces destructans*, likely from Europe, and that transmission is primarily from bat-to-bat. The disease is highly virulent in colonial bats and many species of bats exhibit high susceptibility to WNS. When exposed to a highly contagious pathogen such as *G. destructans*, temperate bats are at risk because of the occurrence of colonial mixing and multitudes of bat-to-bat contacts at different life history stages and physical sites such as maternity roosts, swarming, and hibernation. A management option that has been considered by several state and federal agencies is to cull bats in specific diseased hibernacula with hope that this strategy will help prevent the spread of WNS. I address the culling proposal by constructing an energetic best case model and demonstrate in a theoretical setting that culling will not mitigate WNS in bats and, additionally, it only reduces the force of infection for a temporary period.

***The Impact of Environmental Niche Specialization on the Evolution of Olfaction in Bats**
Hayden, Sara, Michael Beakert, and Emma C. Teeling, University College Dublin, Dublin, Ireland
*** Sara Hayden** received the **Karl F. Koopman Award**

Olfaction is considered one of the most important modes of sensory perception in animals and provides the basis for the extraordinary sensitivity required for the discrimination of environmental and sexual cues. The olfactory receptors (ORs) are essential for the sense of smell; accordingly the ORs form the largest gene superfamily in the mammalian genome. Increasingly, environmental niche specialization is found to be reflected in mammalian genomes. A correlation between loss of function of olfactory receptors and the gain of full trichromatic vision has been shown in primates. Bats are nocturnal sensory specialists that can use sophisticated laryngeal echolocation to create an acoustic image of their environment, potentially negating the need for enhanced vision and olfaction. Initial studies on the functional OR gene repertoire of mammals showed bats possessed a distinctly different OR gene repertoire than all other species studied. To investigate if the evolution of the OR gene repertoire within bats has been influenced by rudiments such as habitat, diet, sensory-specialization, and other life history traits, we PCR-amplified, cloned, and sequenced the OR genes from 25 bats spanning the chiropteran tree. To reduce phylogenetic signal within our data set but also retain a broad spectrum of niche specializations we focused our sampling on the Phyllostomidae. The class and familial composition of these ORs also was examined and compared to that of *Myotis lucifugus*—the only bat with a genome sequenced at a high coverage, confirming the validity of our laboratory procedure. The percentage of functioning and non-functioning olfactory receptor genes was assessed along with the estimated number of OR genes in each species. We found a wide range of variation within the functional and pseudogene OR repertoires within the order Chiroptera and also within the Phyllostomidae, indicating that environmental niche specialization plays a large role in defining the OR gene repertoire in bats. These data illustrate the evolution of the mammalian OR gene repertoire over the past 56 million years and suggest that the functional OR gene repertoire of bats has been significantly molded through natural selection.

Geographic and Elevational Distribution of Fringed Myotis (*Myotis thysanodes*) in Colorado
Hayes, Mark A., and Rick A. Adams, University of Northern Colorado, Greeley, CO

Fringed myotis (*Myotis thysanodes*) is a species of conservation concern in Colorado and throughout western North America. The purpose of this research was to describe and map all available information on occurrence of this species in Colorado and evaluate the elevational distribution among sex and reproductive classes. The rationale for compiling capture and occurrence records and mapping the Colorado distribution of *M. thysanodes* is prompted by the need for comprehensive information on this species to help inform conservation and management decisions. The rationale for comparing the relationships of sex and reproductive class on elevation of occurrence is prompted by the desire to understand the distribution of reproductively active female and juvenile *M. thysanodes* and test the hypothesis that juveniles and reproductive females tend to occur at lower elevations than do non-reproductive adults. Occurrence locations were mapped using Arc-GIS software and this distribution map was compared to the distribution maps developed for this species by other authors. A two-way analysis of variance (ANOVA) was then used comparing elevation of occurrence among two sex classes (male and female) and three reproductive classes (adult non-reproductive, adult reproductive, and juvenile), with significance set at $\alpha = 0.05$. A Student-Newman-Keuls test was then used to look for group means that were significantly different. We compiled a data set of over 600 records of *M. thysanodes* in Colorado. The resulting distribution map strongly supports a bifurcated geographic distribution with separate populations occurring in a narrow band along the Front Range and in western Colorado. We used 546 of these records that included information about sex and reproductive status in the ANOVA comparing elevational distribution among sex and reproductive classes. There were significantly different elevational mean sum of squares among reproductive classes ($F = 7.03$, $p = 0.0010$), but not between sex classes ($F = 0.10$, $p = 0.7578$). The geographic distribution of *M. thysanodes* we describe here suggests that dispersal and gene flow in Colorado likely occur among the sub-population along the Front Range and among sub-populations in western Colorado, and that the Southern Rocky Mountains are a barrier to dispersal between these populations. These results also indicate that juvenile and reproductive female *M. thysanodes* tend to occur at lower elevations than non-reproductive adults of both sexes.

A Preliminary Study of *Plecotus macrobullaris* in Zanjan Province, Northwest Iran

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To date more than 40 species of bats have been identified of the fauna of Iran. The distribution, abundance, or ecological status of any of these species is well-known. One of the least observed and collected species of bat in Iran is *Plecotus macrobullaris*. This study was conducted to study the status of *P. macrobullaris* in northwest Iran from winter 2008 to spring 2009. The calcareous Goljik Cave is located at 36º 41’ 78” N and 48º 05’ 59” E, at an altitude of 2191 m, and is approximately 50 m in height and 500 m in length. Mist nets and hand traps were used to capture the bat species living in the cave. The following species were identified: *Plecotus macrobullaris*, *Myotis blythii*, *Miniopterus schreibersii* (Family Vespertilionidae), *Rhinolophus hipposideros*, and *Rhinolophus ferrumequinum* (Family Rhinolophidae). It seems that poorly known *P. macrobullaris* is the least abundant sympatric bat species in one of the best known caves in northwest Iran. Searching for *P. macrobullaris* in 19 other Zanjan caves was fruitless indicating that this species of least concern status has very limited distribution and very low abundance in northwest Iran. This warrants its careful protection and conservation by undertaking specific conservation measures by the Department of Environment of Iran.

Cool Muscle Properties in Hibernating and Summer *Eptesicus fuscus* in New York

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It has been shown that hibernating big brown bats (*Eptesicus fuscus*) may utilize proteins in the pectoralis muscle to supply metabolic needs during hibernation. Further, active big brown bats (recovered at structures where they were periodically aroused during the winter) were shown to exhibit greater body mass loss than inactive, hibernating *E. fuscus*. This study tested an hypothesis that there were adaptive decreases in pectoralis muscle mass as well as shifts in muscle characteristics during hibernation in big brown bats in central and northeastern New York. Consideration of additional muscles, especially the hind limb gastrocnemius, was included. Analysis included histochemical and immunocytochemical study of frozen and serially sections muscle samples. Ten bats were included in this preliminary study, primarily including four bats collected in July 2001 and four matched bats collected during March 1997. Additionally, two bats were collected in March 2008. Hibernating bats had a higher mean body mass compared to summer bats (15.0 g vs. 13.8 g) but had significantly reduced pectoralis mass (0.36 g vs. 0.79 g). Despite the apparent catabolism of the pectoralis muscle, flight muscle fiber properties remained consistent (100% fast twitch muscles with no significant difference of mean fiber sizes). Brigham et al. (1990, J. Comp. Physiol.) reported no difference during the winter months in pectoralis fiber types, but noted an increase of slow-twitch muscle fibers (38%) in hibernating compared to pre-hibernation (17%) *Myotis lucifugus* hind limb muscles necessary for hanging within the roost. These muscles demonstrated an increasing proportion of slow-twitch, postural muscle myocytes. The 1997 bats sampled in the present study had only about 11% slow-twitch fibers, which is less than the figure reported by Brigham et al. in the little brown bats. In this age of white nose syndrome, it was of interest that the 2008 bats included in the current report showed a higher proportion of slow-twitch muscle fibers (23%) compared to the 1997 bats. Further analysis of muscle composition is ongoing.

Landscape Scale Assessment of Bat Roosting Habitat Selection in Response to Anthropogenic Noise

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Most assessments of bat habitat use have focused on the availability and selection of resources that presumably provide some benefit to the study species (e.g., foraging and roosting). However, conservation biologists are gaining a greater appreciation that not all aspects of habitat selection are necessarily positively related to resources. Wildlife avoidance of anthropogenic disturbance as a determinant of habitat selection has been investigated in a variety of taxa, but has not been widely investigated in bats. Such information has the potential to be of particular value when assessing impacts to rare and protected species. The U.S. Army is particularly interested in quantifying the response of protected bat species to military-related activities on its installations, where weapons training and testing potentially represent a somewhat unique source of anthropogenic disturbance. The objective of this research was to assess whether sources of anthropogenic noise affect habitat selection of Indiana, northern long-eared, and little brown myotis within military and non-military landscapes. Minimum convex polygon (MCP) and 95% kernel roosting ranges were estimated for 77 female bats at 3 military (Camp Atterbury, Jefferson Range, Fort Knox) and three control (Muscatatuck NWR, Mammoth Cave NP, and Spencer Co.) sites in southern Indiana and northern Kentucky. Distance-based analyses of land cover and noise variables were performed on 5-km buffered roosting ranges. Buffered roosting ranges of bats at military and control sites did not differ in total area, road density, forest area, agriculture area, or wetland area, but did differ in the area of developed land. Additional analyses summarizing the location of roosting ranges in relation to military unique sources of noise (e.g., artillery firing points and impact areas) will also be presented. The results of this research are important because DOD landholdings play a significant role in the conservation of numerous chiropteran species, including the recovery of several federally listed as endangered under the Endangered Species Act.

Identifying Critical Stopover Areas for Migratory Bats

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Bats require stopover areas where they can rest and refuel during migration. Identifying such areas will aid in the development of successful conservation and management strategies. Long Point, Ontario, Canada, a 35-km-long sandspit, is an important stopover site for migratory birds, and recent evidence has shown that bats migrate through Long Point as well. Our objective was to determine a quantitative measure of what characterizes a critical migratory area for bats. We predicted activity levels would vary seasonally on Long Point and that activity would be greater on the point than in the surrounding area. We also predicted that during migration, bats from a variety of summer populations would converge at a common stopover site and consequently bats captured on Long Point would have greater genetic diversity than those captured at summer resident sites. Using a combination of acoustic monitoring and mist netting, we measured activity levels of bats on Long Point and at sites along the shoreline and inland. We took tissue samples for genetic analysis of the control region of the mitochondrial DNA from *Lasionycteris noctivagans* migrating through Long Point and from a summer resident population in Cypress Hills, Saskatchewan, Canada. Activity was highest during the spring and fall migrations, and activity was higher on Long Point than in the surrounding area. There was no substantial difference in genetic diversity between *L. noctivagans* captured at Long Point and *L. noctivagans* from the summer population. Our research indicates that migrating bats stopover at specific locations. Activity was concentrated at Long Point and not in the surrounding area. It does not appear that genetic diversity can be used as a reliable indicator for bat migratory stopover sites. Future studies of other known migratory bird stopover sites may identify additional bat migration stopover areas based on seasonally fluctuating activity levels.

How Do Fast Bats Fly: Wing Kinematics of the Brazilian Free-tailed Bat (*Tadarida brasiliensis*) Flying at a Range of Flight Speeds

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Bats are unique among mammals in their ability to fly. Although flight in bats originated from a single common ancestor, the primitive flight apparatus has diversified over evolutionary time to match the tremendous radiation of bats, and diverse species now achieve astonishing flight prowess under a spectrum of flight environments. However, to date, there is little knowledge about how bat species of different sizes and wing shapes are capable of producing the aerodynamic forces necessary for flight under different flight conditions. Understanding the mechanistic basis of bat flight requires realistic, accurate 3D kinematic descriptions of the wings of bats with diverse flight strategies. In this study we present a detailed description of the wing kinematics of a bat specialized for fast flight, flying at a range of speeds. Brazilian free-tailed bats (*Tadarida brasiliensis*) were trained to fly in a wind tunnel at speeds between 3.5 and 7.5 m/s. To reconstruct 3D motion of anatomical landmarks, markers were placed on the body and wings of bats and their motion was recorded with multiple high-speed digital video cameras. Kinematic parameters calculated from these motions show striking differences in the overall pattern of wing movement in this species compared to other species of bats. Throughout the wing beat cycle, *T. brasiliensis* maintained a relatively flat wing surface with minimal wing-bending and relatively small wing beat amplitude. Furthermore, as flight speed increased, there was little change in the pattern of wing motion, rather bats changed the shape of their wings by modifying wing extension, camber, and angle of attack. This study demonstrates that the use of simple models to represent the diversity of flight strategies among bats is insufficient to capture their diversity. Bats that differ in wing form and/or flight ecology may differ substantially in the patterns of wing movement, and hence are likely to differ in flight aerodynamics and energetics as well.

Design Considerations for Bat Fatality Mitigation Studies at Wind Energy Facilities

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We implemented the first U.S.-based experiment on the effectiveness of changing turbine cut-in speed on reducing bat fatality at wind turbines at the Casselman Wind Project in Somerset County, Pennsylvania. Our objectives were to 1) determine if delaying turbine rotation until winds had reached pre-determined speeds would result in fewer bat fatalities, and 2) determine the economic costs of the delay. We defined three treatments that could be implemented at a turbine over an entire night: 1) fully operational (F treatment), 2) rotation disallowed until wind speed exceeded 5.0 m/s (C5 treatment), and 3) rotation disallowed until wind speed exceeded 6.5 m/s (C6 treatment). Several design issues arose: 1) What was the appropriate experimental unit to which to assign our treatments—the turbine, the night, or the turbine-night? With only 12 turbines available at which to conduct the research and having observed high variation in fatality among turbines in previous years, we were reluctant to use the turbine as the experimental unit, risking the chance that turbines with higher fatality rates might randomly be assigned to a particular treatment. 2) Although defined treatments could be randomly assigned, their actual realization was a function of wind speed at the site on any given night. If the wind speed never exceeded 5.0 m/s or was always greater than 6.5 m/s the treatments were indistinguishable. 3) Carcasses in different vegetation types can differ greatly in their detectability. Cleared areas, where detectability is highest, vary in area and configuration among turbines making simple carcass counts among turbines not directly comparable. Methods used to correct for imperfect detection cannot be applied because these rely on average tendencies, applicable in the long run, but not on a specific night at a specific turbine. Our solution was to treat each turbine as a block, with each night as a sampling unit, randomly assigning 25 nights to each of 3 treatments (total 25 nights). No adjustment for variable detectability was necessary because we limited our comparisons to fresh carcasses observed in similar habitat. Although detectability was less than 1, it was assumed equal among carcasses and variation in searchable area among turbines was accommodated by an offset. With this design, the inherent variation in fatality among turbines was absorbed by the random effect of turbine (block), allowing direct comparison of carcass counts among treatments within turbines.

Test of the "Reproductive Landmarks Hypothesis" to Explain the Mortality of Bats at Wind Turbines

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The global wind energy sector is rapidly growing and numerous studies are reporting large-scale bat mortality at wind plants due to collisions with turbine blades or barotrauma injuries. In North America, the migratory tree bats comprise most of the fatalities at turbines. Reasons for such widespread mortality of these bats, while birds and other bat species are less affected, is still unclear. Available evidence suggests that these species are attracted to turbines but few data exist to explain this apparent attraction. One possible explanation, which has been termed the "Reproductive Landmarks Hypothesis" and which is supported by a body of circumstantial evidence, proposes that migratory tree bats use tall, prominent landscape features as focal points for mating activity during their fall mating/migration season, much like some hibernating bat species use hibernacula as landmarks for mating behavior. This seems reasonable given that migratory tree bats likely rely primarily on visual orientation to recognize landscape features during long distance flights, have higher mortality rates at wind plants during the fall mating/migration period, generally roost alone or in small groups, cover enormous home-range areas, and migrate long distances. Selection should, therefore, favor mechanisms that improve their likelihood of finding mates during the reproductive season. In 2008 I tested several predictions of this hypothesis using a combination of mortality surveys at wind turbines and acoustic activity surveys at turbines, other tall structures (communication towers), and control sites. Understanding whether bats are attracted to turbines and testing the "Reproductive Landmarks Hypothesis" is especially important for determining the value of pre-construction monitoring at proposed sites for wind plants because, if bats are strongly attracted to turbines, they may not be present when pre-construction surveys are conducted.

One Piece of the White Nose Syndrome Puzzle: Torpid Metabolic Rates of (*Myotis lucifugus*)

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White nose syndrome (WNS) is a large-scale epidemic that is killing cave-dwelling bats in the northeastern United States during the winter by causing bats to deplete all of their fat reserves before hibernation is over. We hypothesized that little brown bats (*M. lucifugus*) with WNS have elevated metabolic rates while torpid. We measured *in situ* oxygen consumption rates and body temperatures (with iBBat temperature-sensitive data-loggers) throughout the 2008–2009 hibernation season at a Williams Lake mine (WNS-affected area in New York), at Woodward Cave (unaffected by WNS at the beginning of study in Pennsylvania), and at Brooks Cave on Ft. Leonard Wood military base (unaffected area in Missouri). Most bats showed normal torpor ($n = 7–27$ bats per site and month), but the metabolic rates of bats in New York were two to three times higher that of bats in Pennsylvania ($p = 0.001$). Torpid metabolic rates of bats in Pennsylvania were similar to rates measured in other bat species in our lab. This is consistent with our hypothesis, even though WNS was detected in Woodward Cave by March 2009. Bats in Missouri had intermediate rates of metabolism, possibly due to geographic differences. We estimate that the higher metabolic rates during torpor (not accounting for changes in arousal patterns/metabolism) in New York bats would utilize an additional 0.7 g of fat over the winter and this may be part of the reason why affected bats are starving to death.

Bat Use of Rocket-style Bat Houses in the Central Valley and the Sierra Nevada Foothills of California

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Rocket-style bat houses have been used in a number of states in the U.S. to provide roosting habitat for various bat species. For this study, four locations were chosen in Northern California to install rocket-style bat houses in three different heights (12-foot, 16-foot, and 20-foot). Two of the locations are in the Central Valley and two locations in the Sierra Nevada foothills. At each of these sites, three bat houses of the differing heights were installed and monitored for use by bats. Monitoring methods included the use of Sony Nightshot camcorders with infrared lights and Anabat acoustic detectors and visual observation during daylight hours as well as collecting guano from under the bat houses. Guano was collected from under bat houses at all four locations and bats were observed and recorded using or exiting bat houses at three of the four locations. Three of the locations had guano present within one month of installation of the bat houses and the fourth location had guano present within three and one-half months of installation. *Myotis californicus* was present at three locations as directly observed and/or recorded exiting the bat houses. Other bat species observed or recorded using the bat houses included *Eptesicus fuscus* and *Parastrellus hesperus*. The rapid colonization of these bat houses indicates the suitability of this style of bat house for use by bats in Northern California.

Roost Selection by Indiana Myotis Following Forest Fires in Central Appalachian Hardwoods Forests

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Following decades of fire suppression in eastern forests, the use of prescribed fire to restore or enhance the oak-dominated communities is gaining widespread acceptance. Interactions of fire with other biotic components such as wildlife that might benefit from such reintroduction are poorly documented. From 2001 to 2009, we examined roost selection of Indiana myotis (*Myotis sodalis*) in burned and unburned forest in Tucker County, West Virginia. We radio-tracked 16 male and 1 female Indiana myotis to 54 roost trees—17 in burned stands and 37 in unburned stands. In burned stands, Indiana myotis roosted exclusively in fire-killed maples (*Acer* spp.). In unburned stands, they used hickories (*Carya* spp.), oaks (*Quercus* spp.), and maples. Roost trees in burned stands were surrounded by less basal area and by trees in advanced stages of decay, resulting in larger canopy gaps than at randomly-located potential roost trees in burned stands and at roost trees located in unburned stands. Compared to randomly-located potential roost trees in unburned stands, roost trees in unburned stands were less decayed and taller, had higher percent bark coverage, and were surrounded by less basal area, resulting in larger canopy gaps. Roost switching frequency and distances moved among roost trees were similar between burned and unburned stands. Indiana myotis roosted in stands that had initially been burned 2–3 years prior to their roosting in them, suggesting a delayed response to the increase in snag abundance created by fire. Our research suggests that the use of fire can be an effective management tool for Indiana myotis, through an increase in snags and creation or enlargement of canopy gaps.

Seasonal Range Maps for Western Red Bats (*Lasiurus blossevillii*) in California and Wintering Western Red Bat in Red Gum Eucalyptus (*Eucalyptus camaldulensis*) Leaf Litter
Johnston, Dave S., and Susan Whitford

We used GIS-based ArcView 9 and 527 western red bat (*Lasiurus blossevillii*) location records from the California Natural Diversity Data Base, museum records, and capture and acoustic data from E. Pierson, W. Rainey, C. Corben, D. Johnston, D. Stokes, S. Whitford, and S. Remington and various reports to predict seasonal ranges in California. Land cover attributes, political boundaries, and records were combined into a single table. GAP polygons that showed only the primary wildlife habitat relationship (WHR) vegetation community were used to generate the GIS-based range maps. The breeding (summer female and young) range comprised valley foothill woodland habitats in the Central and Salinas valleys, and in coastal areas of Southern California. The male summer range included the Sierra Nevada and other mountainous regions adjacent to the female–young summer range. The winter range was mostly limited to the San Francisco Bay Area, the Delta and central portion of the Central Valley, and coastal areas with valley foothill riparian habitat. Additionally, we documented locations and habitats of two wintering western red bats in non-native river eucalyptus (*Eucalyptus camaldulensis*) leaf litter. For 20 randomly selected points of this leaf litter habitat we determined a mean thickness of 9.9 cm, se = 0.82; a mean distance of 1.31 m to the nearest tree >20 cm, se = 0.20; and 5 of the 20 points were relatively dry after heavy rains. These data suggest that the leaf litter from groves of non-native eucalyptus potentially provide valuable wintering roost habitat for the western red bat.

Differences in the Hibernation Strategies of Male and Female Little Brown Bats (*Myotis lucifugus*)
Jonasson, Kristin A., and Craig K. R. Willis, University of Winnipeg, Winnipeg, MB

Male and female little brown bats (*Myotis lucifugus*) are on different energetic schedules. Although both sexes must acquire sufficient fat reserves to survive the winter, males make their energetic investment in reproduction during fall and winter while females invest in reproduction during spring and summer. Females must retain more fat during hibernation to emerge with adequate reserves to stimulate ovulation. This leads to the prediction that females will be thriftier with their hibernation energy stores than males, relying more heavily on deep, long-term torpor, while males will avoid presumed physiological/ecological costs of torpor and spend energy more quickly. To test the predictions we assessed body condition during fall swarming, mid-winter, and just prior to emergence from hibernation in a population of bats from central Manitoba, Canada. To quantify patterns of torpor and arousal, we also monitored skin temperatures of five male and five female bats using temperature-sensitive radiotransmitters. Near the end of hibernation, females were in better body condition (mass/forearm) than males ($p = 0.014$, $n = 244$). Torpor bouts lasted for 17.4 ± 8.7 days on average. There was no significant difference in bout duration between males and females ($p = 0.29$, $n = 8$) but arousals were significantly shorter in females (48.9 ± 10.1 min) than males (79.2 ± 17.3 min; $p = 0.026$, $n = 8$ arousals). This difference in over-winter energy expenditure could have consequences for the relative impacts of white nose syndrome (WNS) on survival of male vs. female bats and for long-term population impacts of WNS.

