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Table of Contents for Volume 49, 2008

Volume 49: Number 1, Spring 2008

Volume 49: Number 2, Summer 2008

BAT RESEARCH NEWS

Table of Contents for Volume 49, 2008

(cont.)

Volume 49: Number 3, Fall 2008

Volume 49: Number 4, Winter 2008

BAT RESEARCH NEWS

Volume 49: No. 1 Spring 2008

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From the Editor

Hello Everyone!

I am very pleased to announce that Dr. Jacques Pierre Veilleux (Franklin Pierce University, Rindge, NH) has agreed to serve as the new Editor for Recent Literature. Jacques will assume these duties beginning with the next issue of *Bat Research News*, Volume 49: Number 2. Therefore, please note his contact information, which is listed on the inside front cover of this issue, in the preface of the Recent Literature section, and also on the *BRN* Web site.

This issue includes a short paper about the mysterious ailment termed "white-nose syndrome" that is threatening our bat populations in the northeastern United States. The paper, prepared by Jacques Veilleux, presents the facts as we know them at the present time. I thank Al Hicks (New York Department of Environmental Conservation), Susi von Oettingen (United States Fish and Wildlife Service), Scott Darling (Vermont Fish and Wildlife Department), Kim Miller and David Blehert (U.S. Geological Survey, National Wildlife Health Center), Jenny Dickson (Connecticut Department of Environmental Protection), Jonathon Reichard (Boston University), and Jacques Veilleux for their assistance in preparing the information provided in this issue of *BRN*. These individuals, in addition to many others, are working both in the field and in the laboratory to understand and resolve this serious issue. Hopefully we will be able to report updated information in future issues of *BRN* during the 2008 volume-year.

Thanks to all of you from all of us at *Bat Research News* for renewing your subscription—we appreciate your continued support. Have a great spring and summer!

Cheers,
Marg.

Sample Size and the Characterization of Roosting Habitat of Forest-living Bats

Daniel R. Cox[1], Michael J. Lacki[1], Michael D. Baker[2], and Joseph S. Johnson[3]

[1]*Department of Forestry, University of Kentucky, Lexington, KY 40546;*
[2]*Eco-Tech Consultants, Inc., Frankfort, KY 40601; and*
[3]*Stantec Consulting, Topsham, ME 04086*
Email: *mlacki@uky.edu*

Abstract

Roosts are critically important to bats, and many previous studies have examined roost preferences of forest-living bats. However, it is unclear what constitutes an adequate sample of radio-tagged bats for modeling use of habitat. Therefore, we evaluated the effect of number of radio-tagged bats on habitat models, using Akaike's Information Criterion and logistic regression with a bootstrap analysis, for 48 adult female long-legged myotis (*Myotis volans*) and 168 roost trees in north-central Idaho. A roost-landscape model outperformed other models when all radio-tagged bats were used. However, bootstrapping demonstrated changes in rankings among models as number of bats decreased, suggesting instability of outcomes with smaller sample sizes. Percent of roosts that were correctly classified increased with increasing sample size of bats, but the reverse occurred for percent of random snags. A change in the sign of parameter estimates in models based on subsets of bats, relative to models with all bats, occurred more frequently (15.4%) when only 5 bats were used compared with 1.5% when 20 bats were included. These analyses suggest that number of roosts alone does not necessarily ensure good predictive models, because sample size of radio-tagged bats affects stability and predictive capability of individual habitat characteristics, and models intended to describe roosting habitat of forest-living bats.

Introduction

Use of multivariate models for identifying important features of habitat is a promising direction for research on forest-living bats (Brigham, 2007). Not surprisingly, a range of statistical methods has been employed to study bat-habitat relationships, including correspondence analysis (Gehrt and Chelsvig, 2004), discriminant analysis (Lacki et al., 1993; Menzel et al., 2002), conditional logistic regression (Weller and Zabel, 2001), paired logistic regression (Bernardos et al., 2004; Broders and Forbes, 2004), stepwise logistic regression (Ormsbee and McComb, 1998; Rabe et al., 1998; Waldien et al., 2000), paired stepwise logistic regression (Elmore et al., 2004), maximum likelihood analysis (Yates and Muzika, 2006), and Poisson models (Broders et al., 2006). Furthermore, the application of Akaike's Information Criterion (AIC) has become popular in habitat-modeling studies (Bernardos et al., 2004; Broders et al., 2006; Miles et al., 2006; Zimmerman and Glanz, 2000), because of the ability to rank proposed models and identify those that are most strongly supported by the data (Burnham and Anderson, 2002).