Bat Activity Across the Vertical Gradient of an Old-growth Redwood (*Sequoia sempervirens*) Forest
Kennedy, Jean-Paul, and Joseph M. Szewczak, Humboldt State University, Arcata CA

Despite being a habitat of special concern and the tallest forests on Earth, there exists little understanding of associated bat use and interdependency on old-growth redwood forests. Rich with suitable roosting habitat, a temperate year-round climate, and spatial complexity, these forests may provide refuge for a greater number of bat species than previously recognized. Unfortunately, due to historic timber harvest and poor land management practices, less than five percent of these original old growth redwoods remain and our understanding of how bats use these forests provides insufficient support for management decisions. We developed a protocol to remotely and continuously monitor bat activity across the more than 100-m vertical gradient in old-growth redwood forests. Remote acoustic detector units consisting of a Pettersson D240x bat detector housed in a weatherproof steel electrical box were lashed to two old-growth redwood trees at ground (3 m), mid-canopy (50 m) and canopy levels (100 m) near Bull Creek in Humboldt Redwoods State Park, Humboldt County, Northern California. Recording units for each detector (iriver H320 with Rockbox firmware), a SFC Energy For You 600 fuel cell and battery were housed at the base of each tree and were connected to the remote detector units by electrical cables and audio cables. Baluns (Intelix AVOA2MINI-WP, as per recommendation by Mike Balisteri of Avian Consulting Services) facilitated the remote transfer of audio signals from the remote detectors to the recording units. We performed call analysis and species identification using SonoBat software (SonoBat, Arcata, CA). Initial assessment reveals presence by the following species: *Eptesicus fuscus*, *Lasionycteris noctivagans Lasiurus cinereus*, *Myotis californicus*, *M. evotis*, *M. lucifugus*, *M. thysanodes*, *M. volans*, *M. yumanensis*, and *Tadarida brasiliensis*. *L. cinereus* accounted for 50% of calls identified at canopy level followed by *L. noctivagans* (23%) and *T. brasiliensis* (10%). The overall bat activity at mid-canopy was < 10% of those recorded at the canopy and 32% of those recorded at ground level. *L. cinereus* accounted for 42% of all identified calls at mid-canopy while *M. californicus* accounted for 42% of the calls identified at ground level. Further research will include greater spatial and temporal analysis to elucidate bat use of this forest.

The Influence of Social Context on Behavior in Big Brown Bats (*Eptesicus fuscus*)

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Among gregarious animals, interactions between an individual and other group members define the individual's role in its society. Variation in behavioral phenotypes between group members can affect fitness by impacting an individual's access to resources. To fully understand the role of an individual within its social system, the behavior of individuals in a variety of social contexts needs to be examined. Many species of bats are social, yet there are virtually no published data examining the underlying social relationships between individuals. Therefore, my goal in this study was to examine how social context impacts behavior in big brown bats. Big brown bats are a highly social species in which females form maternity colonies in summer ranging in size from tens to hundreds of individuals. I measured the relationship between individuals in both competitive and exploratory settings, and the role of dominance in social relationships. I conducted experiments using adult females captured at four different maternity colonies. Individuals were brought into captivity where I measured exploratory behavior with novel objects in both solitary and social treatments. Dyadic competition experiments were also staged between all pairs of individuals. These data were used to assess each individual's competitive ability in a social context. Exploratory behavior was highly variable between individuals, and changed consistently depending on social context. Counting the number of wins and losses of individuals was a consistent measure of competitive ability among pairs, indicating the presence of a dominance hierarchy. Variability in the aggressiveness of bats was found in dyadic competitions and was consistent among individuals. These results are the first to describe the nature of social relationships and to experimentally explore dominance in bats.

The Malaysian Bat Education Adventure: A Research-based Learning Environment for Teaching Biological Concepts

Kingston, Tigga, Charles D. Squire, Mark A. McGinley, Kenneth A. Schmidt, and Lakshmi Tirumala, Texas Tech Univ., Lubbock, TX

K-12 science education in the U.S. is insufficient to meet projected needs for science and engineering jobs and equip our future citizens with the levels of science literacy required to assess the social and ethical impacts of technical advances. Two causes for the low performance of science education in the United States identified by recent research are 1) standards and curricula are unfocused and disconnected and 2) information is not presented in a realistic environment that provides context. We developed the first module—"Biodiversity"—of a focused learning progression for evolution for grades 2–8 with bats as a common focus. We provide context for the curriculum by embedding it in a research project on bat diversity in the rainforests of Peninsular Malaysia, brought to the classroom using multimedia technology to teach "live from the field." Learning goals for the Biodiversity module centered on students' ability to: 1) describe how scientists measure species diversity and distinguish between the two fundamental components of species diversity—species richness and abundance; 2) recognize that species vary in abundance within an assemblage; 3) describe intraspecific variation using simple physical measurements; 4) enter raw data into tables; and 5) collate these data and construct and interpret frequency histograms and scatter plots. Materials included over 20 instructional videos describing the bats at the field site, and providing introductions to bat biology, research methods, and the rainforest environment. Presentation materials and background information for teachers were developed, and all products posted on the project Web site www.ttu-mbea.org. In Spring 2009, the project went live and over 300 fourth and fifth grade students from North Ridge Elementary School, Lubbock, Texas, tracked real-time research in Malaysia for four weeks. Through the Web site, students received the daily capture data, which they recorded and tabulated in workbooks. Students used the data to construct graphs tracking daily capture rates of individual species, species abundance distributions, and the distributions of forearm length and body mass within and among species. Video-conferences enabled students to interact with the research team in Malaysia. After the four-week trapping period, students synthesized the data and answered a series of questions designed to evaluate the extent to which the learning goals had been attained.

Foraging Ecology of Bats in San Francisco, California

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Management of urban natural areas to maximize wildlife species richness and abundance is challenging, and often must be done based on poorly defined and sometimes conflicting requirements. In addition, responses of different taxa to habitat differences at very high levels of urbanization are poorly understood. This study examined: 1) the distribution and abundance of bat foraging activity in San Francisco natural areas; 2) which characteristics of natural areas influence the observed patterns of distribution and foraging activity; 3) species-specific responses to those characteristics; and 4) seasonal patterns in distribution and abundance of bat foraging activity. Twenty-two parks were surveyed quarterly during 2008–2009 using Pettersson D240x acoustic monitoring equipment. Four species were confirmed (*Tadarida brasiliensis*, *Myotis yumanensis*, *Lasiurus blossevillii*, and *M. lucifugus*). *T. brasiliensis* (84% of all calls) were found in all parks, while *M. yumanensis* (14.9%) occurred in nine parks. Using linear and generalized linear regression and Akaike information criterion (AIC) models, I compared a priori models to explain activity based on park size, amount of forest edge, distance to the nearest large park, distance to water, and percent of park containing native plants. I used Discriminant Function Analysis (DFA) to model species richness in parks using the same explanatory variables. Results indicate that amount of forest edge and distance to water were the factors best explaining species richness and foraging activity. Park size and distance to the nearest large (> 1 million ha) park were somewhat less important and primarily for *T. brasiliensis.* Activity peaked in September but continued throughout the year. This study shows that bats are present even in densely populated urban centers, although at reduced species richness, and that habitat factors explaining their community composition and activity patterns are similar to those documented in less urbanized environments.

Nightly Dispersal and Foraging Behavior of the Brazilian Free-tailed Bat—Testing Predictions of Refuging Theory

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Refuging theory predicts that individuals of gregarious-roosting animals should disperse daily or nightly to feed at different distances and directions from roosts, depending on energy requirements and the availability of local food resources. To date, analyses of NEXRAD Doppler radar data have shown that Brazilian free-tailed bats (*Tadarida brasiliensis*), in general, disperse nightly from their roosts over highly variable landscapes, and collectively move in the direction of available food resources. Although Doppler radar data can provide valuable insight into the general patterns of nightly dispersal of large Brazilian free-tailed bat colonies, this technology provides no information on the dispersal and foraging behavior of individual bats to test predictions from refuging theory. To evaluate nightly dispersal and foraging behavior of individual bats, we used radiotelemetry and doubly labeled water to test four prediction of refuging theory—namely that distance and direction traveled, and time and energy spent foraging should be highly variable among individuals of a colony. To test these predictions, we captured lactating females and: 1) attached small radiotransmitters to individual bats and, using ground-based telemetry, recorded their daily and nightly time budgets based on presence and absence from their maternity roost; 2) attached radiotransmitters to other individual bats and, using aircraft-based telemetry, recorded their nightly dispersal patterns (direction and distance traveled) and foraging behavior (time spend foraging in a given patch); and 3) measured field metabolic rates of individual bats to estimate daily energy expenditure based on 24-h turnover of doubly labeled water. Our results indicate that distance and direction traveled and nightly time and energy budgets of *T. brasiliensis* were highly variable, supporting predictions from refuging theory.

Facial and Lip Projections: Unique Integumentary Morphology

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Faces of phyllostomid bats have been previously noted to have varied epithelial patterns of projections associated with lips and chins (i.e., warts, verracue, bumps, facial projections, etc.). These projections are also found on bats of other families; this suggests common morphological and functional features that are shared among bats. Facial and lip structures have received some attention from naturalists and have been described as glandular, although distinct morphological and functional investigations are lacking. As a first attempt to characterize lip-associated and chin projections, we describe scanning electron and light microscopic and immunohistochemical studies of epithelial and sub-epithelial structures from various bats, including individuals from Phyllostomidae, Mormoopidae, and Vespertilionidae. Tissues examined were from specimens collected, fixed, and preserved for other purposes but nonetheless were useful in revealing some unique integumentary characteristics heretofore not described in the literature. Histomorphological preparations included techniques for general architecture and nerve tissue. Scanning electron microscopic studies revealed another type of surface structure on the inner surface of lips projecting into the buccal cavity. Histological preparations revealed hairless and glandless integumentary features, scalloped epidermal-dermal junctions with well-defined epidermal pegs and dermal papillae, and abundant epidermal undifferentiated nerve endings. Epidermal pegs near the dermal-epidermal junction contained numerous, presumably mechanosensory, Merkel cells, but the arrangements of nerve endings and cellular contacts need transmission electron microscopic clarification. The lack of muscular and glandular efferently-controlled tissue in the epithelia and undifferentiated nerve endings and Merkel cells in the epidermis suggest mixed sensory functions.

Morphology of the Female External Genitalia in the Mormoopidae

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Previous studies on the structure of the reproductive tracts of bats have neglected the characterization of the external genitalia of females. Based on observations of the apparent enlargement of the external genitalia in female *Mormoops blainvillei*, we undertook a study of detailed description and measurement of histological sections of the structures, along with a comparison to males of the same species, and to other species of bats. The enlarged external genital structure visible in female *M. blainvillei* is roughly conical in shape, compressed cranio-caudally and bears a longitudinal urogenital slit on the caudal surface. It extends approximately 3 mm from the ventral body wall. The structure is sparsely covered in coarse hair and a thin stratified squamous epithelium. As in most cases, the hair follicles are rooted in connective tissue that underlies the stratified squamous epithelium, and are richly supplied with sebaceous glands. Underlying the epithelium is dense, irregular connective tissue forming the bulk of the structure. Deep to this tissue, the vagina and the urethra open into a common urogenital sinus lined with nonkeratinized squamous stratified epithelium. The entire structure contains only small amounts of erectile tissue and, therefore, is best described as a urogenital papilla rather than a clitoris. Sections of the penis of *M. blainvillei* show an essentially identical glandular epithelium and connective tissue overlying erectile tissue. Female and male genitalia of *Pteronotus quadridens* are essentially identical in structure to those of *M. blainvillei*. Genitalia of female fetuses collected along with pregnant females were proportionately larger than those of the adults. Allometric analysis of these structures is ongoing.

Constant Frequency Calls as Determinants of Divergence between Antillean Populations of *Pteronotus parnellii* (Mormoopidae)

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Among New World bats the use of constant frequency-frequency modulated (CF-FM) biosonar calls for Doppler-shift compensation is highly developed in a single, polytypic species. More than simply a behavioral characteristic, the frequency of the CF component of the call is precisely tuned to match the zone in the cochlea that has an exaggerated frequency resolution, the acoustic fovea. As such, this behavior reflects an anatomical and physiological adaptation, and constitutes a character for the evaluation of relatedness of populations. We recorded standard measurements and calls from three populations each of both the Puerto Rican and Hispaniolan subspecies of *Pteronotus parnellii*. Calls were recorded in real time at a sampling rate of 357 kHz from bats restrained in a cage in order to minimize the Doppler-shift induced by movement. We found no significant difference in mean frequency of the CF component of the calls, or body size among the populations on each island. However, we found that the mean frequency of the CF component of Hispaniolan bats was significantly higher (67.65 kHz, n = 25) than those on Puerto Rico (62.28 kHz, n = 17; $p < 0.001$). Furthermore, the mean weight and forearm length of the Hispaniolan population was smaller than those from Puerto Rico. Differences in genetically determined features between the populations of this species on the two islands could be due to phenotypic plasticity, adaptation to the environment, or simply genetic drift from founder populations. Considering the similarity of the islands in latitude and climate and the variety of habitats, there are no obvious ecological explanations for these differences. The higher frequency of the CF component of the Hispaniolan subspecies could be driven by its smaller body size, as has been reported in other bat species. Differences in these characters suggest that the populations have minimal genetic interchange and have diverged from their original founder populations although it remains unclear what factors have driven the divergence.

White Nose Syndrome Related Declines of Hibernating Bat Species in the Northeast
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Numerous references have addressed overall bat declines related to white nose syndrome (WNS), but little attention has been paid to variation in declines among affected species. All six species of hibernating bats in the Northeast (*Myotis lucifugus*, little brown bat; *Myotis sodalis*, Indiana bat; *Myotis leibii*, eastern small-footed bat; *Myotis septentrionalis*, northern long-eared bat*; Perimyotis subflavus*, tri-colored bat; and *Eptesicus fuscus*, big brown bat) have shown evidence of *Geomyces destructans* infection. Although evidence for declines in *M. lucifugus* and *M. sodalis* are compelling, there is considerable variation in the strength of data for other species due to small sample sizes and differences in hibernating behavior. In 20 sites with multiple years of species counts both pre- and post-WNS infection, the cumulative decline has been 92%. Species declines ranged from 49% (*E. fuscus*) to 93% (*M. lucifugus* and *M. septentrionalis*). Variations in declines existed among sites, but are most consistent for *M. lucifugus* and *M. septentrionalis*. While it appears that hibernating temperatures and humidity can account for some of the observed variation, it is not obvious that it can explain all of the differences.

Morphometrics and Plasticity in Echolocation Calls of Little Brown Bats (*Myotis lucifugus*) at the Northern Edge of their Range
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Little brown bats (*Myotis lucifugus*) reach the northern edge of their range in Yukon, Canada. At higher latitudes they encounter short, luminous nights, relative to conspecifics at lower latitudes. *Myotis lucifugus* is often the only bat found in an area, and they face less competition with ecomorphologically similar species with slightly different ecological niches. We were interested in how morphology and echolocation-call characteristics may be influenced by environmental conditions in the North, and the lack of competition with congeners. In 2007 and 2008, echolocation calls were recorded from captured *M. lucifugus* at various locations in western Canada (British Columbia and Yukon), via Anabat and Pettersson D240x detectors. Calls of *M. lucifugus* in the Yukon were found to be of steeper slope and shorter duration than conspecifics further south. Because short duration broadband (steep) calls tend to be most associated with long-eared bats flying among clutter, we examined ear length. We found that Yukon *M. lucifugus* had longer ears than conspecifics in British Columbia; this piece of evidence together with observations of these bats foraging more often in clutter, and less often in the open, supports the observation that little brown bats in the North have evolved echolocation calls best suited for foraging in cluttered habitats, possibly in response to an elevated predation risk associated with high light levels. We also report a south-north cline in forearm length, similar to that found for *M. lucifugus* in the prairies.

Bat Surveys on the Flathead Indian Reservation, Montana
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Prior to this study there was limited information on the bats of the Flathead Indian Reservation. Most records were submitted prior to 1978. Of the 7 species previously identified, all but *Myotis lucifugus* had less than 10 observations. *Eptesicus fuscus* and *Lasiurus cinereus* had each been documented only once and *M. volans* had been observed twice at the same location. During the summer of 2009, we conducted surveys using a grid protocol to establish an even distribution sampling design. Methods included mist netting, and acoustic and roost surveys. These surveys reconfirmed the presence of seven species: *M. lucifugus*, *M. evotis*, *M. volans*, *E. fuscus*, *Lasionycteris noctivagans*, *L. cinereus*, and *Corynorhinus townsendii*. We also documented an additional three species—*M. californicus*, *M. ciliolabrum*, and *M. thysanodes*—and a likely fourth species, *M. yumanensis* (pending genetic results). Species diversity was high at some locations with at least nine species captured at one netting site in a single night of sampling. Of special interest was the large number of net captures of two species of special concern, *C. townsendii* and *M. thysanodes*. The latter is a species rarely documented in Montana with only five records west of the Continental Divide. We captured a total of 21 *C. townsendii* at 10 different locations. Based on pregnant and lactating females we suspect there are at least 4 maternity colonies on the Reservation including one previously documented location. We also captured a total 30 *M. thysanodes* at 10 different locations. A female was fitted with a transmitter and tracked to a grand fir snag. This is a relatively unique sighting as most roost sites for this species are described as rock crevices.

Bats and Fruits: Ecological Association or Mutual Evolution

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A study of the evolutionary history of seed dispersal is important for developing our understanding of the ecological and coevolutionary processes that shape tropical forests. A combination of simple morphological fruit traits was shown to reveal broad character syndromes associated with different groups of consumers, mainly bats, arboreal mammals, and birds. However, the possibility of coevolutionary processes between plants and their dispersers that could contribute to such syndromes is greatly debated and largely untested. We used a data set composed of 871 plant species with fleshy fruits/infructescences from the lowland rainforest in French Guiana, including 306 species in 56 families known to be dispersed by animals, to examine ecological and evolutionary relationships between plant characters, fruit sizes (volumes), and dispersal agents. Two kinds of tests were employed. First, the 'ecological' relationships between categorical traits (life form, fruit type, fruit color, animal disperser) and fruit size were evaluated using ANOVA. Second, the 'evolutionary' approach was used to test whether divergence between closely related taxa with respect to the type of animal disperser is consistently associated with divergence in fruit size. For the latter, we examined phylogenetically independent contrasts using the software program Phylomatic to construct a phylogeny based on sampled species and Phylocom software to analyze patterns of character divergence between closely related taxa. Ecological analyses demonstrated that plant taxa dispersed by arboreal mammals bear larger fruits than closely related taxa dispersed by bats or by birds among berries, drupes, and all species pooled, but not among dehiscent fruits. Also, taxa with brown and yellow berries (colors usually associated with arboreal mammal dispersal) have larger fruits than closely related taxa with green berries (associated with bat dispersal), which, in turn, are larger than species with blue berries (bird dispersal). Among plants with drupaceous fruits, brown drupes (mammal dispersal) were larger than red and blue (bird dispersal) while species with dehiscent fruits did not exhibit significant differences among colors in size. Evolutionary analyses revealed a significant association between fruit size and the type of animal disperser within the majority of life forms, fruit types and fruit colors and among all species pooled. Larger-fruited species tend to be dispersed by arboreal mammals while their closely related smaller-fruited species are dispersed by bats.

Factors Affecting Detection Probabilities of Five Species of Eastern Bats

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Inventory and monitoring programs are critical for assessing the status and distribution of bats and the effects of management activities and other factors on their populations. Because detection probabilities are < 1 for most species, assessment of species' presence requires consideration of detection probabilities and the sources of variation that affect them. The objective of our study was to determine the effects of two factors—sampling duration and habitat type—on the detection probabilities of five bat species using AnabatII acoustic detectors. Thirty sites were sampled from dusk to dawn on three consecutive nights in late June and mid-late July 2008 at two locations in central Kentucky. Four habitat types were sampled at each location: linear/non-water sites (e.g., corridors, edges), linear/water sites (e.g., streams), non-linear/non-water sites (e.g., open fields), and non-linear/water sites (e.g., ponds). We identified calls to species using a discriminant function analysis and determined the probability of detecting each species using Program PRESENCE. Big brown bats (*Eptesicus fuscus*), red bats (*Lasiurus borealis*), hoary bats (*L. cinereus*), little brown bats (*Myotis lucifugus*), and Indiana bats (*M. sodalis*) were the most common species recorded. Although not statistically significant, detection probabilities for all species except hoary bats were lower during the first 5 hours of sampling as compared to full night sampling. Habitat was not an important factor determining big brown bat detection probabilities. In contrast, red bats, hoary bats, and little brown bats had higher detection probabilities at water sites (either linear or non-linear) whereas detection probabilities of Indiana bats were highest in linear/water habitats followed by linear/non-water sites. Our results suggest that the effectiveness of inventory and monitoring studies can be increased by conducting pilot studies to determine the best sites for detecting the species of interest or sampling multiple site types to ensure that all species have a good probability of being detected.

Bat Diversity and Habitat Use on Three Military Installations in Mississippi
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Field studies were conducted on three military installations in Mississippi to determine bat species diversity and distributional patterns and to assess habitat use by selected species. Mist-net and Anabat II surveys were conducted on Camp Shelby and Camp McCain Army National Guard installations in 2004–05 and on Naval Air Station (NAS) Meridian in 2005–06. Additionally, surveys of bats roosting in elongated airstrip culverts were conducted on NAS Meridian during 2005–08. Eight species of bats were documented to occur on Camp Shelby, an ecologically diverse 54,230-ha installation in south-central Mississippi; these included the big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), Seminole bat (*L. seminolus*), hoary bat (*L. cinereus*), evening bat (*Nycticeius humeralis*), eastern pipistrelle (*Perimyotis subflavus*), southeastern myotis (*Myotis austroriparius*), and Rafinesque’s big-eared bat (*Corynorhinus rafinesquii*). These same species were confirmed for NAS Meridian, a 4,035-ha base located in eastern Mississippi. Only four species (eastern red bat, hoary bat, evening bat, eastern pipistrelle) were recorded on Camp McCain, a 5,259- ha facility located in a less diverse region in the north-central part of the state. Mist netting resulted in an average capture rate of 9.26 bats/night on Camp Shelby, 2.42 bats/night on Camp McCain, and 12.2 bats/night on NAS Meridian. Evening bats and eastern red bats were the most common species captured on all installations. Roost surveys included examination of Rafinesque’s big-eared bat roosts in artificial structures on Camp Shelby and monthly surveys of bats roosting in elongated airstrip culvert complexes on NAS Meridian. Southeastern myotis used only the taller culverts (3 units, each 7-m tall x 5-m wide x 180-m long) as maternity roosts, whereas eastern pipistrelles used the shorter culverts (4 units, each 3-m tall x 3-m wide x 250-m long) as winter roosts. The southeastern myotis population increased from a summer high count of 473 in 2005 to 1,706 in 2008. This population is considered significant because it represents the largest maternity colony of this species of special concern in eastern Mississippi. Management recommendations emphasized protection of roosting habitat, primarily for Rafinesque’s big-eared bats on Camp Shelby and southeastern myotis on NAS Meridian. Conversion of pine plantations and improvement of riparian areas was recommended for Camp McCain.

Feasting, Fasting, and Freezing: Energetic Effects of Meal-size and Temperature on Short-term Torpor Use in Little Brown Bats
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In general, torpor use tends to increase when food availability and/or temperature decrease but proximate factors influencing individual differences in torpor expression are still not well understood. Recent feeding may influence an individual’s use of torpor due to the energy available within the meal, but also via the so-called heat increment of feeding (HIF). The HIF is an obligatory increase in heat production during digestion and assimilation of a meal, and some mammals and birds are able to use this heat production to substitute for active thermogenesis, reducing the costs of thermoregulation. The overall objective of this study was to determine how recent feeding and temperature influence between-individual differences in short-term torpor expression by little brown bats. We also tested whether little brown bats use the HIF to substitute for active thermogenesis. Using open-flow respirometry we monitored metabolic rates of nine adult male little brown bats over 22-h periods at both high (17° C) and low (7° C) ambient temperatures. Prior to respirometry trials, bats were either sham fed or fed a small (1.32 ± 0.17 g) or large (0.75 ± 0.11 g) high protein meal. We quantified characteristics of torpor expression and measured the total energy expended over each 22-h trial. Bats’ overall energy expenditure was positively correlated with the amount of energy they assimilated but they spent approximately equal amounts of energy at both high and low temperatures. These findings suggest that little brown bats optimize, rather than maximize, their expression of torpor on a daily basis. We also found evidence that little brown bats use the HIF to substitute for active thermogenesis, and that bats may postpone digestion, possibly to delay the HIF response in order to enter torpor as soon as possible following feeding.

Migratory Behavior in Bats Linked to Their Ability to Track and Exploit Migratory Insect Populations

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Long distance migrations of insects have been documented on every continent where they have been investigated. Billions of insects exploit seasonally available winds in spring and early summer to assist their migration into seasonally productive regions at higher latitudes. In fall, migratory insect populations abruptly reverse this pattern, engaging in return migrations to tropical and subtropical regions on winds associated with autumnal cold fronts. Within these strong seasonal patterns of insect movements and abundances, factors ranging from the impacts of hurricanes to the daily vagaries of local weather impose annual, regional, and local variation on insect availability. Insect scouting data, combined with fecal DNA analysis of the bats' diets, confirm that Brazilian free-tailed bats *Tadarida brasiliensis* track and exploit migratory populations of corn earworm moths (Lepidoptera; Noctuidae; *Helicoverpa zea*) as insect populations fluctuate in space and time. Focusing on the period immediately prior to the bats' fall migration, day-to-day variation in weather and wind patterns is shown to impact insect movements, and their local abundance and availability to the bats. The insect resource base shows dynamic, short-term fluctuations in space and time during this period. Total mass of feces excreted by individual bats increases 4-fold, and body mass can increase at a rate of up to 10% per day during periods of peak insect abundance. The bats' ability to track and exploit this rapidly changing resource base provides the fuel for the seasonal migration of the bats.

Molecular Analysis of Insectivorous Bat Diets

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With bat populations declining worldwide, it is important to understand as much of their biology as possible in order to make appropriate management decisions. Information on bat diets is particularly important, yet this information has proven challenging to obtain. Historically, diets of insectivorous bats have been characterized through the dissection of guano to identify undigested insect remains, but this method is limited by its inability to identify soft-bodied insect prey as well as challenges in identifying insect remains beyond the ordinal or familial level. Molecular genetic techniques can potentially provide considerable insight into bat diets. To test whether insect prey in bat feces can be identified using molecular techniques, we collected guano from captive *Pteronotus parnellii* (mustached bats) given known diets, including moth larvae (waxworms), crickets, beetle larvae (mealworms), and flies. We extracted DNA and used universal genetic primers to amplify and sequence the *cytochrome oxidase I* (COI) region of insect mitochondrial DNA. Phylogenetic analysis of the obtained sequences and those from known insect sequences verified that the expected insect markers could be recovered from guano. We concluded that both soft-bodied prey (insect larvae) as well as hard-bodied prey (crickets, flies) can be identified from guano. These techniques were then used to identify prey species from wild caught *Antrozous pallidus* (pallid bats) and *Myotis ciliolabrum* (western small-footed myotis). We found these bats are foraging primarily upon beetles and flies. Flies identified included *Delia* (Diptera: Anthomyiidae), which are opportunistic pests of numerous crops, and *Simulium* (Diptera: Simuliidae), which are biting flies effecting livestock and humans. In contrast, some beetles identified are often used as biological control agents because they are predators of important crop pests. This includes *Anthicus* and *Notoxus* (Coleoptera: Anthicidae), predators of the pink bollworm, a major cotton crop pest, and *Bembidion* (Coleoptera: Carabaeidae), a predator of many root maggots. This is the first study to show that molecular genetic methods can be used to determine the diets of insectivorous bats. Further use of these techniques will provide a better understanding of the diets of insectivorous bats, which may help in the management of foraging habitat as well as identifying other risks to bats of conservation concern.

Stopover Ecology of Migrating Silver-haired Bats (*Lasionycteris noctivagans*) Using Automated Digital Radiotelemetry

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Little is known of bat migration, and one specific component of migration that is very poorly understood is stopover. Bats that make long-distance migrations must stop and rebuild their nutrient stores, but virtually nothing is known of the ecology and behavior during these periods of stopover. We studied the stopover of silver-haired bats during fall migration at Long Point, Ontario, a recently documented stopover area. Long Point is a peninsula extending from the north shore of Lake Erie. We captured bats near the base of the point and used 0.3 g digital radiotransmitters in conjunction with four automated receiving towers to monitor stopover duration, meso-scale movements, departure time and direction, and roost selection. Three receiving towers on the point and one on the mainland allowed us to record the movement of bats along the point and the shoreline, each tower having an approximate detection radius of 10 km. Tower data were supplemented with daily manual localizations to identify roost sites. We set mist nets from dusk until dawn and captured the majority of the bats in the period leading up to dawn, suggesting that the bats we captured had just arrived in the area after migrating through the night. Preliminary analysis suggests that silver-haired bats generally made short stopovers (1–2 days) with some individuals staying longer. During stopover, bats were not faithful to any particular region on the point. Individuals traveled between all four towers, a linear distance of approximately 40 km. During the day, bats roosted in a variety of locations, some in natural wooded areas and some in residential cottage neighborhoods. Bats roosted primarily in trees, but were also found in man-made structures. On departure, many bats returned to the mainland and departed along the shoreline, while others crossed the lake. The results of this study provide answers to many questions about the ecology and behavior of bats during migration. The results also are important when considering the placement of wind energy facilities along shorelines or for offshore wind.

Highlights of the 2009 Southeastern Bat Diversity Network Bat Blitz in Missouri

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The purpose of the Southeastern Bat Diversity Network (SBDN) Bat Blitz is to provide an intensive survey over an expansive area by combining the effort and expertise of several bat biologists and volunteers. This event has been hosted in several southeastern states in each of the last eight years. This year's Bat Blitz was held 9–13 August 2009 in southeastern Missouri and benefited four public land agencies in a six-county region. This was the first year that so many public lands were covered for the Blitz; valuable data were collected as supplementary information for Mark Twain National Forest (MTNF) and Army Corps of Engineers (ACOE) Lake Wappapello Project Office and initial baseline data for Mingo National Wildlife Refuge (NWR) and Missouri Department of Conservation (MDC). Two endangered species (*Myotis sodalis* and *M. grisescens*) and three state species of concern (*M. austroriparius*, *Lasiurus seminolus* and *Corynorhinus rafinesquii*) were captured during the Blitz. Fifty-five participants from fifteen states, assisted by twenty-five local support staff members, pooled their efforts to make the Bat Blitz a huge success. A total of 35 sites were surveyed, and 620 bats representing 12 species were captured during the Blitz. We used radiotelemetry to locate roost trees for a post-lactating female *M. sodalis* and a building roost for a *C. rafinesquii*. The highpoint of the event was capturing 342 bats (55% of the total captures) from 6 sites at Mingo NWR. Captures at the refuge, where bottomland hardwoods are interspersed with seasonally and permanently flooded forest and open land, were dominated by *Nycticeius humeralis* (215 bats), *Lasiurus borealis* (84 bats), and *Perimyotis subflavus* (35 bats). Tissue and hair samples were collected for molecular genetics and stable isotope analyses. The data collected at the 2009 SBDN Bat Blitz will be used to drive management decisions and build research and monitoring programs for the MTNF, ACOE, Mingo NWR, and MDC.

Assessing the Utility of Genetic Data as a Monitoring Tool: A Case Study of Eastern Red Bats (*Lasiurus borealis*)

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High levels of bat and bird mortalities have been documented at wind energy facilities. Particularly hard-hit among bats are the tree-roosting migratory species, *Lasiurus cinereus*, *L. borealis*, and *Lasionycteris noctivagans*. Traditional demographic methods have proven ineffective for these species because these bats roost in small numbers, fly very high, and are difficult to catch. Thus it is hard to tell what effect these deaths at wind energy facilities are having on population numbers. Genetic data may provide a means of monitoring populations when demographic methods are unsuitable. We used coalescent-based simulations to determine the efficacy of genetic data as a monitoring tool for short-term changes in population size. Simulations were run under demographic models parameterized using mitochondrial DNA sequence data from the eastern red bat, *L. borealis*. DNA sequence data and microsatellite genotypes were simulated in both panmictic and structured populations using the computer program, *ms*. Summary statistics including the number of segregating sites, haplotype diversity, nucleotide diversity, Tajima's *D*, and the number of alleles were used to assess decline in genetic diversity. We found that direct measures of diversity (segregating sites, number of alleles) are much more informative for detecting population declines than neutrality tests. Between the two types of markers, microsatellites provide more power to detect population declines over short timescales. We expect that genetic data will prove a useful metric for monitoring population declines due to wind turbine-associated deaths.

Diet of Two Species of Vampire Bats (*Desmodus rotundus* and *Diphylla ecaudata*) in Northeastern Puebla, Mexico, Using a Non-invasive Technique

Menchaca, Angélica, Rodrigo A. Medellín, and Guillermo Muñoz-Lacy, UNAM

Vampire bats have differential feeding habits, depending on their prey. Since the introductions of cattle and poultry, vampire bats have had a constant and abundant availability of food sources. Some populations, especially those of *Desmodus rotundus*, have increased dramatically and have been considered a pest. The importance of documenting, evaluating, and understanding the specific feeding habits of vampire bats will serve as a powerful tool to help in the prediction of epizootic outbreaks that can occur across broad spatio-temporal scales but are still little, if at all, understood. Traditional methods to identify dietary items, by means of feces content in bats fail when studying the diet of vampire bats, given their hematophagous condition. Alternative methods such as analysis of stomach content are invasive and immune assays are not species specific. An alternative methodology that has been used is to amplify mitochondrial host DNA with the Polymerase Chain Reaction (PCR) technique. No data have been reported about the species-specific blood source in the diet of vampire bats in Mexico. Here we present the species-specific description of the diet of two species of vampire bats by means of the PCR technique. Universal molecular markers were used for PCR amplification of a mitochondrial *cytochrome b* gene region using DNA extracted from bat's feces. The study took place in a disturbed area of northeastern Puebla, Mexico; 96 samples were analyzed (18 of *Diphylla ecaudata* and 78 of *D. rotundus*). Seven possible mammalian hosts were tested, including cow, horse, pig, donkey, goat, sheep, and dog. With the use of this technique we were able to successfully identify the main blood sources in the diet of *D. rotundus* and *D. ecaudata*. This non-invasive technique was successful in amplifying highly degraded DNA and hosts were identified to species level. These results are part of the model being constructed to understand the rabies outbreaks and the role played by different prey species.

An Open-field Personality Test for Bats

Menzies, Allyson K., Mary E. Timonin, Claire McKibbin, Joel W. Jameson, and Craig K. R. Willis, University of Winnipeg, Winnipeg, MB

Animal "personality" or temperament refers to repeatable differences in patterns of behavior exhibited by different individual animals and is often measured in terms of "bold" vs. "shy" or "explorative" vs. "docile." Personality may be linked to within-species variation in behavioral, physiological, and ecological traits. It has been measured using a variety of tests tailored for particular species to quantify particular patterns of behavior (e.g., aggressiveness, curiosity, fear). Animal personality has received considerable recent attention from behavioral ecologists working on a range of taxa (e.g., fish, songbirds, small mammals), but so far there has been little work on personality in bats. We have devised an open-field test to measure exploratory behavior of different individual little brown bats (*Myotis lucifugus*) in a novel environment. The test is based on a protocol originally designed to quantify personality traits of voles and other small mammals but is modified so that bats can climb vertically, as they might on the inside or outside of a roost tree, and so that we can record echolocation calls during the trials. We report preliminary results of experiments testing for within-individual repeatability of particular behavioral traits within individuals. This method could allow us to test hypotheses about the influence of personality on within-species variation in other characteristics such as metabolic rate, life history traits, roosting and foraging behavior, and ultimately, survival and reproductive fitness.

Efficacy of Scent Detection Dogs in Detecting Bat Roosts in Ponderosa Pine Snags

Mering, Elisabeth, Carol Chambers, Christina Vojta, and Alice Chung-MacCoubrey, Northern Arizona University, Flagstaff, AZ; USDA Forest Service, Washington, DC; NPS, Boulder City, NV

Identifying roosts of bats can reduce likelihood of their damage or destruction during forest management operations; however, roosts can be hard to locate. Conservation detection dogs are trained to detect specific odors such as guano at very small concentrations. We tested efficiency of two dog-handler pairs in locating known roosts of bats in ponderosa pine snags. Dogs were trained using a blend of guano from five species of bats. From 28 trials, we tested effects of weather (wind speed, relative humidity, temperature), characteristics of the roost tree (dbh, height), roost (height, number of bats), and dog-handler pair on success in identifying roosts. Dogs located 71% of known roosts and were most successful when roosts had higher numbers of bats or were closer to ground. Dog-handler pairs were equally effective. We also compared success of dogs in finding bags in 1-ha plots with varying quantities of guano (0, 5, or 20 g) and placed at different heights (2 or 6 m). Dogs were more likely to find large (20 g) amounts of guano closer (2 m) to ground (78.6 % of finds) than smaller (5 g) amounts placed higher (6 m; 27.3% correctly identified). Dogs never indicated on empty bags. Scent detection dogs were most effective in detecting roosts in ponderosa pine forests that had large populations of bats (e.g., > 15 individuals) in roosts that were close to the ground (e.g., < 10m). Detection dogs are likely to be most effective in woodlands (e.g., pinyon-juniper) where bats roost close to ground or in locating ground (e.g., hidden cave) roosts.

Bat Activity Increases during Summer in Ponderosa Pine Forests in Northern Arizona

Mering, Elisabeth D., and Carol L. Chambers, Northern Arizona University, Flagstaff, AZ

Capture rates of bats on the Colorado Plateau in Arizona are high during summer but decline sharply after August. We suspected that some bats hibernated in northern Arizona but that others might migrate to lower elevations or more southerly latitudes. We continuously monitored six ponderosa pine forest stands using six Anabat ultrasonic bat detectors for one year, May 2008–2009. Peak activity was in June, July, and August with average call rates (se) of 2.14 (0.42), 4.99 (1.25), and 2.96 (0.83) calls/hr, respectively. Moderate activity occurred in May (0.49 ± 0.34) and September (0.35 ± 0.09). Very low activity levels were recorded in November, February, and March, and no activity in December and January. Activity during winter probably indicates that some species of bats hibernate but occasionally exit hibernacula to drink (e.g., *Eptesicus fuscus*). Additionally, the large changes in rates may also indicate that other bats move into the area during the summer. Protecting and providing habitat for bats that require hibernacula and those that seasonally use the Colorado Plateau is essential for protecting forest bats.

Genetic and Stable Isotope Analysis of a Potentially Novel Colony of *Tadarida brasiliensis mexicana* in West Texas

Miller, Jennifer J.[1], Raymond S. Matlack[2], and Brenda E. Rodgers[1], [1]Texas Tech University, Lubbock, TX; [2]West Texas A&M University, Canyon, TX

The objective of this research is to evaluate the status of a colony of *Tadarida brasiliensis mexicana* (the Brazilian free-tailed bat, also known as the Mexican free-tailed bat) in west Texas. Populations of *Tadarida brasiliensis mexicana* are thought to be migratory in the central and southwest regions of the United States, but a roosting location in west Texas has been observed to have year-round emergences. This behavior is contradictory to the published literature. Both genetic and stable isotope analysis will be employed to determine whether this roost supports a stationary colony or whether it is being used by a number of transient populations throughout the year. If a stationary colony of *Tadarida brasiliensis mexicana* is roosting in west Texas, it may be the first documentation of such behavior.

Bats, Zoonoses, and Emerging Infectious Diseases: Challenges for the Future

Mistry, Shahroukh, Butte College, Oroville, CA

Increasingly, bats are being linked to a growing number of infectious diseases including those associated with Marburg, Ebola, Hendra, Nipah, and SARS viruses. Sixty-six viruses have been isolated or detected in bats and serological evidence exists for even more. As emerging infectious diseases (EIDs) become more prevalent the importance of a greater understanding of wildlife biology underlying susceptibility and transmission becomes an imperative. Increased spillover of zoonotic pathogens from wildlife to humans is enhanced by various factors such as deforestation, climate change, translocation, increased human-wildlife contact, as well as the migration patterns

and population dynamics of animals. Understanding EIDs is crucial not just from the human disease perspective but also for maintaining biological diversity, as many of the animal species that encounter these viruses are themselves susceptible. Loss of diversity not only affects ecosystem function and stability but also has economic ramifications—as the loss of insectivorous bats in the Northeast is likely to have as a result of white nose syndrome. Bats do not represent a group more likely to harbor viruses than any other. Yet, as they come under increasing scrutiny, more research is needed to accurately assess the role of Chiroptera in EIDs. With bats being implicated in at least three of the ten most threatening EIDs (SARS, Ebola/Marburg, and Nipah), the challenges that face bat biologists are numerous but not insurmountable. Indeed, the isolation of a virus or the presence of antibodies does not necessitate that bats are the reservoir responsible for transmission. Yet, without further research we are unlikely to gain answers anytime soon. Unfortunately, policy decisions regarding strategies for dealing with disease outbreaks can often be formulated during a crisis and without much regard to wildlife. Thus a positive proactive approach is necessary that informs policy and preempts unwarranted action. In spite of this need for more emphasis on disease biology, the number of EID-related papers at recent NASBR symposia has been negligible. Even for diseases like rabies, where our knowledge far exceeds others, we have few studies that approach what is known for Lyme disease. Indeed, bats may provide us with an ideal model system with which to study infectious diseases in mammals. As a scientific research society, NASBR needs to focus on identifying EID research priorities, enhancing funding and increasing opportunities for students to gain vital experience, and to forge interdisciplinary collaborations between biologists, virologists, epidemiologists, and economists.

***Mercury Exposure and Immune Responses in the Little Brown Myotis (*Myotis lucifugus*)**

Moore, Marianne S.[1], David Yates[2], Bita Zahedi[1], Pedro B. Ardapple[2], Casey L. Huck[2], Stephen T. Vito[3], John J. Schmerfeld[4], Thomas H. Kunz[1], and David C. Evers[2], [1]Boston University, Boston, MA; [2]BioDiversity Research Institute, Gorham, ME; [3]University of California, Davis, CA; [4]U.S. Fish and Wildlife Service, Gloucester, VA

*** Marianne Moore** received the **Organization for Bat Conservation Award**

Mercury (Hg) is a global contaminant that is introduced into ecosystems through natural mechanisms (e.g., volcanism, erosion) and by human activities (e.g., industrial electrolysis, biocides). It can enter ecosystems through atmospheric or point-source deposition, and is known to impair multiple aspects of physiology, including cardiovascular, neurological, renal, and immune functions. In 2008, we measured concentrations of Hg in the hair and blood of little brown myotis (*Myotis lucifugus*) that foraged over and near the South River in Waynesboro, Virginia, where waterborne discharges of Hg occurred from 1929–1950 and elevated levels persist. We tested the hypothesis that Hg contamination negatively affects immunological functions of these bats. To this end, we compared concentrations of Hg in the blood and hair sampled from bats that were captured while foraging in the contaminated area to those captured in a reference (control) area and correlated the recorded tissue burdens with four measures of immune function: bactericidal ability, response to phytohemagglutinin (PHA) injections, total white blood cell counts, and neutrophil-lymphocyte (N-L) ratios. Mean concentrations of Hg in hair were 77 times higher in bats captured at the contaminated sites compared to the reference site, and mean concentrations of Hg in blood were 66 times higher in bats captured at contaminated sites compared to the reference site. Bactericidal ability varied according to site and season, and response to PHA was associated with site, reproductive stage, and relative body condition (mass/forearm length). However PHA response index and bactericidal ability were not correlated with Hg concentrations in blood or hair. Although total white blood cell counts also did not correlate with Hg tissue concentrations, N-L ratios decreased with increasing blood Hg levels. This later result suggests that the innate immune responses of bats feeding on insects along the South River may be impaired. Specifically, the presence and therefore ability of neutrophils to phagocytize potential pathogens decreases with increasing blood levels of Hg. Results also suggest that further studies are needed to test the effects of Hg on immune function in little brown myotis using techniques targeting different immunological responses.

Immunological Correlates of 'White Nose Syndrome' in Hibernating Little Brown Myotis (*Myotis lucifugus*)

Moore, Marianne S., Jonathan D. Reichard, Timothy D. Murtha, Bita Zahedi, Renee M. Fallier, Neda A. Mofrad, and Thomas H. Kunz, Boston University, Boston, MA

White nose syndrome (WNS) is one of the most devastating conditions ever reported for bats in North America—with losses exceeding 90% in some hibernacula during the winter of 2007–2008 and 95% during the winter of 2008–2009. As part of an investigation assessing levels of immunocompetence in affected and unaffected hibernating little brown myotis (*Myotis lucifugus*), we measured: 1) complement protein activity using bactericidal and fungicidal assays; 2) total and differential white blood cell counts using blood smears; 3) levels of the inflammatory marker C-reactive protein; 4) total circulating antibody levels; and 5) cytokines associated with inflammatory/anti-inflammatory mechanisms and T-cell mediated immunity. From known affected sites, we compared bats with visible signs of the syndrome to those without. We also compared asymptomatic and symptomatic bats from affected sites to bats from presumably unaffected, or control sites. Finally, we compared immune responses of bats with different internal body temperatures, or stages of arousal, to test the hypothesis that bats must arouse from torpor to mount effective immune responses against invading pathogens. Preliminary results from the winter of 2007–2008 and additional results from the winter of 2008–2009 suggest that, on average, bats from affected sites have greater complement protein activity compared to bats from unaffected sites. This may be related to the observation that bats hibernating in affected sites arouse from torpor more frequently, which could result in elevated immune responses, or due to up-regulated immune function in response to pathogen exposure. Comparing bats from affected sites only, individuals exhibiting fungal growth demonstrated significantly less ability to kill bacteria compared to asymptomatic individuals. Additionally, our results demonstrate that complement protein activity in *M. lucifugus* increases with body temperature as individuals arouse from torpor and decreases with body mass index (mass/forearm length), an estimate of fat reserves. Our results from various immunological assays are being analyzed to test if bats affected with WNS are immunocompromised and to identify whether alterations in immune responses are due to an infectious pathogen, physiological constraints associated with torpor, or other extrinsic or intrinsic factors.

Gaining a Bat's Perspective on Echolocation: Recording Ultrasound Calls and their Resulting Echoes *in situ* from Flying Bats

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Although the ability of insectivorous bats to navigate and hunt using echolocation is impressive and has been the subject of numerous investigations, the amount of information that bats may perceive with ultrasound is poorly understood. Current hypotheses about how bats echolocate, such as determining speed, direction, size, and fine structure of targets, are generally based on acoustic theory. However, these hypotheses are difficult to test empirically because most studies of echolocation have been conducted using recordings from stationary, ground-based microphones. To overcome this problem, we developed instrumentation to record ultrasound calls and their resulting echoes *in situ* from flying big brown bats (*Eptesicus fuscus*). The device is tethered to a zip-line, affixed to a bat with surgical cement, and transmits audio data during flight to a ground-based radio receiver. Tests using initial monaural versions of the device resulted in recordings of bat calls, echoes from background vegetation, artificial targets and presumed prey, and apparent responses by bats to the arrival of other echolocating bats. Preliminary results comparing bat-based recordings with those from ground-based instruments will be presented, as well as plans for experiments with binaural versions of the device. This work is supported by a National Science Foundation grant (IDBR 0754788).