There is a need for increased rigor in studies of habitats used by forest-living bats (Hayes and Loeb, 2007; Miller et al., 2003), and meta-analysis (Kalcounis-Rüppell et al., 2005) and power analysis (Lacki and Baker, 2003) have demonstrated the advantages of combining data sets or increasing sampling effort, respectively. However, it is unclear what constitutes an adequate sample of radio-tagged bats for generating predictive models. This is especially important in studies of roosting habitat because AIC scores will produce a best model from logistic regression analysis regardless of the number of bats that are radio-tracked. We predict that parameter estimates and models of roosting habitat that are based on data from a small number of radio-tagged bats should exhibit more variability than those based on a larger number of bats. Furthermore, use of fewer radio-tagged bats should be more likely to result in selection of an alternate and potentially incorrect model as best choice in an AIC analysis than when the same models are evaluated using data from a larger number of bats. To test these predictions, we used AIC and logistic regression with a bootstrap analysis on data obtained during a study of long-legged myotis (*Myotis volans*) in north-central Idaho. We evaluated effect of sample size of bats on stability of rankings for different models of habitat, and relative importance of the characteristics of the habitat that are used in development of models.

Methods

Data were collected near Elk River, Idaho (46.783°N, 116.178°W). We sampled bats in two predominantly forested watersheds ranging in elevation from 760 to 1,410 m and 480 to 1,080 m above sea level. Ownership and management of the land was diverse, with most of the area intensively managed for timber production. Forests included even- and uneven-aged stands created by various silvicultural treatments. Dominant vegetation consisted of grand fir (*Abies grandis*), western red cedar (*Thuja plicata*), western white pine (*Pinus monticola*), western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga menziesii*), and western larch (*Larix occidentalis*).

We attached 0.35–0.42-g radio-transmitters (model LB-2N, Holohil Systems Ltd., Carp, Ontario) to long-legged myotis weighing more than 7 g; addition of the transmitter increased wing loading by less than 6%. We radio-tracked 48 adult females to 168 snags used as day roosts from June through August 2004 and 2005. Details of the capture, handling, and tracking of bats were published elsewhere (Baker and Lacki, 2006; Johnson et al., 2007).

We sampled 50 random snags (i.e., dead or declining trees) from each watershed for comparison with roosts. At each roost and random snag, we recorded geographic position and characteristics of the habitat inside plots with a radius of 20 m. For each snag, we measured diameter (cm), height (m), decay class (Hunter, 1990), amount of exfoliating bark (%), thickness of bark (thin: <5 mm vs. thick: ≥5 mm), canopy closure (%), difference in height between snag and canopy (m), distance to the nearest snag greater than or equal to 30 cm in diameter (m), distance to the nearest live tree greater than or equal to 10 cm in diameter (m), distance to the nearest live tree greater than or equal to the snag in height (m), distance to nearest body of water (m), slope (%), elevation (m), and position of snag in the landscape (lower, middle, or upper slope: 1–3). Within each plot, we determined density of snags (snags/ha), basal area of live trees (m^2/ha), and basal area of snags (m^2/ha). We performed F_{max}-tests on each characteristic to assess homogeneity of variance, and when variances were unequal ($P < 0.05$), we log transformed data. All data based on percentages were arcsine transformed.

We performed logistic regression analysis using PROC LOGISTIC (SAS Institute, 2001) on four a priori models, each of which was composed of five characteristics of the habitat. The first model (roost model) was based on characteristics of the roost tree only and included diameter, height, difference in height between the snag and canopy, canopy closure, and distance to nearest tree greater than or equal to the snag in height. The second model (roost-stand model) included decay class, amount of exfoliating bark, basal area of live trees, basal area of snags, and thickness of bark. The third model (roost-landscape model) was based on diameter, height, canopy closure, density of snags, and distance to water. The final model (stand-landscape model) was composed of distance to nearest live tree, distance to nearest snag, slope, elevation, and position in the landscape. The roost model (Lacki and Baker, 2003) and the roost-landscape model (Kalcounis-Rüppell et al., 2005) were based on characteristics proposed as biologically meaningful to forest-living bats. The remaining models were combinations of habitat characteristics that we perceived to be important to roost selection in long-legged myotis.

We performed a bootstrap analysis on the full data set and generated 10 random subsets using data based on only 5 bats, and we repeated the analysis to generate 10 random subsets of data based on 20 bats. We chose these two sample sizes because they approximate the minimum (Elmore et al., 2004; $n = 5$) and maximum (Waldien et al., 2000; $n = 21$) sample sizes of radio-tagged bats in published models for forest-living bats. Although two other studies used more than 21 radio-tagged bats, individuals were pooled across sexes, age classes, or species (Miles et al., 2006; Rabe et al., 1998).