Computer Modeling of the Acoustic Effects of Bat Noseleaves and Ears

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Bats often have elaborate morphological structures that surround the sites of ultrasound emission (e.g., nostrils) and reception (ear canals). Examples are the noseleaves of nasal emitters and the intricate outer ear shapes in a large number of species. Emitted and received ultrasonic waves are diffracted by these structures, which may have functional relevance in shaping the spatial distributions of emitted sound energy and receiver sensitivity. Such potential functional consequences as well as the physical mechanisms that cause them can be investigated using computer methods. This approach has four key merits: efficiency, resolution, malleability, and physical transparency. The efficiency results from the (semi)automatic nature of computer analysis and allows the evaluation of larger sample numbers than would be possible with physical experiments at the same level of effort. One way to take advantage of the efficiency is to produce estimates with a high spatial (or frequency) resolution. Malleability means that the digital models used to represent the biological shapes can be easily modified to investigate the role of local or global morphological features experimentally. Physical transparency is a consequence of the numerical models' capability to provide dense estimates of the acoustic near-field. Such estimates can uncover the causes for any acoustic property of the noseleaves and ears, because these causes must be located in the areas where sound waves and surface geometry interact. The input data for the numerical predictions are digital models of surface geometry of the biological structures. Such models can be obtained with sufficiently high resolution using micro computer tomography. Dense estimates of the acoustic near-field can be obtained using a finite-element approach. The shape of ultrasonic emission and sensitivity beams at a distance (far-field) can be derived from these estimates using a projection technique that capitalizes on the simple behavior of sound waves under free-field conditions. Individual numerical case studies have uncovered physical mechanisms used by bats such as resonance in half-open cavities, shadowing gnomons, ridge diffraction, as well as interactions between effects such as shadowing and resonance. A pattern frequently seen in the directional sensitivity of bat ears are frequency-swept sidelobes, i.e., secondary sensitivity peaks that change the direction in which they are pointed with frequency. These patterns may be interpreted as adaptations for precise sound source localization.

Impact of Common Vampire-Bat (*Desmodus rotundus*) on Cattle in Puebla, Mexico
Muñoz-Lacy, L. Guillermo, Rodrigo A. Medellín, Angélica Menchaca, and Oscar Rico, UNAM

Vampire bats represent a serious and only partially understood problem in the Neotropics. The continuous cattle expansion in tropical areas has promoted vampire bat population growth, and their habits and occasional rabies outbreaks affect the economy of the poorest, more remote areas of Mexico and Latin America. We determined the actual vampire bat impact on a highly productive cattle ranch in Hueytamalco Puebla, Mexico. We checked an average of 390 cattle heads of 6 breeds every 45 days (August 2007–September 2008) to document vampire bat attack selection on breeds, age category, bite location, number of bites per animal, and percentage of cattle affected. Additionally, nearly 180 bat brains of several species were extracted and analyzed by Immunofluorescent Antibody Test (FAT), and an antibody detection test (ELISA) was applied to specifically detect rabies G-protein antibodies. The potential economical effects of rabies outbreaks in cattle production systems were estimated on the basis of cattle losses reported and the value per head depending on the production system. Less than 10% of the cattle heads were found bitten, and it showed an increase along the year. Holstein breed and young individuals were preferentially bitten. The mean number of bites per bitten individual is 1.4. Preferred bite locations are neck and ears. All analyzed bat samples were negative by FAT, but the majority of samples were positive for rabies G-protein antibodies, which were present in most tested species. Estimated potential loses reach several tens of thousands of dollars. These results are crucial to evaluate and understand the real social impact of vampire-mediated rabies, and are part of a predictive model for rabies outbreaks in rural, livestock-dominated Mexico.

The Aversive Effect of Electromagnetic Radiation on Foraging Bats—A Possible Means of Discouraging Bats from Approaching Wind Turbines
Nicholls, Barry, and Paul A. Racey, University of Aberdeen, Aberdeen, United Kingdom

Large numbers of bats are killed by collisions with wind turbines and there is at present no accepted method of reducing or preventing this mortality. Following our demonstration that bat activity is reduced in the vicinity of large air traffic control and weather radars, we tested the hypothesis that an electromagnetic signal from a small portable radar can act as a deterrent to foraging bats. From June to September 2007 bat activity was compared at 20 foraging sites in northeast Scotland during experimental trials (radar switched on) and control trials (no radar signal). Starting 45 minutes after sunset, bat activity was recorded for a period of 30 minutes during each trial and the order of trials were alternated between nights. From July to September 2008 aerial insects at 16 of these sites were sampled using two miniature light-suction traps. At each site one of the traps was exposed to a radar signal and the other functioned as a control. Bat activity and foraging effort per unit time were significantly reduced during experimental trials when the radar antenna was fixed to produce a unidirectional signal, therefore maximizing exposure of foraging bats to the radar beam. However, although bat activity was significantly reduced during such trials, the radar had no significant effect on the abundance of insects captured by the traps.

Preliminary Investigation into Habitat Selection of Northern Myotis in Louisiana
Nixon, Bridget, and Paul Leberg, University of Louisiana at Lafayette, LA

The northern myotis (*Myotis septentrionalis*) was first observed in Louisiana in 2000, marking either a southern expansion of the species' range or a previously undetected population. While this population is known to use bridges as summer roosts, it is unknown how these bridges are selected and if any additional roosts are used. Additionally, it is unclear how many individuals may be in this population. Our work involves bridge surveys to locate the northern myotis and evaluate other species using these habitats. When discovered, northern myotis are evaluated, banded, and fixed with a radiotransmitter. Biopsy punches are also taken for future genetic analysis. During this project, I have so far discovered five individuals underneath four bridges and observed their use of six trees as additional roosts.

Future work will consist of comparisons of habitat characteristics between known roost sites and bridges that the species does not appear to be using. This work should add to our understanding of the ecology of what appears to be Louisiana's newest mammal.

A Comparison of Summer Torpor Expression between Overwinter Hibernators (*Myotis lucifugus*) and Migratory Bats (*Lasionycteris noctivagans*)
Norquay, Kaleigh, and Craig K. R. Willis, University of Winnipeg, Winnipeg, MB

Torpor expression during summer can result in significant energy savings for temperate mammals but is associated with costs, including reduced milk production and slowed juvenile growth. In bats, species that hibernate during winter are predicted to use torpor less frequently during summer than species that migrate because hibernators face strong selection pressure for their young to grow as quickly as possible before winter. We tested this hypothesis using temperature radiotelemetry to track little brown bats (*Myotis lucifugus*; a hibernator) and silver-haired bats (*Lasionycteris noctivagans*; a migratory species) and record skin temperatures (T_{sk}). The influence of meteorological variables other than air temperature on torpor expression is also not well understood so we measured weather variables, including ambient temperature, barometric pressure, and wind speed while recording T_{sk}. We found no significant difference in minimum T_{sk} (a reflection of depth of torpor) between species, possibly due to a small sample size. There was a significant effect of daily minimum air temperature on minimum T_{sk}, and for post-lactating *M. lucifugus* there was a significant effect of average daily barometric pressure. Interestingly, the T_{sk} recorded immediately prior to dusk departure was significantly lower for *M. lucifugus* than for *L. noctivagans*. T_{sk} at emergence was also affected by wind speed.

Determinants of Population Genetic Structure in Bats
Olival, Kevin J., Wildlife Trust, New York, NY

Studies of population genetic structure are fundamental to evolutionary biology and our knowledge of the speciation process in mammals. Population genetic structure is critical to understand connectivity and dispersal in species, and even correlates with viral richness in bat species. However, our understanding of how different life-history traits, ecologies, behaviors, and morphologies shape population structure among related species is lacking, as most published studies are taxon-specific. Here I use a comparative, meta-analysis approach to examine patterns and potential determinants of population genetic structure for 60 species (9 families) in the order Chiroptera. I use a common statistical measure of population genetic subdivision, F_{ST}, to test against morphological, ecological, and behavioral variables for each bat species. In bivariate analyses, wing aspect ratio—a measure of wing shape relating to flight efficiency—was the most significant variable correlated with F_{ST} measured from mitochondrial DNA across all taxa, explaining up to 36% of total variation (r^2). This relationship remained significant in analyses controlling for phylogeny, and supports the hypothesis that long narrow wings, more efficient for long-distance dispersal, will facilitate increased gene flow between bat populations. In addition, categorical variables related to a species' food resource, roost type, geographic distribution, seasonal migration, mating system, and IUCN threatened status were included and tested using a general linear model and controls for phylogenetic dependence. A multivariate model that includes wing aspect ratio, harem mating, colony size, and food resource was the best fit and explained up to 75% of variance in mtDNA F_{ST}. Results from this comparative analysis significantly expand our understanding of how life-history traits and a species' ecology may determine population genetic structure mammals, and specifically may allow us to predict levels of population subdivision in the majority of bat species not yet examined with genetic tools.

Roosting Behavior of Little Brown Bat (*Myotis lucifugus*) Maternity Colonies in Forests
Olson, Cory R., University of Calgary, Calgary, AB

Although the gregarious nature of little brown bats (*Myotis lucifugus*) is well documented, the behavior of maternity colonies that occupy ephemeral roosts—such as tree cavities—is poorly understood. Assemblages of bats occupying individual roost trees may be short lived and frequently change in both size and composition. Consequently, studies that have examined individual bats or roost trees may provide limited information for understanding the behavior of entire colonies. If fission-fusion dynamics are present, colonies of little brown bats may consist of stable social units even when individual roosting subgroups are in continual flux. From 27 June to 15 August 2009, I used radiotelemetry to track 30 individuals from two colonies of little brown bats occupying boreal forest habitat in northern Alberta, to better understand the roosting behavior of whole bat colonies. I present preliminary data on 1) roosting associations of bats within these colonies, 2) home range sizes, and 3) patterns of roost use within colony roosting home-ranges. The roosting home-range area of these two colonies differed considerably. Preliminary analysis indicates that fission-fusion type roosting behavior was present in both, although important sub-structuring among colony members may be present that could explain observed differences in roosting area between the two colonies. Bats roosted exclusively in trees, switched roosts frequently, and used a variety of roosts throughout the summer, but, unexpectedly, some roost cavities were reused frequently during the tracking period.

The Importance of Water Developments to Sonoran Bats

Orr, Teri J.[1], Theresa C. Hyde[2], and Blair O. Wolf[2], [1]University of California, Riverside, Riverside, CA; [2]University of New Mexico, Albuquerque, NM

The importance of water to vertebrates in desert regions is intuitive, but in many cases remains to be fully quantified, particularly in the context of percent of water intake from a known water source. In cases where bats from a single guild co-occur but have differing water concentrating abilities we might expect their utilization of freestanding water to vary in accordance with these known physiologies. However, in extreme settings these physiological differences may be masked by the overall scarcity of a particular resource, such as water. We were interested in determining the relative contribution of known sources of water to total body water of the members of a Sonoran bat community. Furthermore, we wished to examine how reproductive state might impact water utilization. Specifically, we predicted that water use would be higher in pregnant females than non-pregnant females, and the highest overall in lactating females, but that it would not differ between non-reproductive females and non-reproductive males, nor between males of different reproductive stages. To assess these predictions, we netted the Sonoran desert bat community at water developments at the Kofa Wilderness Refuge in southwestern Arizona for three summers (2007, 2008, and 2009). By labeling water sources with known concentrations of stable isotopes of hydrogen (deuterium) we assessed the percent of isotopes in the plasma of bats captured at watering holes. An average of 12% of total body water was derived from labeled sources of water. Given a known insectivorous diet that constitutes a food source between 60–80% water, their large usage of water developments is likely due to the abiotic environmental extremes these bats endure. Interesting water use patterns were noticed in females from different reproductive stages. By directly quantifying the use of supplemented water sources by the Sonoran bat community we can determine the effectiveness of current wildlife management.

Guild Structure of the Insectivorous Bats from the Yucatán Península, Mexico

Ortiz-Ramirez, David, Fabricio Villalobos, and H. T. Arita, UNAM, Morelia, Mexico

Several works revealed the complexity of guild structure in varied groups of vertebrates. Bats are not the exception—there is evidence of regular segregation of species among guilds. However, there are some communities in which the guilds are randomly constructed. Our work focused on the guild structure among 12 species of aerial insectivorous bats belonging to the families Natalidae, Emballonuridae, Mormoopidae, Vespertilionidae, and Molossidae, distributed in the northwestern Mexican state of Yucatan. We sampled seven localities based on previous observations and literature. The sites were selected and classified based on structure of vegetation and presence of water ponds. We used mist nets and ultrasonic detectors to assess the bat diversity and morphological traits used in the analysis. The guilds were constructed according to wing morphology, echolocation frequencies, and diet. We used principal component and cluster analysis. The relative importance of each variable used in the classification of species in each guild was estimated using Euclidean distance matrixes, and they were examined with a Mantel test. In this study echolocation (76%) and wing morphology (74%) accounted for more of and defined the guild structure, followed by diet. The results from this study agreed with current taxonomic classification and phylogeny of the group.

Factors Affecting the Distribution and Roost-site Selection of Bats on the Island of Newfoundland

Park, Allysia C., and Hugh Broders, Saint Mary’s University, Halifax, NS

Studies of bat ecology at the northern edge of their distribution provide an opportunity to explore their biology under unique conditions, which is not possible from areas where most studies occur. Although knowledge of roosting and foraging ecology of temperate bats has increased, little is known about factors influencing their distribution. The goal of this project is to characterize distributional-limiting factors of Newfoundland bats by species and gender. In 2008 we documented the occurrence of little brown (*Myotis lucifugus*) and northern long-eared (*Myotis septentrionalis*) bats throughout much of the island. We found that northern long-eared bats are further east and north on the island than previously documented but are not ubiquitous. This past summer (2009), we conducted a more intensive study on the northern peninsula of the island to characterize roost-site selection of female, forest dwelling northern long-eared bats using radiotelemetry. Because of differences in local forest characteristics and weather conditions we expected that behavior (torpor use) and resource selection might also be different in this study area from results of studies conducted in parts of the species distribution that are more central.

***Social Networks of Female Northern Long-eared Bats (*Myotis septentrionalis*) Vary with Reproductive Period and Age**

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*** Patriquin, Krista** received the ***Bat Research News*** **Award**

Social structure is a function of the frequency, temporal pattern, and nature of interactions among group members. The likelihood that two individuals will interact or associate is strongly influenced by similarities or differences in sex, age, reproductive condition, and genetic relatedness, which in turn influence social structure. However, the influence of individual characteristics on bat social structure has, until recently, received little attention. The purpose of our study was to explore how associations of female northern long-eared bats (*Myotis septentrionalis*; MYSE) in summer roosts varied with reproductive condition and age. Also, because temperate bats spend prolonged periods in hibernation, away from summer roosts, we tested whether females prefer to roost with the same individuals across years. We obtained measures of association (half-weight index; HWI) among females by radio-tracking and PIT-tagging individuals in Dollar Lake Provincial Park, Nova Scotia. Using network analyses, we determined that preferred associations and social networks varied with reproductive period and age. Females roosted in smaller groups and roosted more often with the same individuals during gestation than lactation. Females of all age classes roosted more often with younger individuals, which in turn had more direct and indirect associations than all other age classes. Temporal analyses suggest that, despite dispersal to hibernacula at the end of each summer, relationships may persist for years as some individuals roosted with the same females for multiple summers. Therefore, female northern long-eared bats form long-term relationships, and social networks vary with reproductive period and age, which could have implications for information transfer and cooperation.

Multivariate Morphological Analysis of Niche Partitioning among Costa Rican Bats

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Numerous studies have suggested that competition is greater among members of an ensemble than it is between members of different ensembles but this has rarely been empirically tested. Competition and resource partitioning are typically most pronounced for food resources. The feeding niche can be approximated from a morphological perspective by measuring features relevant to foraging abilities, thereby enabling visualization of how animals in a community partition multivariate niche space. In this study, we evaluated feeding niches of Costa Rican bats using multivariate statistical analyses of 82 cranial and skeletal measurements. Measurements were taken with digital calipers from skins and skulls of 875 specimens representing 111 species. Data were analyzed using principal component analysis to visualize niche partitioning and assess niche breadth and overlap within and between feeding ensembles. We predicted that there would be little morphological overlap among species and that all multivariate morphological space would be optimally occupied; that is, maximal utilization of morphological multivariate niche space would lead to little or no overlap among species. We found that the data support our predictions. These ecomorphological data suggest that bats divide niche space in an extremely fine-grained manner, presumably as a consequence of extensive interactions at the community level.

Reconstruction of the Rhinolophid Vocal Tract

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Approximately one-third of extant Microchiroptera emit their echolocative calls through their nose. The evolution of this complex morphological innovation required a substantial redesign of the microchiropteran head, literally reinventing much of the rostrum. Several of these modifications supercede the mechanical demands imposed on the skull by other cranio-dental adaptations (e.g., durophagy). Arguably, the rostrum and vocal tract of *Rhinolophus* are the most extensively modified examples of this nasal emitting innovation within the Order. Sound is produced according to a source-filter theory—sound is produced in the larynx and filter characteristics of the sub- and supraglottal vocal tract shape the source signal. Previously, source and filter were modeled as if they were linearly coupled. Those linear models of the supraglottal vocal tract in rhinolophoids suggested that the differential developmental dynamics of the mid-face directly affected fixed cavity resonances thereby imposing restrictions on what sound levels and frequency profiles are permitted by the supraglottal vocal tract in different rhinolophoids. Recently, we reopened this line of inquiry readdressing the physics of the enormous sound levels produced by some species. The airways of several *Rhinolophus* were reconstructed by microcomputer tomography in order to quantify vocal tract dimensions. We evaluate the resonant mechanics of this complicated system and test linear and nonlinear numerical models of the sub- and supraglottal vocal tract. Our goal is to simulate a signal with realistic acoustic output power and efficiency. Preliminary data indicate that linear transfer functions are insufficient to explain the functioning of this sophisticated acoustic device.

The Malaria Parasites of Bats

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Malaria parasites currently encompassing six different genera within the family Haemosporida have been described from bats. Little is known about the effects that these parasites have on their hosts, or in many cases, even what dipteran insects serve as vectors or what the evolutionary relationships of the bat parasites are to other malaria parasites. The taxonomic distinctions and generic breakdowns have all been based on morphological characteristics and few samples exist that can be used for molecular systematic work. Recent studies based on DNA sequence data have suggested that *Hepatocystis* is a paraphyletic genus that is contained within *Plasmodium*. Here, I will present new results from screening chiropterans from both Africa and Asia using both microscopy and molecular methods. Molecular systematic data and morphological characters suggest that the malaria parasites that were observed fall into two groups. The majority of parasites seen in both African and Asian bats were closely related to other "*Hepatocystis*" species. However, three individuals of *Lissonycteris angolensis* collected in Guinea harbored parasites that were closely related to rodent malaria parasites in the genus *Plasmodium* that naturally infect thicket rats in the region. These results combined with other data uniting rodent malaria parasites with the virulent human pathogen, *Plasmodium falciparum*, suggest that bat malaria may possibly be another example of a zoonotic disease and highlights the critical importance of conducting more research on the bat malaria parasites.

Winter Roosting Ecology of Silver-haired Bats in an Arkansas Forest

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Although summer roosting by *Lasionycteris noctivagans* (silver-haired bats) has been studied in various ecological regions of North America, no quantitative studies have examined winter roost selection. We radio-tracked 11 bats to 31 roosts during winter in forests of the Ouachita Mountains, Arkansas. We quantified roost structures and examined habitat associations of roosts. We also examined effects of temperature on use of roosts. Ninety percent of roosts were in trees (5 species) and 55% of all roosts were under loose bark on the bole of live overstory shortleaf pines (*Pinus echinata*), 3% of roosts were in a rock outcrop, and 6% were at ground level (under a tree roost or in a cavity at the base of a live pine). Bats preferred roosting in pine or pine-hardwoods stands > 50 years old, including stands that had been recently thinned and burned; they avoided forest stands 15–50 years of age. Roost locations were influenced by temperature; most (90%) roosts were on southern aspects and bats roosted in the rock outcrop or on the ground on the coldest days. Retaining open pine and hardwood stands > 50 years old on south slopes would likely maintain roosting habitat for wintering silver-haired bats in the Ouachita Mountains.

New Method for Quantifying Physical Clutter in Forest Edges

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Bat ecology has long searched for a simple method of quantifying physical clutter. Most researchers use qualitative visual estimations of canopy closure or clutter levels in addition to other forestry metrics (diameter at breast height, DBH; stem densities; etc.). We present a method for quantifying and visualizing vegetation structure in forest edges and canopies using a canopy analysis device, and relate that structure to bat activity levels. Bat activity was sampled in 12 different locations in the mixed aspen-fir alpine forest of north-central Utah over several weeks using Anabat SD1 bat detectors. Vegetation was sampled in the same 12 locations using an LAI-2000 canopy analysis device. We created visualizations of the subsequent vegetation profiles and evaluated correlations between these and local bat activity. We anticipate that the results of this investigation will provide researchers and management agencies with the tools to do more specific research on the relationship between bat ecology and habitat structure.

Significance of Karst Formations to Bat Conservation in Peninsular Malaysia

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Limestone outcrop formations, known as karsts, are sources of high species diversity and endemism. Solution caves formed within karsts are of inherent importance to bat conservation, providing secure shelter from adverse weather and predators, and for roosting and rearing young. It is well known that Old World fruit bats provide numerous economic services, particularly as primary pollinators and seed dispersers for hundreds of plants used to produce numerous economically valuable products. Similarly, insectivorous bats provide ecological services as agents of pest control, ultimately reducing the destruction of agricultural crops by pest species. Unfortunately, anthropogenic disturbances at caves, particularly commercial quarrying, imperil many of these biodiversity arks resulting in the decline of cave-dependent bat species. Our objective is to document the diversity of bat species within limestone caves of Peninsular Malaysia in order to identify priority caves to target conservation efforts. With approximately 50 cave-dependent bat species, Malaysia is a biodiversity hotspot within Southeast Asia. Employing standard trapping methods, coupled with acoustic monitoring methods, will provide insight into the relative importance of particular caves in maintaining viable populations of cave-dependent bat species. Surveys conducted during June–August 2009 at a karst formation, Kota Gelanggi, in central Peninsular Malaysia resulted in capturing 21 species—4 species of Old World fruit bats and 17 insectivorous species—at 6 caves within this single karst. A total of 19 species were captured utilizing standard trapping methods (i.e., harp traps, mist nets, and hand nets) and 7 species were identified using acoustic monitoring methods (an additional 9 species were recorded but could not be identified). Methods to measure microclimate variables and cave morphometrics were tested at each surveyed cave. Future plans include comparing geo-referenced cave locations to landscape-level variables, such as dominant vegetation cover, land use, and distance-to-nearest karst, to estimate the relative amount of anthropogenic disturbance caused by quarrying operations and commercial logging. Additionally, social surveys will be conducted to gauge the local residents' attitudes and knowledge of bat diversity, as well as their direct use of caves. Ultimately, our goal is to use such information to devise management plans that will provide protection for cave-roosting bats and develop community education programs, while taking into account the scientific, cultural, and economic values of these caves for local communities.

Genetic Study of *Desmodus rotundus* in an Area of High Incidence of Bat Rabies in Cattle, San Luis Potosí State, Mexico: Meta-population Dynamics, Expansion, and Movement of Rabies

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The common vampire bat *Desmodus rotundus* feeds on mammalian blood and creates significant economic impacts through transmission of rabies to livestock. In a multi-year study we have investigated population dynamics of *D. rotundus* using mitochondrial DNA (mtDNA) sequences and 12 microsatellites. In Mexico field studies have revealed that *D. rotundus* populations may be expanding. Evidence of population expansion from DNA is critical for providing confirmation. If populations are expanding, vampire bat rabies outbreaks could occur in areas not previously considered at risk, including across the U.S. border. Further, we wished to test for meta-population dynamics among vampire bat populations as a process that allows rabies, a fatal disease in bats, to be maintained among vampire bat populations. To test for meta-population dynamics and population expansion we have used samples collected from the states of San Luis Potosi and Tamaulipas, Mexico, where an outbreak of vampire bat rabies in livestock has occurred. The results of this study contribute to our knowledge of *D. rotundus* population movements and allow us to infer how these bats move rabies virus across the landscape.

Bats and the Origin of Chagas Disease

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Bats have been involved in the emergence and re-emergence of several human pathogens (e.g., SARS, monkey pox, rabies). However, little attention has been paid to the role that bats have played in the evolution of major established human pathogens. Here, using published phylogenies and biogeographic patterns of mammals and their trypanosomes, I propose a scenario whereby bats are key players in the origin of *Trypanosoma cruzi*, the causal agent of Chagas disease. The five known closest relatives of *T. cruzi* are exclusive parasites of bats; two are restricted to the Old World (*T. dionisii*, and *T. dionisii breve*) and the other three are present only in the New World (*T. cruzi marinkellei*, *T. hedricki*, and *T. myoti*). Several bat genera have been found infected in the Old World: *Eptesicus*, *Myotis*, *Nyctalus*, and *Pipistrellus*. In the New World, *Artibeus*, *Carollia*, *Eptesicus*, *Myotis*, and *Phyllostomus* are among the several infected genera. The phylogenies show that the Old World trypanosomes are older than the New World taxa, implying a colonization of the Americas by Old World taxa, perhaps carried by members of the Vespertilionidae family about 10–14 million years ago. Once an ancestral bat trypanosome was established in the Americas, a subsequent host switch to non-flying mammals (e.g., *Didelphis*) would have resulted in the origin of *T. cruzi*. This idea is contra to a previous hypothesis suggesting an ancient origin of *T. cruzi* in Gondwanaland and a subsequent bat trypanosome invasion to Laurasia.

Timing of Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) Echolocation Activity by Season on Windward Hawaii Island

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The endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) annually migrates from the windward slopes of Mauna Kea volcano to forested lowlands along the Hamakua coastline. Past visual and aural surveys have documented high bat abundance at lower elevations during the summer and fall seasons, with a shift of bat occurrence to higher elevations during the winter. This upland movement, possibly coupled to opportunistic torpor, may be used as a means to conserve energy and avoid wet lowland weather when foraging for aerial prey is difficult. We investigated the seasonal nature of bat activity in both summer and wintering foraging areas over a 2.5-year period. Bat activity was monitored using automated ultrasound detectors along transects at a major wintering area (Hakalau Forest National Wildlife Refuge), an important summer breeding ground (Laupahoehoe Natural Area Reserve), and a high elevation fall site (Mauna Kea State Park). We examined the timing and patterns of nightly echolocation activity by season to determine relationships to roost proximity and movement. We found seasonal changes in presence and activity patterns consistent with the theory that Hawaiian bats make several migratory movements during a year. From spring to summer, bats moved from high elevation areas, down into lowland forests. Bats began to disappear from the lowland site in late fall, dispersing back up to higher elevations. During winter, bats concentrated activity in eastern highland forests. Timing of emergence and foraging activity was found to be highly variable over individual nights. Both nightly and seasonal patterns are likely driven by bat reproductive needs and influenced by weather variables and food availability.

Bats in the Attic: Roost under Construction

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Anthropogenic pressures have affected the distributions of species. Most bats in Canada historically used foliage or more commonly tree cavities, both created naturally or by other species, as shelter during the summer months for rearing young. Now several species, including the little brown bat (*Myotis lucifugus*) and the big brown bat (*Eptesicus fuscus*) frequently make use of buildings. These roosts provide the relatively stable microclimates needed by these species and may provide better protection from predators and inclement weather. Usually bats are simply found clustered on the rafters in attics, under the eaves, or within the walls. However, recently a maternity colony of little brown bats was identified that appear to have modified the fiberglass insulation within an attic by tunneling into it and creating multiple entrance and exit points. The colony only appeared to use the insulation early in the summer when it was cool in the attic (< ~80˚ F) and when caring for non-volant juveniles. As the summer progressed and temperatures increased the insulation was not used. It is not known if the insulation is further used as a hibernation site due to the apparent lack of major hibernacula in Saskatchewan, Canada. This is the first known observation of a temperate bat species in Canada actively creating a roost site from a non-naturally occurring substrate.

Seasonal and Spatial Variation in Montane Meadow Bat Acoustic Activity

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Although bats comprise a substantial fraction of mammalian diversity in montane parklands in western North America, widespread efforts to inventory bat species and monitor their populations have only recently begun. Consequently managers lack the historical records that have allowed detection of long-term range and abundance alterations of other mammals and birds against a background of landscape and climate change. Consistent orientation and prey detection vocalizations provide signals that can be used for activity monitoring, even though both bats and their largely airborne insect prey are highly mobile, often showing short term activity variation. To assess variation in bat acoustic activity and evaluate the consequences for design of long-term monitoring, we deployed twelve solar-powered frequency-division bat monitors sequentially in three configurations in Yosemite National Park: clusters of three monitors in four meadows (235 nights, November 2006–July 2007, 1200–1800 m), one monitor per meadow on an elevation gradient (110 nights, July 2007–October, 2008, 1200–2700 m), and two monitors at center and edge in six meadows (236 nights, March–November 2009, 1200–1400m). Analyses of minutes per night of acoustic activity for twelve species or multi-species categories show significant differences among meadows at similar elevation during the spring to summer seasonal activity increase for some, more activity and slower decline in activity in autumn at low or moderate elevation relative to higher, colder sites, and seasonally varying center vs. edge differences in activity. Based on the mean nightly activity in the pooled center-edge data, the minimum detectable change in activity from year to year with 2000 detector nights of sampling ranges from 17% for common species (e.g., *Eumops perotis*) to 30% for those infrequently detected (e.g., *Myotis thysanodes*).

Isolation of Microsatellite Loci from the Lesser Long-nosed Bat (*Leptonycteris yerbabuenae*) and Population Structure in Arizona

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The lesser long-nosed bat (*Leptonycteris yerbabuenae*) is a nectarivore that migrates up to 1500 km between wintering and breeding grounds. Females mate in southern Mexico, and migrate to maternity roosts in northern Mexico and southern Arizona to give birth. We isolated microsatellite enriched DNA and obtained 96 clone sequences, 46 of which had microsatellite repeats. We designed primers for 40 of the sequences and obtained 10 polymorphic microsatellite DNA markers. Microsatellites can be used to resolve finer scale population differentiation, individual ID, as well as to determine the magnitude and directionality of gene flow. Consequently, we will use these markers to determine population structure of lesser long-nosed bat roosts in Arizona and present preliminary results.

The Effect of Forest Disturbance on Bats (*Myotis lucifugus*) of the Southwestern Yukon

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I investigated the effects of two natural disturbance factors: a recent infestation of spruce beetles (*Dendroctonous rufipennis*) and forest fire, and an anthropogenic form of disturbance—logging—on the habitat use of little brown bats (*Myotis lucifugus*) in the southwestern Yukon. I also examined how these sources of forest disturbance affect habitat characteristics important to bats. Because bats at northern latitudes experience large seasonal variation in temperature and solar illumination, they may respond differently to forest disturbance than southern conspecifics do. I acoustically measured bat activity using Anabat II detectors, and sampled forest structure, microclimate, and insect biomass in the three types of forest disturbance, with five replicates of each disturbance type. I statistically analyzed my data using the Restricted Maximum Likelihood (REML) method for repeated measures mixed-model or fixed-effect ANCOVA. In general, bat activity was greater in beetle-affected forests, less in burned, and least in logged forests. However, this depended on proximity to water and time of year. Close to Pine Lake, bat activity was greater in beetle-affected forests, lower in burned, and least in logged forest, but activity was consistently low far from Pine Lake. Near solstice bats flew and foraged in forested areas such as beetle-affected forest more than in open areas such as logged forest. This may be because beetle-affected forests have greater canopy closure and are darker, perhaps providing visual protection from predators or due to variation in roost abundance, but this pattern could not be explained by differences in temperature, wind speed, clutter, or insect abundance amongst the three types of disturbance.

Altered Arousal Patterns and Suppressed Immunity in Little Brown Myotis (*Myotis lucifugus*) Affected by White Nose Syndrome

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White nose syndrome (WNS), a mysterious condition first described in 2007, has killed an estimated million+ cave-dwelling bats in the northeastern U.S. and is rapidly spreading west and south. WNS is characterized by: 1) the presence of a cold-loving fungus on the muzzle and/or wing membranes; 2) aberrant behavior (hibernating near the entrance of caves/mines and/or midwinter emergence from hibernacula); and 3) poor body condition (damage to wings and loss of body weight). To test the hypothesis that WNS-affected bats either arouse from torpor too frequently during hibernation or remain euthermic for longer periods than normal, resulting in the depletion of body fat stores and eventual death, 221 temperature sensitive data-loggers were attached to WNS-affected and unaffected little brown myotis (*Myotis lucifugus*) at 6 hibernacula in 5 states. Although large site-to-site variation in hibernation patterns was evident—likely due to variations in ambient temperature and initial body condition—WNS-affected bats exhibited shorter torpor bouts than unaffected bats (but rarely remained euthermic for extended periods of time), which presumably rapidly depleted fat reserves. Immune competence during the winter was studied in bats from two of these hibernacula. Although there is a relative paucity of data on how bat immune systems function and how they vary over the annual season, evidence suggests that bats display reduced immune responses compared to other mammals and that immune competence is lower during hibernation than during the active season. Beyond the 'normal' suppression thought to occur during hibernation, WNS-affected bats appear to have even lower immune competence than unaffected bats. While the relatively energetically inexpensive innate immune mechanisms appear to be either unchanged or slightly upregulated, the more expensive B-cell mediated adaptive immune system is hyporesponsive in WNS-affected bats. In mid-winter, WNS-affected bats had significantly lower levels of total immune globulins (primarily IgG) than unaffected bats, and levels were even lower near the end of the hibernation season. At this time, splenocytes from WNS-affected bats also showed significant unresponsiveness to challenge with lipopolysaccharide (LPS), which *in vitro* stimulates B-cell proliferation. Phytohemagglutinin (PHA) stimulation did not differ in WNS and healthy bats. It is important to note that the immune data collected from WNS-affected and unaffected bats came from bats that did not differ in body mass index (BMI). This suggests that the immune deficiencies shown by WNS bats are not simply due to differences in energetics.

***Thermal Radiators: A Unique Adaptation for Long-distance Foraging and Migration in Bats of the Family Molossidae**

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*** Jonathan Reichard** received the **Titley Electronics Award**

Heat generated as a byproduct of energetically costly flight must be dissipated to avoid hyperthermia. Brazilian free-tailed bats, *Tadarida brasiliensis*, dissipate large amounts of heat from the head and body. However, wings and tail membrane remain significantly cooler than air temperature during flight, reducing their ability to dissipate heat, especially at higher air temperatures. Thermal infrared (TIR) imaging of free-ranging bats revealed thermal windows on Brazilian free-tailed bats that are absent from syntopic cave myotis, *Myotis velifer*. These areas on the lateral flanks and proximal portions of the wing are uniquely vascularized and hairless, exhibiting properties of a thermal radiator, which can dissipate heat at a greater area-specific rate than the adjacent body surfaces and wings. The anatomy of the region was analyzed with light and TIR imaging, microscopic x-ray computed tomography (microCT), and light microscopy to characterize form and function. In Brazilian free-tailed bats, two branches from the ulnar artery are uniquely developed, creating a web of blood vessels. We postulate that radiators facilitate thermoregulation and water balance through localized heat loss. Transcutaneous water loss through the hairless wing membranes is reduced while blood is shunted away from the wings to fuel flight muscle activity. Countercurrent exchange may also play an important role in thermoregulation at lower air temperatures such as those encountered at high altitude. Comparative analysis of 133 fluid-preserved Chiropteran species from 15 families suggests that similar anatomy is present only in the Molossidae, many of which are known to undertake extended foraging flights and migration in warmer geographic regions. Notably, similar vascular structures were absent from other migratory bat taxa (e.g., *Lasiurus*, *Leptonycteris*, and *Eidolon*). We suggest that this thermal radiator is a unique adaptation for long-distance foraging and migration in members of the family Molossidae.

Changes in Body Mass and Fat Reserves in Pre-hibernating and Hibernating Little Brown Myotis (*Myotis lucifugus*), at a White Nose Syndrome-affected Cave

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White nose syndrome (WNS) is associated with fungal infection and emaciation in hibernating bats of the northeastern United States. The impacts of WNS are most evident in late winter when affected bats exhibit atypical hibernating behavior and reduced body mass (M_b). We quantified changes in M_b and total body fat (TBF) in pre-hibernating and hibernating little brown myotis, *Myotis lucifugus*, at Aeolus Cave, Vermont, a site previously confirmed with WNS. For comparison of pre- and post-WNS fat accumulation, we replicated a 1976 study to quantify pre-hibernation fattening. Active bats were trapped outside the cave from mid-August to mid-October and torpid bats were collected inside the cave in November, January, and March. On average, in 2008, adult females reached a maximum M_b = 9.22 g in mid-September, but adult males and juveniles peaked two weeks later with maximum M_b = 9.36 g and 8.26 g, respectively. Maximum M_b was similar in 1976 and 2008. At the end of the pre-hibernation period, adult males (M_b = 8.24 g) were significantly heavier than juveniles (7.65 g); adult females were in-between (M_b = 8.18 g). In mid-October, M_b was markedly lower in 2008 than in 1976, but no active bats were sampled in the earlier study. Maximum TBF was 2.77 g, 2.38 g, and 1.93 g for adult females, adult males, and juveniles, respectively, and coincided with maximum M_b. By mid-October, TBF had declined to 65.7% of the maximum in adult females and 78.2% in adult males; 96.4% of the maximum TBF remained in juveniles. Between mid-October and mid-November, M_b declined by more than 0.75 g for all cohorts. An additional 0.65 g was lost by mid-January, bringing all cohorts to about M_b = 6.50 g. On average, only adult males lost M_b after January, suggesting fat reserves were depleted earlier in hibernation in females and juveniles. Throughout hibernation, fat provides energy for essential activities and physiological processes including, but not limited to, mounting immune responses, ovulating in early spring, and migrating. Premature depletion of fat reserves may make bats more vulnerable to disease during hibernation and reduce fecundity the following summer.

The Hibernating Bats of New Hampshire: Are We Climbing to the Edge of a Cliff?

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Research into the population biology of bats has been characterized by temporal snapshots of major demographic events that are often stitched together in an attempt to understand their complete life cycle. But what do you do when these fragments do not fit together? I present census data on hibernating bats in New Hampshire, with emphasis on the little brown myotis (*Myotis lucifugus*), which pose such a dilemma. Three extensive hibernacula surveys have been conducted in New Hampshire since 1999. These data show that New Hampshire's hibernating population of bats increased 31% from 2008 to 2009, with a total increase of 155% since 1999. Of the five species that hibernate in New Hampshire, *M. lucifugus* has shown the largest increase in population size. Census data of summer colonies, however, present a very different picture. Maternity colonies of house-roosting bats in New Hampshire appear to have gradually become fewer and smaller over this same time period, with a massive decline of *M. lucifugus* at several well-studied colonies documented in 2009. Detailed demographic analysis of a *M. lucifugus* maternity colony in Peterborough, New Hampshire suggests a 90% reduction in colony size in 2009, with similar reductions occurring at other colonies throughout the region. These reductions appear to differ in both scale and magnitude to the general decline documented over the last decade and are likely the result of white nose syndrome (WNS). How do we reconcile the different trajectories of these winter and summer census data? Are we sampling the same population with incompatible methodologies or are we sampling two separate populations?

Sucker-footed Bats Do Not Suck

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Most bats hang head-down by their toes, but Madagascar's endemic sucker-footed bat (*Myzopoda aurita*) clings head-up to smooth leaves using specialized pads on its wrists and ankles. How do these bats adhere to smooth surfaces, and why do they roost head-up? We investigated the adhesive performance of 28 individuals to determine

the mechanism of attachment, and found that adhesion to brass was not affected by the presence or absence of a seal around the pad-surface interface. Suction requires a seal, but wet adhesion does not. Also, on smooth lexan the wrist pads were more than nine-fold weaker when pulled perpendicular to the surface than when pulled parallel to it. That directional force dependence on a smooth surface is characteristic of wet adhesion, but not of suction. Thus, despite its name, the sucker-footed bat uses wet adhesion. The directional dependence of that mechanism probably permits rapid detachment during locomotion, but would also cause passive detachment if bats roosted head-down. This is the most likely explanation for the head-up posture of *Myzopoda aurita*. Also, one corollary of our results is that New World thyropterid bats (*Thyroptera* spp.) appear to be the only mammals that adhere to smooth surfaces by means of suction. Our results give insight into the morphological specialization that corresponds to novel roosting habits, linking biomechanics, behavior, and roosting ecology for an enigmatic Malagasy endemic.

Protocol for Determining the Presence or Absence of Indiana Bats: Does One Size Fit All?
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The current Indiana bat (*Myotis sodalis*) Recovery Plan mist-netting guidelines were developed as a means of determining presence or probable absence at a specific time and a specific place in anticipation of a habitat perturbation (road, power line, pipe line, mine, construction, etc). The Recovery Plan guidelines recommend habitat evaluation, a mist-netting protocol, and depending on the state or region, may include acoustic monitoring. If Indiana bats are found to be present, the habitat cannot be disturbed during the time of use whether it is normal summer activity, maternity roosting, or winter hibernation. These same guidelines, however, are being used in conjunction with wind energy developments that are fundamentally different from other activities in that bat habitat (air space) will continually be disturbed throughout the life of the facility. Although regulations or guidelines vary widely among states, when pre-construction surveys are conducted, they usually include the Recovery Plan netting guidelines, as well as acoustic monitoring at meteorological (met.) towers. The netting protocol only establishes presence/absence for a limited and specific time frame, and sampling is not often conducted when most mortality is likely to occur. It is often assumed that data from detectors on met. towers that are sampling bat activity at different heights are an accurate representation of bat activity on the site. However, studies indicate that bats are attracted to the structure or movement of wind turbines, and that bat activity, specifically Indiana bat activity is highly correlated with landscape features not usually associated with met. tower locations. No data are currently available on the patterns of mortality of Indiana bats at wind farms, and hopefully never will be. However, a new, more specific protocol will be proposed for industrial wind farms that requires pre-construction acoustic monitoring and mist-netting throughout the period when Indiana bats, as well as the other species, may be present. The information obtained in the pre-construction period should then be compared or contrasted with the data provided from post-construction surveys and monitoring to determine if any changes have occurred from construction and operation of the wind energy facility. These results could be used to develop better predictive models in future risk assessment related to both project siting and operation.

A Flexible Sampling Design for Acoustic Surveys of Bats along Streams and Other Linear Habitat Features
Rodhouse, Thomas J., National Park Service Upper Columbia Basin Network, Bend, OR

Locating bat detectors for surveys along streams and other linear features such as trail and road networks presents unique challenges, particularly when a probabilistic sample is required for drawing inference to unsampled areas. Sampling frame errors and other logistical constraints often require sites to be dropped from the sample and new sites added. Maintaining spatial balance and representativeness of the sample when these changes are made is problematic. Spatial dependence among survey locations effectively reduces overall sample size and can confound patterns in data. Two analogous spatially-balanced sampling designs, the generalized random tessellation stratified (GRTS) design and the reverse randomized quadrant-recursive raster (RRQRR) design, have recently been developed to support aquatic surveys along rivers and streams. These spatially-balanced designs provide solutions to a number of practical challenges faced by bat researchers. They allow for sample additions and deletions, support unequal-probability selection of survey locations, and provide a locally-weighted variance estimator that is efficient even in the presence of spatial correlation among survey locations. I demonstrate the implementation and analysis of a spatially-balanced design to survey bats along a stream network with acoustic detectors. My results showed that the spatially-balanced design did accommodate a number of typical logistical challenges and yielded a 30% reduction in estimated variance than if the usual (i.e., averaged squared deviates or “Horvitz-Thompson”) estimator had been used. Although I focus here on acoustic surveys along linear features, spatially-balanced sampling designs have broad application to bat research and monitoring programs generally, and will improve both capture and acoustic surveys in areal sampling frames as well. Designs involving the use of transects, such as are commonly employed along road systems, can also be easily accommodated. Freely available resources for drawing spatially-balanced samples, including R statistical software code and an ArcGIS toolbox extension, will be presented.

Social Structure and Implications for the Mating System of *Ectophylla alba*

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Among mammals, bats have the widest diversity of social structure and mating strategies. Roost characteristics exert a strong influence on the social structure. For example, if the roost is defensible and spatio-temporally limited, it becomes an important resource that can partly determine the type of mating system. In species that use tents as a roost, it has been suggested that males can defend the tent to gain access to females. The Honduran white bat roosts exclusively in tents. Their mating system has been reported as polygynic, where a solitary male supposedly defends the resource (tent) to gain exclusive temporary access to a group of females. The objective of this study was to determine the composition and stability of groups and document whether the males defend the tent and/or females to gain access for copulation. During 2006 we worked on Tirimbina Biological Reserve, Sarapiquí, Costa Rica, where we captured entire groups of bats several times during one year (n = 38), marked all individuals (n = 98), and recorded their reproductive status. We videotaped the behavior of individuals in one group, from 17:30–05:30 h on 25 nights (March–May, 300 h in total). During the year individuals showed associative patterns indicating that the groups are stable regardless of the reproductive season. The proportion of males in the groups remained seasonally stable, and most groups have more than one adult male. Males spend varying amounts of time in the tents and there was no agonistic behavior with other group members. Based on these observations, the mating system of *E. alba* is not polygyny, but a stable group of several males and females. Ongoing paternity studies will likely confirm this.

Diet of the Puerto Rican Mustached Bat (*Pteronotus portoricensis*) in Wet and Dry Habitats

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Puerto Rico, the smallest island in the Greater Antilles (ca 8900 km^2), contains three physiographic regions: the coastal plains, a northwestern karst region, and a mountainous interior. This mountainous interior creates a difference in rainfall between the northern (wet) and southern (dry) portions of the island, which receive an annual precipitation of 150−80 cm and 100−130 cm respectively. This study investigated the dietary differences of the Puerto Rican mustached bat (*Pteronotus portoricensis*), an endemic insectivorous species, between the wet and dry portions of Puerto Rico. A collapsible harp trap or mist net was placed at the opening to four caves, two in the wet portion and two in the dry portion of the island. The 32 captured *P. portoricensis* individuals were placed in individual holding bags for approximately one hour, or until defecation occurred. The sex, age, and reproductive condition of all bats were determined, and guano was placed in individual Zip-lock bags and dried in a heating oven. Standard fecal methodology was used. Individual pellets within each sample were treated as subsamples, and the percent volumes of all orders of insects in all pellets were averaged to obtain overall proportions for individual *P. portoricensis*. Preliminary analysis shows that the diet of *P. portoricensis* contains: Lepidoptera, Hymenoptera, Hemiptera, Diptera, Orthoptera, Odonata, and Coleoptera. A slightly higher proportion of Hemiptera was consumed in the north, whereas bats in the south consumed more Diptera and Coleoptera.

Searcher Efficiency and Carcass Persistence Rates of Bats and Mice for Use in Post-construction Monitoring at Wind Energy Facilities

Romeling, Shannon E., C. Ryan Allen, and Lynn W. Robbins, Missouri State University, Springfield, MO

The potentially high mortality rate of bat species caused by wind turbines requires mortality estimates to assess the effects of wind turbine operation on bat populations. Before bat mortality can be estimated, correction factors must be accounted for by conducting trials before or during post-construction studies. These factors include searcher efficiency (SE), the proportion of bats the searcher is able to find, and carcass persistence (CP), the proportion of carcasses that remain unscavenged over time. It is an option for these trials to use mice as surrogates when bats are not available. To examine the potential differences between mice and bat carcass use for SE and CP trials, both species were randomly placed in a 60 m radius circular plot in an unused agriculture field at the Missouri State's Field Station in Taney County, Missouri. Nineteen big brown bats (*Eptesicus fuscus*) and 20 small brown mice (*Mus musculus*) were used. SE trails were conducted twice, once by one person and once using two people simultaneously. Both SE trials followed the methods of Bearwald (2009). Results of both SE trials found more mice than bats. A two-tailed t-test showed a greater difference between the number of mice and bats located using two people (p = 0.09) than using one person (p = 0.59). This likely occurred because only 3 of 39 (7.7%) of carcasses were found by one person whereas 6 of 26 (23.1%) were found in the two person trial. CP trials were performed every day for 9 days, on day 17 and on day 25. Bat carcasses lasted an average of 8.05 days (CI ± 3.52) and mice lasted an average of 4.65 days (CI ± 2.14). Although the difference was not significant (p = 0.110), it appears that mice were scavenged faster than bats. Further investigation using larger sample sizes and different bat species is necessary to clearly determine if there is difference between SE and CP of bats and mice. A comparison of bats and birds should also be performed, as many post-construction surveys use birds as surrogates for bats.

Population Growth of Mexican Free-tailed Bats (*Tadarida brasiliensis mexicana*) Predates Human Agricultural Activity

Russell, Amy L.[1], Murray P. Cox[2], Veronica A. Brown[3], and Gary F. McCracken[3], [1]Grand Valley State University, Allendale, MI; [2]University of Arizona, Tucson, AZ; [3]University of Tennessee, Knoxville, TN

Populations of the Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) have extremely large census population sizes, estimated to be in the tens to hundreds of millions. Maternity colonies of this subspecies have been suggested to be some of the largest aggregations of mammals in the world. During the energetically demanding time of pregnancy and lactation, females may ingest up to two-thirds of their body weight in insects every night. The bats thus depend upon a very large and reliable base of insect prey to maintain these large maternity colonies. A number of studies, utilizing data from NEXRAD Doppler, high-altitude echolocation surveys, and fecal analyses, have documented strong links between *T. b. mexicana* and agricultural insect pests such as the cotton bollworm or corn earworm. Previous genetic work on *T. b. mexicana* has indicated that the subspecies evolves as a single very large effective population size with a history of significant population growth, but the question remains as to the reason for this population growth. The current feeding ecology of the bats suggests a link between human agriculture, agricultural insect pests, and the bat predators of those insects. By this logic, population growth in *T. b. mexicana* should be very recent and associated with the spread of agricultural Native American populations no earlier than ~15 thousand years ago (kya) or, more likely, with the widespread expansion of agricultural land during European settlement. We used maximum likelihood analyses of DNA sequence data from the mitochondrial D-loop and a nuclear *RAG2* intron to infer the timing of population growth in *T. b. mexicana*. Data were simulated using the coalescent under a demographic model of a single population growing exponentially from the ancestral population size (N_A) to the current size (N_0) at time t. Considering both loci in a composite analysis, we obtained maximum likelihood estimates of N_A = ~230,000, N_0 = ~12 million, and the onset of growth at ~220 kya. While the observed data provided little power to estimate N_0 or an upper bound for t, we had considerable power to infer N_A and a lower bound for the time of onset of growth. Using only two loci, we can confidently exclude dates more recent than 120 kya. These analyses thus make it clear that the *T. b. mexicana* population has grown substantially (~50-fold) and that this growth occurred well before the arrival of humans in the Americas. We suggest that the behavioral flexibility and catholic diet of these bats allowed for this early success of their populations.

Density Response to Habitat at Different Scales: Perspectives from the Tent-roosting Bat (*Uroderma bilobatum*)

Sagot, Maria[1], Richard D. Stevens[1], and Bernal Rodriguez-H.[2], [1]Louisiana State University, Baton Rouge, LA; [2]Tirimbina Rainforest Center, Sarapiqui, Costa Rica

Peter's tent-making bat (*Uroderma bilobatum*) is one of the largest tent-roosting bats and an important seed disperser. However, little is known about their roosting ecology. Preliminary data gathered in Costa Rica show that *U. bilobatum* are more abundant in rural and altered areas than in forested areas in places where they inhabit both habitats, and they are even absent from the forest in certain locations. It is known that use of different habitats with different characteristics (such as roost density and distribution, food availability, exposure to weather, commuting distance, etc.) can influence abundance of organisms. Thus, we were interested in determining the ecological consequences of changes in habitat use in *U. bilobatum*. For this, we compared population and roost density in forested and altered habitats. Habitat was measured at three different levels: macrohabitat, microhabitat, and structural. Data were analyzed using a variation partitioning analysis to disentangle the variance explained by macrohabitat, microhabitat, and structural variables. Disentangling density response to habitat at different scales will improve our understanding of spatial and temporal dynamics of these populations as well as habitat effects on group cohesion.

Metabolic Rates, Nutritional State, and Thermoregulatory Behavior of *Molossus molossus* (Molossidae) and *Brachyphylla cavernarum* (Phyllostomidae) in Puerto Rico

Sandoval, Jean Manuel, and Armando Rodríguez-Durán, Universidad Interamericana, Bayamón PR

Preliminary data are presented on metabolic rates and thermoregulatory behavior for two species of bats, *Molossus molossus* (Molossidae) and *Brachyphylla cavernarum* (Phyllostomidae), on the Neotropical island of Puerto Rico in the West Indies. *M. molossus* roosts predominantly in anthropogenic structures where it is exposed to wide variations in ambient temperature. *B. cavernarum* is a cave-dwelling species roosting in microclimatically stable environments. Body temperature was measured at the beginning and end of each experiment and, in the case of *M. molossus*, upon departure and return to the roost. Oxygen consumption experiments began eight to ten hours following capture and were terminated before the beginning of the next foraging period. All *B. cavernarum* were allowed to feed the night before the experiment. Half of all *M. molossus* were deprived of food the night before the experiments. Resting metabolic rate for *M. molossus* was 1.17 ml O_2/g/h, and 1.01 ml O_2/g/h for *B. cavernarum*. Both species closely regulate body temperature. We did not find statistically significant differences in oxygen consumption based on the nutritional state of bats.

The Evolution of Biting Behavior and Bite Performance in Phyllostomid Bats

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Variation in behavior, performance, and ecology are traditionally associated with morphological variation. A relatively neglected part of this ecomorphological paradigm is the interaction between behavior and performance, despite its crucial role for a full understanding of adaptive processes. Neotropical leaf-nosed bats (family Phyllostomidae) are an ideal system for studying the interactions between behavior, performance, and ecology because they display marked diversity in diet, feeding behavior, and bite performance (bite force), and these traits are likely to have undergone strong selection in the lineage. Here we investigate the relationship between biting behavior and bite force among 20 species of ecologically diverse phyllostomids. We studied the patterns of evolution of plasticity in biting behavior and bite force, and reconstructed ancestral states for plasticity in biting behavior. Both behavioral and performance plasticity exhibited accelerating evolution over time, and their rapid evolution coincided with major dietary shifts in the lineage, from insect-feeding to plant-feeding. We found a significant, positive correlation between behavioral plasticity and bite force. Bats modulated their performance by changing their biting behavior to maximize bite force when feeding on hard foods. The ancestor of phyllostomids was likely a generalist characterized by high behavioral plasticity, a condition that also evolved in specialized frugivores and potentially contributed to their diversification.

Bite Force Analysis of Rainforest Insectivorous Bats

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Malaysia’s rainforests are home to the greatest diversity of bat species in the Old World with about 70 bat species recorded at a single location, Krau Wildlife Reserve, Pahang. This outstanding diversity is likely achieved through an intricate partitioning of the available resources within the habitat. In insectivorous bat assemblages, niche partitioning of food resources is affected in large part by physical and sensory access to the insect prey base. Differences in wing morphology and echolocation signal design among species influence access to particular foraging habitats and the ability to detect or capture prey within them. Differences in biting ability to process food may further mediate resource partitioning in species-rich assemblages. However, experimental data documenting biting ability (bite force) at the assemblage level are limited. Here we examine the relationship between bite force and body size in over 20 species from 5 genera of insectivorous bats from a single rainforest bat assemblage at Krau Wildlife Reserve, Pahang, Malaysia. Although there was no significant relationship between bite force and body size at the assemblage level (i.e., across all species), within genera bite force increased exponentially with body size. The consequences of these findings for structuring mechanisms in species-rich monophagous assemblages are discussed.

The Evolution and Development of Wing Form and Body Size in Large and Small-bodied Fruit Bats (*Artibeus jamaicensis* and *Carollia perspicillata*)

Shaw, Jason B., and Rick A. Adams, University of Northern Colorado, Greeley, CO

The evolution of taxonomically and ecologically similar species produces assemblages of organisms that may overlap substantially in niche breadth. In such instances, continued coexistence among species may be reliant upon spatial or temporal resource partitioning and dependent upon flight ability and wing morphology. To understand the developmental timing of trait differences, such as size and body shape, heterochronic comparisons can be used. Any shifts in developmental timing (heterochrony) can be quantified. Specifically when age is known, rates of growth between species can be compared. The differences in growth rates can bring insight to how two closely related species can be of different body size and shape. The purpose of this study was to describe and compare the growth rates between *Artibeus jamaicensis* and *Carollia perspicillata*. These bats are members of the same family, Phyllostomidae; however they are in different subfamilies with *A. jamaicensis* being approximately twice as large as *C. perspicillata*. We hypothesized that growth rates between *A. jamaicensis* and *C. perspicillata* will be significantly different in all measured morphometric traits due to the overall size difference. We predicted that *A. jamaicensis* and *C. perspicillata* would show rapid growth, necessary for early volancy, with *A. jamaicensis* growing at a more accelerated pace than *C. perspicillata*. *A. jamaicensis* and *C. perspicillata* juvenile weight, forearm, and wing area were measured on a daily basis from day of birth to adult size. Growth curves were plotted to determine when juveniles reach an asymptote in growth in each specific area measured. The linear portion of the growth curve was analyzed using general linear regression and slopes were obtained for comparison analysis. Slopes from 48 *A. jamaicensis* and 25 *C. perspicillata* were compared using t-tests with alpha set at 0.05. Slopes of all traits measured were significantly different between the two species with $p < 0.0001$. Our results support the idea that *A. jamaicensis* grows at an overall faster rate than *C. perspicillata*, allowing for *A. jamaicensis* to be close to twice as big. Data also support the idea that developmental timing can be an important tool in determining the evolutionary path that closely related species follow in regards to dams differences in size and shape.

Recovering an Endangered Species, *Leptonycteris yerbabuenae*

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Lesser long-nosed bats (LLNB), *Leptonycteris yerbabuenae*, are pollinators and seed dispersers of some columnar cacti such as saguaro and organ pipe cactus, and the species pollinates agaves that produce paniculate flowers. Because of their importance to plants in southwestern U.S., and because surveys in 1970s and 1980s showed drastically reduced numbers of LLNB at previously known roosts, *L. yerbabuenae* was listed federally endangered in 1988. Recovery plans described that critical resources for LLNB are day roosts and concentrations of food plants, and noted that the species is sensitive to human disturbance. Surveys for LLNB at Fort Huachuca, Arizona began in 1989. Fort Huachuca is located in grasslands of southeastern Arizona where LLNB feed from agaves during their return migration south to Mexico in late summer through fall. Fifty LLNB were found in small Manila Mine in 1990 when a monitoring program was established, but no LLNB were observed in previously documented Pyeatt Cave. At the same time, insectivorous bats, *Myotis velifer*, numbered 1000 at Pyeatt Cave in 1990. Beginning in 1991, U.S. Army actions were undertaken to begin restoration of resources for LLNB. Actions included curtailment of military activities in agave fields, gate removal at Pyeatt Cave to natural condition, closure and protection of the cave and mine from human disturbance, and low disturbance techniques employed by biologists. Numbers of cave myotis began to increase the next year, but no LLNB returned to Pyeatt Cave. Ultimately, cave myotis numbers varied from 10,000 to 14,000. Pyeatt Cave remained empty of LLNB until the roost finally revealed 38 LLNB in 1997. By 2005, 14,000 LLNB roosted in Pyeatt. Numbers peaked in 2008 with 21,000 LLNB. No other roost in southeastern Arizona has shown these remarkable increases. Enforcement of protective actions continues to the present. Careful stewardship has been rewarded by successful recovery of this endangered species.

A New Approach to Studying Dental Evolution in Bats

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The evolution of the chiropteran dentition is of interest in fields ranging from systematics to functional morphology and ecology because most dental features are fixed within species, variable across taxa, and highly correlated with diet and feeding strategies. However, in part because of the enormous diversity of extant bats, previous analyses of patterns of evolutionary change in bat teeth have been based almost entirely on scenarios and lacking an explicit phylogenetic basis. No consensus terminology exists for describing many dental structures seen in bats. Dental characters have contributed little to most phylogenetic analyses above the species level, even those based entirely on morphology, because of problems in determining homologies of structures and dental loci. Lack of a well-developed set of dental characters and an explicit phylogenetic framework for interpreting them has hindered attempts to use fossils to constrain important divergence points in bat evolution. To address these problems, we developed a new data set of > 260 dental characters in MorphoBank (http://morphobank.org). MorphoBank is a web-based platform that allows multiple individuals to simultaneously collaborate on morphological data sets, to upload and label images that can be shared with all project members, to store bibliographic references and specimen data, and to engage in on-line discussion of morphological features at a variety of levels. We built a data matrix including species representing all chiropteran families and scored them for every character, documenting each observation (matrix cell) with at least one labeled image. We developed a standardized terminology, and conducted phylogenetic analyses of our data using a molecular scaffold approach to investigate patterns of change and homoplasy in dental characters. We also used stochastic, MP, and ML mapping methods to investigate patterns of character correlation and potential non-independence of characters, a first step in using this data set as a framework for placing hundreds of fossil bat taxa into phylogenetic perspective. Results are promising and we identified potential dental synapomorphies of many families and other higher-level clades. Future work will require expanded sampling within the more diverse chiropteran families.

Donating Bat Tissue and Hair Samples for Genetic and Oxygen Isotope Analyses

Simmons, Nancy B., Ariel Fleming, and Eileen Westwig, American Museum of Natural History, New York, NY

Genetic and isotope studies provide unique data for understanding phylogeny, genetic diversity, geographic structure, population sizes, and migratory patterns of bats. This information is becoming critical for conservation efforts as bat populations are increasingly threatened by habitat loss, wind power development, and white nose syndrome (WNS). To facilitate ongoing research, the American Museum of Natural History is actively soliciting donations of bat tissue samples (including tissue samples, hair samples, wing punches, or any combination of these) for archiving and use by researchers. A Web site (http://research.amnh.org/mammalogy/batgenetics/) has been established containing all the information necessary to collect and donate specimens. The primary requirements are that samples be collected legally (copies of permits are required before we can accept samples) and that the bats be identified to species by a qualified researcher prior to sampling. It is not necessary for donated specimens to be fresh—samples collected from carcasses found in caves or under wind turbines may be submitted as long as the bats are identified prior to sampling. We encourage individuals who are capturing bats for other reasons (e.g., ecological studies) to consider donating wing punches from their study animals. The AMNH will provide free tissue sample tubes and free shipping of specimens for individuals interested in contributing. We are particularly interested in samples from migratory tree-roosting bats at risk from wind farms (*Lasiurus*, *Lasionycteris*), species affected by WNS (e.g., *Myotis lucifugus* and other cave-dwelling bats), and rare and endangered species (e.g., *Myotis sodalis*) because these taxa are the focus of current research efforts. However, specimens of all taxa will be accepted. Samples of bats from other countries are also desirable as these can contribute to ongoing phylogenetic and biogeographic studies. Donated specimens will be archived permanently and made available for use by qualified researchers from around the world.

Bat Activity and Patterns in the Vicinity of Proposed Wind Facilities along the Mid-Atlantic Coast

Sjollema, Angela L., and J. Edward Gates, Frostburg State University, Frostburg, MD; University of Maryland, Frostburg, MD

Wind facilities are considered a partial solution to global climate change but their effect on wildlife in the eastern United States has been profound. For instance, bat fatalities are found by the thousands below wind turbines in the Appalachian Mountains, which were not recognized as a migration pathway for them. Another possible migration route for bats is near and off the Atlantic Coast. A comprehensive study of bat activity offshore has not been conducted although bats have been documented on boats in offshore waters for decades. Recently, wind power plants have been proposed off the Atlantic coast, rendering a comprehensive assessment of offshore bat migration dynamics necessary to prevent a potential catastrophic effect on populations. Determining if there are predictors for high activity such as favorable weather patterns is also vital. Bat species richness and density will be studied using bat monitors near and offshore in the Mid-Atlantic region. Four long-term sites will be set up onshore to record nightly bat calls from the New Jersey to Maryland coast. Offshore acoustic monitoring will be conducted on boats traveling close to shore. Early findings include a substantial number of *Eptesicus fuscus* and *Lasionycteris noctivagans* along the coast. *Lasiurus borealis* and *L. cinereus* calls have also been recorded. One *L. noctivagans* was found five miles offshore in spring of 2009, but fall recordings have included *L. borealis* and *Myotis* spp. Thus preliminary results suggest that migratory bats use offshore pathways in fall and other species venture offshore to forage or travel short distances. Therefore, bats may be negatively impacted by offshore wind energy.

Daily Movements and Evidence of Fission-fusion Behavior in the Pallid Bat (*Antrozous pallidus*)
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We tracked 14 radio-tagged pallid bats (*Antrozous pallidus*; x males and y females) during July and August 2009 in southern Nevada. Pallid bats roosted in vertical and horizontal cracks in cliff faces and boulders. Radio-tagged bats exhibited high fidelity to specific roosting areas, but low fidelity to individual roost sites. We found bats roosting individually or in small groups, and occasionally with other radio-tagged individuals. The daily movements of pallid bats among day roosts, and the reorganization of individuals within those day roosts are consistent with a fission-fusion system similar to that described for some tree bats like the big brown bat (*Eptesicus fuscus*). Radio-tagged individuals left roost sites shortly after sunset and did not return until sunrise. Bats foraged for the majority of the night based on evidence of movement by individuals Night roosting occurred for an estimated 15–20% of the night time hours. Overall, pallid bats foraged in and around the same general locations across nights, exhibiting strong patterns of consistent use of foraging areas between nights.

***Dietary Niche Breadth of *Myotis lucifugus* in Northern Michigan**
Sluzas, Emily M., University of Michigan, Ann Arbor, MI
*** Emily Sluzas** received the **Speleobooks Award**

Myotis lucifugus has a very large geographic range among vespertilionids and co-occurs with varying assemblages of other bats in different parts of its range. Having a large dietary breadth has been suggested as a mechanism for persisting across a wide range of environmental conditions. It has been suggested that generalist species that consume a wide variety of prey items are more resistant to human-produced disturbance. However, broad dietary niches may arise in a variety of manners. All individuals in a population may consume a vast array of food items or individual variation in prey consumed may be responsible for the great breadth in diet seen in many "generalist" species. Individual variation in diet could lead to underestimates of extinction vulnerability if juveniles or reproductive females have more specialized diets than the species as a whole. Therefore, predictions about a species' response to environmental and anthropogenic changes cannot be made without understanding how the species developed such a broad dietary niche. I used molecular techniques to analyze the diet of *M. lucifugus* and to document individual dietary variation to a finer level than previously examined by identifying consumed insects to the species level. I conducted fieldwork in a northern hardwood forest ecosystem at the University of Michigan Biological Station in Pellston, MI. I predicted that individuals would consume varying sets of insects and that males and females would have different prey preferences due to increased energy demands placed on females during pregnancy. Bats were captured using mist nets between May 20 and June 26, 2009 and were held in disposable cloth bags until defecation. DNA was extracted from whole fecal pellets and a variable region of *cytochrome c oxidase subunit 1* (CO1) was amplified using universal insect primers LepF1 and LepR1. PCR product was cloned and 20 colonies per bat were sequenced. Preliminary data show greater variation in insect content between individual samples than within a sample. Although some of this variation may be due to changes in insect availability, the data support the hypothesis that males and females contribute differently to the dietary niche of *M. lucifugus* and suggest one mechanism whereby this species flourishes across a broad range of environments.

Bat Activity within Organic versus Conventional Apple Orchards in Southern Michigan
Smith, Brenna L., and Allen Kurta, Eastern Michigan University, Ypsilanti, MI

Conventional orchards use pesticides to decrease insect damage to fruit, whereas organic orchards do not. I hypothesize that use of pesticides in conventional apple orchards will result in overall less bat activity compared to organic orchards, by decreasing prey potentially available to bats. To test this hypothesis, I am currently quantifying composition and abundance of the insect community, composition and abundance of the bat community, diet of captured bats, and levels of bat activity within five organic and four conventional orchards in southern Michigan.

The present report provides a preliminary analysis of my data on bat activity that was obtained between 05 June and 19 August 2009. An ultrasonic detector (Anabat) was raised to a height of 6 m in each orchard, programmed to record from sunset to sunrise, and moved to a new location every 9 days. Mean number of files containing bat activity per night was 40.3 ± 28.9 for organic orchards and 64.6 ± 34.1 for conventional orchards. The level of bat activity was not significantly different between types of orchards.

An Inordinate Fondness for Rocks: Roosting Habits of Bats at Mesa Verde National Park, Colorado
Snider, E. Apple[1], Paul M. Cryan[2], Thomas J. O'Shea[2], Ernest W. Valdez[3], Daniel J. Neubaum[2], and Laura E. Ellison[2], [1]Colorado State University, Fort Collins, CO; [2]U.S. Geological Survey, Fort Collins, CO; [3]U.S. Geological Survey, Albuquerque, NM

Stand-replacing wildfires have burned much of Mesa Verde National Park (MVNP) in recent decades, and the ancient piñon-juniper woodlands lost to those fires are not regenerating. The potential impacts of wildfire on bat populations at MVNP was cause for concern because in certain areas of the southwestern United States some species of bats use crevices and cavities in piñon and juniper trees as sites to give birth and rear their young. Using radiotelemetry, we studied the roosting habits of selected species of bats at MVNP. We successfully tracked a total of 46 bats of 5 different species to their daytime roosts. Despite the availability of old-growth trees in the remaining piñon-juniper woodlands of MVNP that are similar to those known to be used as roosts by bats in other regions, only two of the bats we followed roosted in trees. All but one of the species we tracked roosted primarily in rock crevices, including western long-eared myotis (*Myotis evotis*), fringed myotis (*M. thysanodes*), long-legged myotis (*M. volans*), and spotted bats (*Euderma maculatum*). Most of the occult myotis (*M. occultus*) roosted in buildings of a nearby valley. Our work at Mesa Verde provided the first observations of reproduction and use of cliff crevices by maternity groups of spotted bats in Colorado, and some of the only detailed roost observations of this species in the United States. Our results underscore the importance of site-specific studies of the roosting habits of bats. Several of the bat species we tracked are known to rely on roosts in trees of piñon-juniper woodlands elsewhere, but we found little evidence for this at MVNP. We suspect that the availability of abundant rock crevices on the park provides bats with more favorable conditions for roosting than do trees. Although radio-tracking studies of this kind are labor intensive, the knowledge gained is essential for the effective management of habitat for bats on a site-specific basis.

***Are Epauletted Fruit Bats Essential for Successful *Ficus sycomorus* Seed Germination during Drought Years in Kruger National Park, South Africa?**
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*** Emily Snode** received the **Luis F. Bacardi Bat Conservation Award**

Kruger National Park (KNP), South Africa, has seen a decline in sycamore fig trees (*Ficus sycomorus*). Figs are known for being keystone species because they provide a food source during the dry season. KNP is inhabited by two species of epauletted fruit bats, *Epomophorus wahlbergi* and *E. crypturus*, and both are known to consume and disperse fig seeds. Epauletted fruit bats effects on germination have remained untested. I investigated the following null hypothesis: there is no significant difference between fig seeds handled by bats and those that were not. I predicted figs handled by bats will affect 1) germination rate and 2) percentage of seeds geminating. In 2008 and 2009, I collected fig seeds found in: a) ripe figs (n = 500), b) spats under feeding trees (n = 1833), and c) guano under feeding trees and in bat holding bags (n = 354). Control samples were separated into two groups: 1) cleaned seeds without pulp and 2) uncleaned seeds with pulp. For both 2008 and 2009 data the two control samples were not significantly different and were pooled for statistical testing. In 2008, *E. crypturus* fecal samples in KNP showed significant differences for germination percentage (c2 = 177.09, $p < 0.001$) and germination rate (U = 31.09, $p < 0.001$) compared to control samples. None of the spat seeds germinated. In 2009, samples collected from *E. wahlbergi* showed a significant difference in fecal (c2 = 31.70, $p < 0.001$) and spat germination percentage (c2 = 65.79, $p < 0.001$) when compared to controls. Significant differences of germination rate were found between treatments and controls (fecal: U = -16.86, $p < 0.001$; spat: U = -13.70, $p < 0.001$). In 2008 and 2009, fruit bats showed significantly positive effects on germination between controls and seeds collected from guano. However, in 2009, the germination percentage of digested fig seeds was nearly 9% less than 2008. Two possibilities account for these differences: 1) field conditions only allowed data collection from one species each year, and differences may be due to level of coevolution between species and figs; 2) weather in both years was dramatically different. Wet season was extended late into 2009, while 2008 was a drought year. Water availability for parent plants may affect fig seeds' ability to germinate. The latter possibility is important as climate change models predict that South Africa will become considerably hotter and drier.

Use of Marine Radar to Study Bat Movements
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Marine radar is a valuable tool for studying the flight patterns of birds and insects, but few studies have used marine radar to characterize bat movements. In 2008, I had the opportunity to study a large colony of Brazilian free-tailed bats (*Tadarida brasiliensis*) using marine radar. I present examples from this work to highlight the advantages and limitations of marine radar, and demonstrate its potential for addressing ecological and applied (e.g., wind energy) bat research questions.

Social Influences and Interindividual Associations in Foraging Short-tailed Fruit Bats (*Carollia perspicillata*)
Spanger Wright, Genevieve, Cynthia F. Moss, and Gerald S. Wilkinson, University of Maryland, College Park, MD

Group-living animals may face both benefits and disadvantages from spending time in the company of conspecifics. For example, animals may conserve energy by gathering food-related information through interactions with conspecifics, but competition for resources may negatively impact a group-living individual. In addition, animals may choose to forage in the vicinity of certain individuals (e.g., roostmates, groupmates, or close relatives). Most bat species are highly social, all must find their way to and from roosts and foraging sites, and many rely on frequently changing food sources. This combination of factors makes bats ideal models for addressing questions about social influences on behavior and interindividual associations. Short-tailed fruit bats (*Carollia perspicillata*) roost in harems. While *C. perspicillata* are generally considered solitary foragers, they have been shown to exchange information about food in a roost setting. Thus, the role of social influences in a foraging context warrants further study. We presented a captive colony of approximately 25 *C. perspicillata* with food-finding tasks (banana hidden behind artificial vegetation) and recorded times to feed for each individual over 15 two-hour periods using a passive integrated transponder (PIT) tag reader and an infra-red sensitive camcorder. In addition, we tested five of these individuals without conspecifics present for ten test periods each. The distribution of number of bats that had fed within a given amount of time on each day of group testing generally reflected a decelerating curve, indicating that social learning was not likely the primary mechanism by which bats were finding the food. While the colony-wide results did not show evidence of social learning, results from bats tested both with and without conspecifics indicate that some individuals may indeed experience increased food-finding success when conspecifics are present. We discuss what might account for this individual variation. We also evaluated instances of pairs of bats repeatedly feeding within a few seconds of one another and discuss possible causes and implications of any such patterns.

Who Infects Whom? Ecological and Evolutionary Drivers of Cross-species Rabies Transmission in North American Bats
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Cross-species transmission is the epidemiological moment of conception for most newly emerging diseases; however, estimates of the frequency and direction of disease transmission between species are virtually non-existent in natural communities, limiting anticipation of disease emergence. The epidemiological and phylogenetic compartmentalization of rabies virus (RV) in a variety of North American bat species provides an exquisite opportunity to understand the intrinsic rates and drivers of cross-species transmission. We present data on cross-species RV transmission taken from the largest phylogenetic survey of RV from American bats to date. We applied robust methods from coalescent theory to infer pairwise rates of cross-species transmission among 18 bat species while controlling for unequal sampling of bat species, variation in the prevalence of RV infection, and phylogenetic uncertainty. Comparative analysis of estimated rates of cross-species transmission revealed inequities in the predisposition of bats to infect other species, which were predicted by ecological and behavioral traits of bats. Furthermore, the directionality of RV transmission, or who infects whom, was non-random, with the highest rates of transmission occurring between closely related bat species. These results emphasize the importance of ecological and behavioral studies of bats for predicting disease emergence, and likewise, suggest that studies of disease transmission can inform basic understanding of inter-specific interactions.

Estimating Occupancy of Rafinesque's Big-eared Bat (*Corynorhinus rafinesquii*) and Southeastern Myotis (*Myotis austroriparius*) in East Texas

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The Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) and southeastern myotis (*Myotis austroriparius*) are species of various levels of concern within their region, the southeastern United States, and are a focus of increased research attention throughout. Despite recent increased research attention for the Rafinesque's big-eared bat and the southeastern myotis, important research questions remain unanswered. First, the lack of reliable and accepted survey techniques limit our ability to assess occupancy. Second, landscape-level variables influencing occupancy are poorly understood. We hypothesized that a combination of acoustic monitoring and active roost search transects could be used to assess occupancy of these rare species in East Texas bottomlands. Data were collected during the summer months (May–August) of 2008 and 2009. Study cells (100 ha, n = 20) were randomly selected among forested bottomland habitats within East Texas. Both survey methods were deployed in each study cell within a single week and were performed as discrete visits, with twenty total sampling occasions per cell. Detection histories and habitat variables were entered into the software program PRESENCE (v 2.2) and analyzed using a single season, constant P model to estimate occupancy and determine detection probabilities. Acoustic data analyzed so far are inconclusive for Rafinesque's big-eared bat detection probabilities ($p = 0.169$); however, they suggest the technique is effective for southeastern myotis ($p = 0.308$). Analysis of additional survey data will refine these estimates further. Initial analysis of habitat data indicates tree size ($\geq$ 30 inches DBH), presence of *Nyssa* spp., and understory density are all important in determining occupancy by these species. Although determining the most effective means of surveying for the Rafinesque's big-eared bat is still unclear, both techniques were successful in detecting both target species.

Wind Energy Bat Mortality—Lessons Learned from Bird Mortality

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The status of our current understanding of bat fatalities at wind energy facilities is comparable to that of avian fatalities in the late 1980s when large scale avian mortalities were first reported at Altamonte. The initial hypothesis that avian abundance and mortality are proportional (Abird ≈ Mbird) was borne out for some avian taxa (e.g., Araptors ≈ Mraptors) but not for most taxa (e.g., Awaterfowl ≠ Mwaterfowl and Ashorebirds ≠ Mshorebirds). Studies of bat mortality have yielded similar results in that there is an apparent relationship between abundance and mortality for some species in some locations but this relationship is not universal. For birds intensive research on collision-prone avian species identified behavioral factors that resulted in increased mortality for these species. For example, engagement in hunting behavior by golden eagles appears to increase mortality (Agoldeneagle + Bhunting ≈ Mgoldeneagle). The equation describing the relationship between abundance and mortality was modified to include behavioral factors (As1+Bs1..sn ≈ Ms1). These lessons learned for birds suggest that: 1) the selection of the taxonomic unit is critical to prevent patterns from being obscured, and 2) the relationship between abundance and mortality may be behaviorally-mediated. If so, then identification of these species-specific factors is critical to improving the strength of pre-construction abundance studies to predict post-construction bat mortality.

How Different is the Flight of Different Bat Species?

Swartz, Sharon, T. Hubel, N. Hristov, and K. Breuer, Brown University, Providence RI

The aerodynamic forces generated during flight are directly reflected in the structure of the wake left behind any airfoil, hence detailed studies of bat flight wakes can provide great insight into the mechanistic basis of bat flight. To date, however, wakes from only 2 of the approximately 1200 bat species have been examined. In this study, we employ time-resolved particle image velocimetry (PIV) to record the wake geometry and investigate the development of wake structure over the wing beat cycle of three bat species that differ substantially in a variety of ways. We correlate the forces computed from the wakes directly with the wing motions captured from high-resolution kinematics, and compare wake architecture and motion patterns among species. We carried out flight studies of three species: *Cynopterus brachyotis*, *Tadarida brasiliensis*, and *Myotis velifer*. These species are roughly similar in body size and are able to fly at the same forward speed, but differ in wing morphology and flight kinematics, as well as migration ecology, phylogenetic affinity, primary sensory modality, roosting ecology, and dietary preferences. They also vary in wing morphology and flight kinematics, although such differences are more subtle than their ecological and phylogenetic differences. We therefore test here between two alternative general hypotheses: H0—diverse bat species show similar patterns of wake structure when flying at comparable speeds due to gross similarities of wing form and motion, vs. H1—bat species that differ in wing structure and/or wing beat kinematics vary in their mechanisms of aerodynamic force production, as reflected in wake structure, when flying at comparable speeds. In each set of recordings, a wind tunnel test section was filled with non-toxic tracer particles, then the flow generated by the bat was visualized by illumination of the particles with laser light to show the wake structure, and captured with high-speed videography. Simultaneously, three high-speed cameras monitored the details of wing motion. Analyses carried out to date show substantial differences in wake patterns among species, and between these species and wakes described to date for birds and one bat species. This supports the hypothesis that mechanisms of aerodynamic force are sensitive to wing architecture and the details of the kinematics of the wing beat cycle.

Descending a Trophic Level—An Account of Vampire Bat Feeding
Szewczak, Joseph M., Humboldt State University, Arcata, CA

As part of an upcoming Discovery Channel feature, I served as a “host” to provide a first-hand account from the perspective of a vampire bat’s prey. Prior to filming, five vampire bats were captured near a local cave and kept as a temporary captive colony in an artificial roost arranged for filming and fed upon pigs, except for two nights prior to filming. To facilitate feeding, I laid still and feigned sleep on a bed in a darkened room adjoining the roost. A sheet covered me except for an exposed elbow and foot. I wore a microphone to whisper a first person account with filming done by infrared and thermal imaging cameras. Bats were released from their roost and eventually flew into the room through a window. I could hear their wings when they flew near me, but otherwise had little awareness of their presence except for one that landed on my hip. I first felt only a subtle tug or pinch on my elbow, but it was my impression at the time that a bat had not made a successful bite and was perhaps just inspecting a potential feeding site prior to an actual bite. However, that was indeed a successful bite and two vampires shared feeding from that same bite. I had only a slight sensation of the feeding activity that progressed. I did feel more of a definite incision and tug from two bites on my toes, from which three bats fed. I similarly had very little sense of the feeding activity that progressed on my toes, and experienced no sensation of pain throughout the one hour while they fed and I believe I could have easily slept through the entire feeding bout. However, the after effects of blood and wet spots from urination during feeding left an unmistakable signature of their action had I slept. Rather than just making a simple incision, the bats sliced out little divots of skin, one of which was found on the bed afterward. Bleeding continued from the wounds for several hours afterward, apparently from the anticoagulant and blood flow promoters in the bat’s saliva. Although the bites were treated with Neosporin afterward, there was minimal sign of inflammation, and the wounds have healed with minimal scarring.

Personality in Two Populations of Little Brown Bats (*Myotis lucifugus*)
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Animal personality, measured as repeatable individual differences in behavior, has been examined for a growing number of species. However, little to no work on personality has been conducted using bats as a study species. We modified a standard test of rodent exploratory behavior used in our laboratory, the hole-board test, to quantify activity and exploration in two populations of little brown bats (*Myotis lucifugus*). First, we set out to determine if individual differences in personality existed within these bat populations. We classified individuals as bold or docile based on their levels of exploration compared to the average and then repeated the hole-board test to determine if these differences in behavior were repeatable over time. We quantified test responses of male and female juvenile bats from a summer roost site in southern Manitoba with those caught during fall mating swarms at a hibernaculum in central Manitoba to test for differences in personality between populations and between sexes. In the future, understanding differences in personality between different groups of bats could help us understand within-species variation often observed in field studies of behavior, such as between-individual differences in home range size, roost selection, or social behavior.

Prey Abundance and Seasonal Movements of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)
Todd, Christopher M.[1], Corinna Pinzari[1], Brad Yuen[2], Frank Bonaccorso[1], and Marcos Gorresen[1], [1]University of Hawaii at Hilo, HI; [2]U.S. Geological Survey, Hawaii National Park, HI

The Hawaiian hoary bat (*Lasiurus cinereus semotus*) is the only terrestrial mammal native to the Hawaiian Islands and currently is listed as an endangered species due to apparent population declines, lack of knowledge concerning it distribution, and habitat loss. Echolocation surveys reported elsewhere in this symposium indicated that Hawaiian hoary bats display striking seasonal movements along the steep gradient of elevation across eastern Hawaii Island. Changes in temperature and rainfall are a likely cause for these migrations. However, the extent to which peaks in food correspond with the bat's migration has received little study. Here we present preliminary data on insect phenology and abundance across an annual cycle at five sites along a gradient of elevation. We link these insect data to echolocation surveys to gain insights on how availability of prey corresponds with seasonal migratory movements. We hypothesize that insect abundance will show a positive correlation with bat vocalization activity. Data collected from early April to August 2009 at two low elevation sites show that as overall insect abundance increase there is an increase in bat activity. Data collected at a mid-elevation site show that in early April there is a spike in insect activity, primarily Lepidoptera, while bat occurrence is still relatively low. The following survey in June shows an increase in bat occurrence and supports a hypothesis previously predicted by T. Menard that bats migrate from high interior elevations to coastal lowlands to reproduce in summer months. Within each survey night there also appeared to be a positive relationship with insect abundance and bat occurrence.

Fruit Bat Ensembles and Availability of Food Resources in Tropical Semi-evergreen Forest Remnants from Central Veracruz, Mexico: A Progress Report

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The tropical semi-evergreen forests of central Veracruz, México, contain relatively diverse ensembles of fruit bats. Although formerly fairly widespread, this habitat has been reduced to small and relatively isolated remnants. Still, bats here are more abundant and diverse than in the surrounding natural (mostly seasonally dry and montane tropical forest) and humanized habitats, which contain impoverished subsets of the bat assemblage present in the semi-evergreen forest. Understanding the mechanistic processes that allow the persistence of these relatively complex ensembles in those relatively small forest patches is essential for planning conservation of bats and forests at a regional scale. Furthermore, isolation of bats in forests with variable floristic composition allows testing the relative roles of neutral and deterministic processes in shaping bat ensembles. We want to assess the links between bat ensemble composition and resource availability along seasonal variation of the annual cycle, establishing the relationships between the trophic ecomorphology of bats and the resources that they consume in the forest remnants. We have been sampling the fruit bat community and their food resources bimonthly since March 2009 in five forest remnants. Bats have been sampled with mist nets and marked with plastic collars, and their diet has been studied from fecal pellet analysis. Availability of fruits has been assessed by counting them in 2700 m^2 transects. The physical properties of fruit (weight, size, hardness) have been measured in a sample of collected fruits, and a sample of bats has been collected for measuring the ecomorphological structure of their trophic structures. This communication is a report of the progress in the study and presents preliminary analyses of the available data. Ten species of fruit bats are present in the region. It is immediately evident that the composition of fruit bat ensembles changes dramatically among seasons and sites. Fruit resources vary as well among seasons and sites, both in quantity and quality. However, *Piper* spp. seem to make up the bulk of the diet of most bat species. These preliminary data indicate a very dynamic character of the bat ensembles in the region, where bats perhaps move relatively long distances looking for temporary patches of resources. The very few recoveries of marked bats support this initial perception.

Large-scale Patterns of Diversity and Distribution of Phyllostomidae Compared with Dynamic Neutral Model

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Phyllostomidae is a Neotropical bat family restricted to the American continent, presenting a strong latitudinal gradient of species richness. The aim of this work is to contribute to a better understanding of the processes responsible for the conformation of the pattern in the distribution of phyllostomid species. Null models have been widely used in macroecology for studying biodiversity and geographic distribution, and for inferring the mechanisms of community assembly. Here we use a neutral model to incorporate a dynamic mechanism to generate quantitative predictions as a benchmark for patterns of diversity and geographic distribution of species in a real data set. The model incorporates a demographic process with speciation and dispersal parameters where all the individuals have identical demographic probabilities, in a spatial context. We compare the results of species distribution generated by simulations with the geographic patterns of the 143 species of Phyllostomidae with continental (non-insular) distribution. The geographic analysis was made for the entire family at a continental scale using two recently developed concepts—the diversity field (the set of species richness values of all sites in which a particular species occurs), and the dispersion field (the set of geographic ranges of species occurring in a given site).

Neutral dynamics can produce spatial patterns of species richness and occupancy distribution showing a particular structure, right skewed frequency distribution of range size, and heterogeneous distribution of richness among sites. The speciation process is essential for the maintenance of diversity in the model so that the distance of dispersion determines the distribution of diversity, the range size, and the overlapping of species. The empirical results present the same mean values as the simulations. The results show that neutral models are capable of providing appropriate null hypotheses for the evaluations of macroecological questions.

Correlates of Viral Richness in Bats (Order Chiroptera)

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Historic and contemporary host ecology and evolutionary dynamics have profound impacts on viral diversity, virulence, and associated disease emergence. Bats have been recognized as reservoirs for several emerging viral pathogens, and are unique among mammals in their vagility, potential for long distance dispersal, and often very large, colonial populations. We investigate the relative influences of host ecology and population genetic structure for predictions on viral richness in relevant reservoir species. We test the prediction that host geographic range area, distribution, population genetic structure, migratory behavior, IUCN threat status, body mass, and colony size are associated with known viral richness in bats. We analyze host traits and viral richness in a generalized linear regression model framework, and include a correction for sampling effort and phylogeny. We find evidence that sampling effort, IUCN status, and population genetic structure predict viral richness in bats, and that these associations are independent of phylogeny. This study is an important first step in understanding the mechanisms that promote viral richness in reservoir species, and will likely aid in viral surveillance efforts and predicting future viral emergence of bat zoonoses.

Systematics of the *Platyrrhinus helleri* Species Complex (Chiroptera: Phyllostomidae)

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Platyrrhinus is a diverse genus of small to large phyllostomid bats characterized by a comparatively narrow uropatagium that is thickly fringed with hair, a white dorsal stripe, comparatively large inner upper incisors that are convergent at the tips, and three upper and three lower molars. Eighteen species are currently recognized, the majority occurring in the Andes. Until recently, *Platyrrhinus helleri* was considered to be a widespread species occurring from Mexico to Peru, Bolivia, Amazonian Brazil, northern South America, and Trinidad. But recent analyses found surprising heterogeneity within it: the name *P. helleri* should be restricted to Central American populations; a new species (*P. matapalensis*) occurs in the Pacific lowlands of Ecuador, Colombia, and Peru; three different lineages inhabit South America east of the Andes; and the name *P. incarum* applies to South American populations (excluding *P. matapalensis*). Here, we explore further the systematics of the *P. helleri* species complex to determine if additional species are present in the South American component. We analyzed molecular, morphologic, and morphometric data to clarify patterns of diversification in this complex of taxa previously subsumed under the name *P. helleri*. The analyses of specimens formerly identified as *Platyrrhinus helleri* support recognition of *Platyrrhinus incarum* as a separate species and reveal the presence of two species from northern and eastern South America—the first from eastern Colombia and Ecuador, northeastern Peru, and Venezuela; and the second from Guyana, Suriname, French Guiana, Trinidad and Tobago, northern Brazil, eastern Ecuador, and southern Venezuela. These taxa are reciprocally monophyletic in genetic terms and can be diagnosed by discrete morphological characters.

Stylohyal Connection Points to Laryngeal Echolocation

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The diversity of bats with respect to echolocation provides an excellent context in which to examine the structure and connections of bones such as the stylohyal. This bone serves as a major point of attachment for many of the muscles and ligaments involved in breathing, swallowing, and sound production. We hypothesize that the

connection between the larynx and the auditory bullae allows bats to register outgoing calls for future comparison with retuning echoes. Using data obtained from microCT scans of 26 bat species (n = 35 fluid-preserved bats), we demonstrate that proximal (cranial) contact of the stylohyal bone with the ectotympanic bone always distinguishes laryngeally echolocating bats from all other bats. In laryngeally echolocating bats, the proximal end of the stylohyal directly contacts the ectotympanic and is often fused with it. This bony feature indicates that the oldest Eocene fossil bat (*Onychonycteris finneyi*) may have had the capacity for laryngeal echolocation, reopening a basic question of the timing of the appearance of flight and echolocation in bat evolution.

The Diversity Field of New World Leaf-nosed Bats (Phyllostomidae): Continental Patterns of Geographic Coexistence

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Geographic variation in species richness results from the differential coexistence among species in different regions. Such geographical coexistence is, in turn, determined by the properties of the geographic ranges of species such as size, shape, and location and the overlap (co-occurrence) among them in particular localities. Consequently, studying the internal structure of ranges based on the overlaps with other ranges can enhance the understanding of large-scale patterns of species richness. In this study, we introduce the concept of "diversity field" to investigate the internal structure of ranges by linking richness and distribution to analyze the geographic variation in species richness within individual ranges in terms of geographic associations. We define the diversity field as the set of species-richness values of sites within the range of a given species. Our goals were to describe how species richness is distributed inside individual species' ranges, identify patterns related to species' characteristics, and determine the potential factors shaping patterns of species associations at geographic scales. We constructed a database of the continental distribution of phyllostomid bats and generated a presence-absence matrix. We extracted information from such matrix to measure the overlap of all species within the range of each individual species. We described and examined the diversity field with three complementary approaches: 1) the analysis of species richness frequency distributions, 2) the examination of maps showing the range of species with the corresponding richness values, and 3) the construction of range-diversity plots. We model the shape and location of species' geographic ranges to generate statistical null hypotheses under the assumption of no association among species. In conclusion, phyllostomid bats show a higher level of co-occurrence than expected by chance. The majority of species have high richness values within most part of their ranges, implying a great number of potential interactions with other bats throughout their geographic distribution and no apparent limitation for coexistence. Based on the null models, we can explain the diversity field patterns of these bats as a result from the interaction of different factors including geometric (range cohesion, mid-domain), geographic (size and shape of continent), climatic, and idiosyncratic of species (potential ecological interactions).

Seasonal and Geographic Trends in Acoustic Detection of Tree-roosting Bats

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Migratory routes, timing, and behavior are some of the least studied facets of bat biology; however, these little studied biological patterns possibly play significant roles in the mortality rates observed at commercial wind energy facilities in North America. A better understanding of the timing of bat migration may be helpful in mitigating direct impacts of wind energy facilities. Between April and November 2007 and 2008, we used acoustic detectors to record activity above the forest canopy at 14 commercial wind facilities (13 proposed and 1 existing) in 7 eastern U.S. states. We first grouped survey locations into three geographic regions, then compared bat activity patterns at survey locations within and among regions. We also compared bat activity at one survey location to bat mortality at an operational wind facility within 50 km. During two years of survey, we identified 6802 eastern red bat (*Lasiurus borealis*), 1908 hoary bat (*L. cinereus*), and 2603 silver-haired bat (*Lasionycteris noctivagans*) calls during 6153 detector-nights. Each species exhibited seasonal activity patterns that varied among geographic regions, although activity patterns were highly correlated across surveys within the same geographic region. These data indicate that seasonal activity of eastern red bats, hoary bats, and silver-haired bats—as recorded by Anabat detectors—reflected migratory patterns of these three species. Results support the use of acoustic surveys to predict the timing of activity events at commercial wind energy developments.

Monitoring Population Trends in a Colony of Mexican Long-nosed Bats (*Leptonycteris nivalis*) in Big Bend National Park Using Thermal Imaging of Emory Cave

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The endangered Mexican long-nosed bat (*Leptonycteris nivalis*) has few roosting sites in the United States. Where sites do exist population surveys must take into account the endangered nature of the species to minimize disturbance. Emory Cave, located in Big Bend National Park, is one such roost where a population can be surveyed. Thermal imaging can provide a more accurate population estimate than using data from surface area of the cave ceiling covered by bats. The *L. nivalis* population differs from year to year correlating to the *Agave* population, their primary food source. A thermal imaging camera (FLIR P65) was mounted outside the entrance of Emory Cave for three nights in July 2009 (July 3–5) and used to record the emergence of bats out of the cave, and this footage was then reviewed by manually counting the emerging bats. When possible *L. nivalis* was distinguished from other species that share the cave such as *C. townsendii* and *M. thysanodes* using factors such as a larger size and a unique thermal profile. When compared with previous surveys, there was a lower emergence in 2009 than would be expected in association with the *Agave*. This could be attributed lunar phobia as the moon was in the waxing gibbous phase during the nights recorded and full two days after completion of recording. Earlier surveys in 2005 and 2008 had a new moon and a waning crescent, respectively, with 2005 having very high numbers. In 2009 numerous bats were noted visually at the cave entrance circling, presumably either negotiating an exit or actively avoiding brightly lit areas. Overall the data suggest that while *Agave* and *L. nivalis* populations were up in 2009 fewer bats emerged, preferring to stay in the cave or circle the entrance, possibly due to lunar phobia.

Using Occupancy Estimation to Design Echolocation Monitoring Studies at Wind Energy Facilities in the Southwestern United States

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Echolocation monitoring is frequently used to measure bat activity levels at proposed and operating wind energy facilities. It is well suited to capture temporal variation in bat activity patterns because it can be configured to operate nightly for weeks without interruption. However, questions remain about its ability to predict bat fatalities and about the number and distribution of detectors necessary to cost-effectively characterize activity patterns for at-risk groups of bats. From Fall 2007–Spring 2009 I conducted nightly echolocation monitoring at a wind energy development in the San Gorgonio Pass Wind Resource Area near Palm Springs, California. A mean of 13.4 detectors per night were deployed at three heights (2, 22, 52 m) over 518 nights. I used these data to link echolocation activity to meteorological data and fatalities discovered during weekly searches. I estimated seasonal occupancy rates that ranged from 0–99% and detection probabilities that ranged from 0.03–0.56 depending on season, echolocation characteristics of the bats, and heights at which detectors were deployed. I argue that a site-occupancy analysis approach yields intuitive results useful for designing cost-effective and precise monitoring efforts. Because it also provides condition-specific predictions of bat activity it has potential to be a vital component of mitigation programs (e.g., operations curtailment). Specific recommendations are provided for designing echolocation monitoring programs in the southwestern United States that are both cost-effective and specifically targeted to species at highest risk.

Prevalence of Rabies Antibodies in Free-flying Insectivorous Bats in Arizona

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Rabies is global in distribution with bats acting as a primary reservoir on all inhabited continents. As vaccination programs have reduced rabies in terrestrial carnivores, bats will continue to provide an important ecological niche in which lyssaviruses will persist, diversify, and provide a source for new variants. Additionally, although human rabies deaths in the U.S. are quite low, in recent decades, bat-associated variants of rabies virus have been responsible for most cases. Therefore, an examination of rabies prevalence, distribution, and diversity in wild bat populations will assist management and control efforts that aim to protect humans from this fatal disease. In this multi-year study, we plan to collect serum and saliva samples from bats in Arizona to determine rabies virus neutralizing antibody (VNA) levels and to screen for rabies virus amplicons, respectively. From this survey in free-flying bats, we hope to obtain a better understanding of exposure rates in a variety of species with varied life history traits, and to gain a better understanding of viral circulation in natural populations, especially as related to potential spillover events (i.e., bat rabies occurrence in terrestrial carnivores, such as skunks). Data collected in 2007 from 282 bats of 16 species showed an average of 8.8% of bats had evidence of rabies VNA, with the highest prevalence in *Eptesicus fuscus*. Additionally, one *Parastrellus hesperus* had amplicons of rabies virus in its saliva. Data from 2008 are under analysis and sampling for 2009 is underway. Results from this multi-year study should allow a better understanding of bat rabies epidemiology in free-ranging populations.

Revisiting Phyllostomid Bat Phylogeny: A Combined Analysis of Morphological and Molecular Data
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Phyllostomidae (New World leaf-nosed bats) is the second largest family of yangochiropteran bats with > 55 genera and > 155 extant species including insectivores, frugivores, nectarivores, omnivores, and even sanguinivores. As such, it is arguably the most ecologically diverse mammalian family. Over the past 60 years, more than 55 studies have used morphology, immunology, allozymes, karyotypes, and various types of molecular data to address relationships among extant phyllostomids. Most recently, two competing hypotheses for higher-level phyllostomid relationships have emerged—one based primarily on morphology and the other on DNA sequence data. To develop a comprehensive, robust phylogeny for phyllostomids that uses both morphological and molecular data, we examined incongruence between these data sets to evaluate the possibility of combining them into a single analysis. We found limited conflict between the data sets when support values and significance testing are considered: strongly-supported clades in one partition are generally not contradicted by strongly supported clades in the other, and vice versa. We revised our previously published morphological data set, added new characters, and scored taxa at the species level to provide a better match to existing molecular data sets, which included > 4600 base pairs from mitochondrial genes (*12S rRNA*, *valine tRNA*, *16S rRNA*, *cytochrome b*, and *cytochrome oxidase I*) and > 1300 base pairs from the nuclear recombination activating gene 2 (*RAG2*). In addition to 71 ingroup terminals (phyllostomid species) we included 9 outgroup terminals: *Saccopteryx bilineata* (used to root the tree), both species of *Mystacina*, 3 species from the family Mormoopidae, and single representatives of Noctilionidae, Thyropteridae, and Furipteridae. Using a variety of methods (maximum likelihood, parsimony, Bayesian), combined data analyses recovered trees that included elements from both the morphology and molecular partitions. Monophyly of many phyllostomid subfamilies was upheld in our analyses; however, none of our analyses supported—and most significantly rejected—phyllostomine monophyly.

The Effects of White Nose Syndrome: Straddling the Line of Pre- and Post-exposure
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White nose syndrome (WNS) was first discovered in New Jersey during the winter of 2009. Hibernacula surveys showed evidence of the characteristically high mortality and raised concerns for summer surveys. Since the 2005 discovery of federally endangered Indiana bats (*Myotis sodalis*) at Great Swamp National Wildlife Refuge (GSNWR) in New Jersey, there has been intensive summer bat work conducted at this site. It has proven to be a species-rich area, with the high-quality habitat sustaining six of the nine bat species found in the state. The 2008–2009 field season provided a valuable opportunity to directly assess the impacts of WNS on these frequently captured species: Indiana bats (*Myotis sodalis*), little brown bats (*Myotis lucifugus*), northern long-eared bats (*Myotis septentrionalis*), tricolored bats (*Perimyotis subflavus*), big brown bats (*Eptesicus fuscus*), and red bats (*Lasiurus borealis*). Mist-net surveys were used, and the same locations were netted each year. The overall health of captured bats was assessed, including weight, reproductive status, and wing damage. Despite an unusually wet early 2009 season, summer capture rates of most species were similar between years: big brown bat numbers increased from 2008 (82 captured) to 2009 (151 captured) and Indiana bats—in part due to low capture rates during the early 2009 season—showed slightly lower numbers (35 captured in 2008; 26 in 2009). The most pronounced difference in capture numbers was exhibited by little brown bats. This species had been the most commonly captured on the refuge (114 in 2008), but only 3 were caught at GSNWR during the entire 2009 season. The three that were captured were found early in the season; no little brown bats were captured after June 16. These capture data give us a strong preliminary look at the changes of the bat population at GSNWR in this first year of WNS exposure. The extremely different numbers of little brown bats caught during these two pre- and post-WNS years indicate that this disease has already had a significant impact on at least this species at GSNWR.

The Effects of Elevation and Associated Environmental Conditions on Species Diversity and Female Abundance

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Habitat degradation and climate change are two critical factors predicted to negatively affect the size of regional bat populations in the future. In Colorado, habitat loss due to increasing human populations and development increases yearly, and with the addition of apparent rapid climate change, we predict wildlife populations, including bats, could be negatively affected. Therefore, close monitoring of populations is critical to effective management. Although much research has been conducted on bats at elevations below 7500 ft. in Boulder County, Colorado, almost nothing is known about bat populations residing at higher elevations under different seasonal climates. I hypothesize that as elevation increases, female abundance and species diversity will decrease, and habitat use and roost characteristics will change. To determine how elevation affects female abundance and species diversity, I netted bats at varying elevations and compared capture data across the gradient. In addition, I used a Pettersson D240X to record echolocation calls and Sonobat analysis software to identify bats to species. Capture data were used to determine species diversity across elevational gradients using a Simpson Index of Diversity. During June, July, and August 2009, we netted 33 nights at 16 different locations in the Front Range of Colorado, ranging in elevation from 1800 m to over 3300 m. I captured 37 females and 83 males. Of the 37 females, 15 were reproductive: 3 *Myotis volans*, 4 *M. lucifugus*, 4 *M. evotis*, 3 *Corynorhinus townsendii*, and 1 *M. thysanodes*. No reproductive females were caught above 2550 m, and only three *M. volans* and one *M. evotis* were captured above 2100 m. Using preliminary capture data we saw a Simpson Diversity Index of 0.254 at low elevation (below 2285 m), 0.511 at mid-elevation (2286–2699 m), and 0.431 at high elevation (above 2700 m). These data suggest that with cooler than average temperature and less than average precipitation in summer 2009, reproductive females tended to occur at lower elevations, and species diversity was higher at lower elevations.

Investigating Migratory Patterns of *Tadarida brasiliensis* in the Southwest from a Cave in the Great Basin of Nevada

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We used aerial and ground-based radiotelemetry during Fall 2008 and Fall 2009 to study a large colony of Brazilian free-tailed bats (*Tadarida brasiliensis*) in east-central Nevada. During the 2008 study we followed 64 bats to collect localized flight and dispersal data, while in 2009 we followed 22 bats to collect migratory data. We found the colony to be highly migratory, with residency periods lasting only a few days before individual bats continued their migration. Some individuals migrated over 100 miles per night. We were prepared to track bats as far south as possible in the United States, and the results were staggering.

An Indiana Bat (*Myotis* sodalis) Maternity Colony's Foraging Activity in Northeastern Missouri: An Unaffected White Nose Syndrome Area

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Studies examining foraging and roosting activities of summering Indiana bats (*Myotis sodalis*) have suggested that selective tree removal in oak-hickory dominated stands should increase *M. sodalis* use. However, no studies have documented the changes in habitat use before and after timber removal. My study focused on maternity colony habitat use in Charles Heath Memorial Conservation Area in Clark County, Missouri, which is currently in an area that is unaffected by white nose syndrome. This area will undergo forest management in the fall of 2010 with two years of baseline data. I will present the telemetry results from 2008 when I monitored foraging and roosting activities for seven female *M. sodalis*. I conducted all-night foraging surveys using radiotelemetry and monitored each female's activity at a minimum of six times an hour. Roost trees were identified each morning and vegetation was sampled using prism plots to get an estimate of basal area. The analysis of individual's foraging activity was done using the GTM3 program with an error polygon to calculate the confidence of each location. I calculated the 95% kernel areas based on roosting locations, and the entire 95% home range kernel based on foraging locations for each individual. Foraging area will be defined as the area outside of the roosting area kernel to the outside edge of the foraging kernel.

Seven Years of Mist Netting in the World's Smallest Mountain Range (1998–2009)

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The Sutter Buttes of California's northern Central Valley are the remains of an extinct volcano that erupted approximately 1.5 million years ago. Locally they have been described as the "world's smallest mountain range." It is essentially a small cluster of peaks that abruptly thrust upward out of the floor of the Central Valley west of the town of Yuba City in Sutter County. The Sutter Buttes cover 16 km^2 and reach an elevation of 645 m at its highest point (South Butte). Since 1998, the author has conducted mist netting and acoustic inventories in two areas of the Sutter Buttes adjacent to North Butte (1998–1999, 2002–2003, 2007–present). A total of 521 bats have been captured from 12 species. In addition, one other species (*Eumops perotis*) is regularly heard and recorded utilizing the Anabat system. Of the 12 species caught via mist netting, *Parastrellus hesperus* was the most commonly captured, accounting for 42% of all captures (n = 218). Other species with 50 or more occurrences include *Tadarida brasiliensis* (n = 75, 14%), *Antrozous pallidus* (n = 55, 11%), and *Lasiurus blossevillii* (n = 50, 10%). The remaining 23% of captures were from the following eight species: *Eptesicus fuscus*, *Lasiurus cinereus*, *Lasionycteris noctivagans*, *Myotis californicus*, *Myotis ciliolabrum*, *Myotis evotis*, *Myotis lucifugus*, and *Myotis yumanensis*.

Cars Can Disturb Commuting Bats, but to What Degree is This Influenced by the Landscape?

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The negative implications of roads on wildlife are a growing concern globally. Understanding these implications and exploring ways to minimize these effects has become a priority. For example, recent studies have shown that bats perceive vehicles as a threat and will turn around along commuting routes in response to the presence of a vehicle. Subsequently roads can act as a barrier or a partial barrier to commuting bats. The question is what influences the bats to turn around in response to the presence of a car and in particular, what features of the landscape facilitate this response. Previously conducted radio-tracking studies at Indianapolis International Airport were used to identify five commuting routes. Data were collected on the characteristics of vehicles traveling along roads intersecting the commuting routes, the characteristics of commuting bats, and the composition of landscape. Observational surveys of the former two were conducted during the primary foraging period from 2100–2400 h at each site at a minimum of three times. The following data were collected: vehicle noise levels, speed of vehicle, the direction of traveling vehicles, the distance of the vehicle from the commuting route when the bat responded, whether the vehicle was using full beam headlights, and the size of the vehicle. Concurrently, information on the flight of the bat was collected including height, direction, and speed of commuting bats and distance from the road when the bat responded. An ANABAT was used to record the echolocation calls of passing bats so that we could potentially identify different species. Surveys were also conducted at intervals along each commuting route to collect data on vegetation composition and structure, and the visibility and audibility of vehicles traveling along the road. The results of these surveys demonstrated that the structure and composition of the landscape comprising commuting routes influenced whether bats reacted to passing vehicles. Differences in the visibility and audibility of vehicles to bats along the routes lead to variations in disturbance-related responses. The management of commuting routes to reduce these factors is vital to minimizing disturbance-related responses and thus the barrier effects of roads.

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BOOK REVIEW

Seed Dispersal by Bats in the Neotropics. Tatyana A. Lobova, Cullen K. Geiselman, and Scott A. Mori. The New York Botanical Garden, Bronx, New York. 471 pp., 2009. ISBN 978-0893275013 ($70.00 United States)

In 1977 Alfred Gardner, a zoologist, reviewed published data on the diets of plant-visiting phyllostomid bats (Gardner 1977). His summary indicated that the diets of these bats included 145 genera of fruits and flowers from 66 families of angiosperms. These taxa included Old World exotics, as well as questionable records of pollen from families such as Graminae and Pinaceae, and a critical review of the food habits of these bats has been long overdue. A recent summary of the diets of nectar-feeding phyllostomids (Fleming et al. 2009) reported that their foods include 360 species of flowers in 159 genera from 44 families. In a new book, *Seed Dispersal by Bats in the Neotropics*, Lobova et al. (2009) report that fruit-eating phyllostomids disperse the seeds of 549 species in 191 genera from 62 families. These recent compilations clearly indicate that plant-visiting phyllostomids provide substantial ecosystem services as dispersers of pollen and seeds in the New World tropics and subtropics.

Seed Dispersal by Bats in the Neotropics was written by three botanists, based at the New York Botanical Garden, who have conducted intensive field research on bat-plant interactions in the lowlands of central French Guiana. Data from this area, which indicate at least 112 species of fruits in the diets of 22 species of phyllostomids, form the core of this new volume. However, the book contains much more than a summary of field work in French Guiana. It is an exhaustive review of most aspects of the role played by fruit-eating phyllostomids in the ecology and evolution of Neotropical fruits.

This new book is organized into five main sections. An introduction provides a general overview of bat-plant interactions and is followed by a section that describes the study area and the techniques of data analysis. In the third part, the authors give a detailed account of bat-dispersed plants, by family, and include 32 color plates illustrating the diaspores (the actual dispersal unit) of the plants. The next section is a comprehensive depiction of the diets and foraging behavior of frugivorous bats by species, and the main text of *Seed Dispersal by Bats in the Neotropics* ends with a section that summarizes the major findings of the book. There also are four lengthy appendices, containing a list of plants and their chiropteran dispersers in central French Guiana, a similar list for the entire Neotropics, a list of frugivorous bats and the plants that they disperse in the Neotropics, and a glossary of botanical terms used in the book.

This volume is a landmark contribution to our knowledge of fruits, frugivores, and seed dispersal in the New World tropics for several reasons. First, it sets a rigorous standard for the description of the fruits, infructescences, and diaspores produced by bat-dispersed plants. Second, this book provides a detailed analysis of the characteristics of bat-dispersed fruits, including such traits as plant life form and fruit/infructescence color, size, shape, and volume, in the context of a thoroughly studied regional flora. As expected, bat fruits tend to be a non-random subset of fleshy fruits available in the flora of central French Guiana, and their features do not always conform to those of the classic bat-fruit syndrome. Third, *Seed Dispersal by Bats in the Neotropics* provides a broad comparative analysis of dietary studies of bats at other Neotropical locations to document geographic variation in the interactions between frugivorous bats and their food plants. Among other things, this comparison reveals that bats in French Guiana eat a greater number of fruits produced by epiphytes, especially those in the Araceae and Cyclanthaceae, than bats in central Panama. Fourth, the text compares the diets of frugivorous bats with those of other vertebrate frugivores in central French Guiana and reveals that the diets of fruit bats overlap more with those of primates than with those of birds. Finally, the authors thoroughly review the literature on the fruiting biology and dispersal of the top-ranked families of bat-dispersed plants, as well as the diets and foraging behavior of both specialized (i.e., species of the subfamilies Carolliinae and Stenodermatinae) and opportunistic (i.e., species of Glossophaginae and Phyllostominae) frugivores. Review of this literature reveals how spotty our knowledge about these plants and their dispersers still is.

Overall, this book is well-produced, is basically free of typographical errors, has beautiful color plates that will help researchers identify the seeds found in bat fecal samples throughout the Neotropics, and has useful summaries of published and unpublished data in the appendices. I would have preferred to see a more rigorous analysis of bat-fruit traits in a phylogenetically controlled framework, but that approach is forthcoming (T. Lobova, pers. comm.). Because it highlights the importance of frugivorous bats as dispersers of the seeds of primary, as well as secondary forest plants, this book has great conservation value. *Seed Dispersal by Bats in the Neotropics* should be in the library of everyone interested in the ecology and evolution of plants whose seeds are dispersed by frugivorous phyllostomid bats.

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ANNOUNCEMENTS

M.S. Research Assistantships, University of Maryland and Frostburg State University

M.S. Research Assistantships are available in Wildlife and Fisheries Biology or Applied Ecology and Conservation Biology at the University of Maryland Center for Environmental Science, Appalachian Laboratory, and Department of Biology, Frostburg State University. Search will continue until openings are filled. To apply (electronic submission preferred), send a cover letter indicating availability, résumé, copies of transcripts and GRE scores, and names and addresses (including email) of three references to J. Edward Gates (egates@al.umces.edu). Please write "Bat Assistantship" in the subject line of your email.

2010 Bat Conservation International Student Research Scholarships

Bat Conservation International is accepting applications for its 2010 BCI Student Research Scholarships. Grants of up to $5,000 each will be awarded for the 2010–2011 academic year. Grants will be awarded for research that is directly related to bat conservation, with an emphasis on research that documents roosting and feeding habitat requirements of bats, their ecological and economic roles or their conservation needs. Ten of these scholarships are supported by the U.S. Forest Service International Programs specifically for research conducted in developing countries. Students enrolled in any college or university worldwide are eligible to apply for BCI scholarships. Applications are competitive and will be reviewed by bat scientists outside BCI. The **application deadline** for 2010 scholarships is **15 December 2009**. Information and the online application form are available at http://www.batcon.org/scholarships

New Book: *Bat Rabies and Other Lyssavirus Infections*

Bat Rabies and Other Lyssavirus Infections (by Dr. Denny G. Constantine) is intended for scientists and the general public. presents the material in a simple, straightforward manner that serves both audiences. The book, written and prepared by the U.S. Geological Survey National Wildlife Health Center, was published with the goal of increasing public understanding of rabies and the often misunderstood bat, and providing a balanced perspective on the risk of bat rabies to people. The publication is available online (USGS Circular 1329) and printed copies are available from the USGS Store (Product #213560). For details, more information, and links, please see: http://www.nwhc.usgs.gov/publications/other/batrabies.jsp

Request for Manuscripts — *Bat Research News*

Original research/speculative review articles, short to moderate length, on a bat-related topic would be most welcomed. Please submit manuscripts as MSWord documents to Allen Kurta, Editor for Feature Articles (akurta@emich.edu). If you have questions, contact either Al (akurta@emich.edu) or Margaret Griffiths (griffm@lycoming.edu). Thank you for considering submitting some of your work to *BRN*.

Change of Address Requested

Will you be moving in the near future? If so, please **send** your **new address** to the managing editor/publisher, Margaret Griffiths (griffm@lycoming.edu), as soon as possible. Thank you in advance for helping us out!

2010 Renewal Notices — *Bat Research News*

It is once again time for subscription renewals! You should be receiving a renewal notice for the 2010 volume-year very soon, if you have not already. In order to keep subscription rates as low as possible, renewal notices will be sent via e-mail whenever possible (or at least the first and second "friendly reminders" will be!). It would be most helpful if you would kindly set your e-mail filters to allow messages through from the Editor, Margaret Griffiths (griffm@lycoming.edu). If an e-mail address is not available for you, notices will be sent via the post. If you do not receive a renewal notice soon (and think you should have received one), please let the Editor know. Thank you for subscribing to *BRN* this past year, and I hope you will consider renewing again for 2010. All of us at *Bat Research News* wish you a happy, safe, and productive 2010!

FUTURE MEETINGS and EVENTS

19–21 February 2010
The 2nd International Berlin Bat Meeting: Bat Biology and Infectious Diseases will be held in Berlin, Germany. More information is available at : http://www.izw-berlin.de/

12–14 July 2010
The 14th Australasian Bat Society Conference will be held at Charles Darwin University, in the coastal city of Darwin, Northern Territory, from 12–14 July 2010. Darwin (population 121,000) is located in the heart of Australia's northern tropics. The conference will feature three days of presentations followed by a 2-night field trip to Pine Creek, home of the world's largest known colony of Ghost Bats, *Macroderma gigas*. Further details are available on the ABS Web site at: http://conference.ausbats.org.au/

23–27 August 2010
The 15th International Bat Research Conference (IBRC) will be held in Prague, Czech Republic, from 23–27 August 2010. For more information please see: http://www.ibrc.cz/

27–30 October 2010
The 40th Annual NASBR will be held in Denver, Colorado, from 27–30 October 2010. Please see http://www.nasbr.org/ for information.

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

2011
The 41st Annual NASBR will be held in Toronto, Ontario, Canada, dates to be announced. Please check the NASBR Web site at http://www.nasbr.org/ for upcoming information.

2012
The 42nd Annual NASBR will be held in San Juan, Puerto Rico, dates TBA.