We performed logistic regression analysis, using prior probabilities adjusted for sample sizes in each grouping (roost versus random), for each model in each subset of bats, and we used AIC scores corrected for small samples (AIC_c scores) and Akaike weights (w) to rank models within each subset. We also performed logistic regression for each model using data from all 48 bats (grand models) as a standard of comparison. Data for all random snags that were sampled were used in regression analysis with all model/subset combinations. To evaluate performance of the models within each sample size of bats, we generated difference values (AIC_Δ) based on AIC_c scores and Akaike weights (w). Within each sample size for each of the four models, we also calculated the average percentage of roosts and random snags that were correctly classified, as well as the percentage of models with AIC_Δ values less than 4 (Burnham and Anderson, 2002).

To assess importance of each characteristic of the habitat in the best grand model, we compared how often parameter estimates (± *SE*) of the various characteristics were non-overlapping with zero (i.e., significant) when different sample sizes of bats were used. In other words, we examined the frequency with which the characteristics could be interpreted as biologically meaningful for separating day roosts from randomly chosen snags. Further, we examined stability of all characteristics by evaluating how often the slope of parameter estimates in models based on subsets of bats reversed sign compared with estimates in the grand models.

Results

When data from all bats were included, the roost-landscape model was the most parsimonious (Table 1). No other grand model had strong support (i.e., $AIC_\Delta < 4$). When data for only five bats were used, bootstrap analysis demonstrated that the stand-landscape model was the best and had the greatest percentage of models with strong support (Table 2). The roost-landscape model was second overall.

The outcome changed when data for subsets of 20 bats were used, with the roost-landscape model producing the greatest number of models with rankings that suggested strong support (Table 2). The roost-stand model was second overall. However,

Table 1. Difference values (AIC_{Δ}), Akaike weights (*w*), AIC_c scores, likelihood ratios (LR), and levels of model significance (*P*) for grand models based on the full data set (48 radio-tagged bats, 168 roosts in snags, and 100 randomly chosen snags).

Model	AIC_{Δ}	*W*	AIC_c	LR	**P**
Roost-landscape	0	0.98	312.2	56.3	<0.0001
Stand-landscape	8	0.02	320.1	47.5	<0.0001
Roost	15	0.0004	327.6	41.0	<0.0001
Roost-stand	21	0.00001	333.0	35.5	<0.0001

the overall ranking of models was still not consistent with that for the grand models, because the roost model was weakest when only 20 bats were used and the roost-stand model was weakest when the full data set was used.

Percentage of roosts that were correctly classified improved, regardless of model, when number of bats used for analysis increased (Table 2). The opposite pattern was observed for classification of random snags, with percent correctly classified declining with increasing sample size of bats.

Frequency with which characteristics in the roost-landscape model were found important increased with increasing sample size of bats, except for distance to water (Table 3). However, all models with a sample size less than the full data set demonstrated that one or more characteristics were not

Table 2. Performance of models using a bootstrap sampling based on 10 subsets of 5 and 20 bats, with the proportion of roosts correctly classified averaged across the models compared. Data on roosts correctly classified with grand models using the full sample (*n* = 48 bats) are included.

Number of bats and type of model	Percent of models within subsets with $AIC_{\Delta} < 4$	Percent of roosts correctly classified	Percent of random snags correctly classified
5 bats			
Roost-landscape	60.0	20.7	97.3
Stand-landscape	70.0	26.6	97.8
Roost	30.0	10.1	97.9
Roost-stand	20.0	16.7	97.3
20 bats			
Roost-landscape	80.0	54.4	84.1
Stand-landscape	50.0	51.5	80.2
Roost	0.0	48.0	80.7
Roost-stand	70.0	56.1	82.6
48 bats			
Roost-landscape		83.3	53.0
Stand-landscape		87.5	47.0
Roost		82.7	48.0
Roost-stand		85.1	37.0

Table 3. Estimates, standard errors, and odds ratios of habitat characteristics in the roost-landscape model based on the full data set (48 radio-tagged bats, 168 roosts in snags, and 100 randomly chosen snags). Relative importance of habitat characteristics in bootstrap sampling (5 bats and 20 bats) is based on the percentage of models for which parameter estimates ± *SE* did not overlap zero.

Characteristic of snag	Estimate	Standard error	Odds ratio	Relative importance (%) for models based on 5 bats	Relative importance (%) for models based on 20 bats
Diameter (cm)	0.012	0.008	1.012	50.0	60.0
Height (m)	0.058	0.01	1.06	80.0	100.0
Canopy closure (%)	-0.759	0.46	0.468	40.0	60.0
Density (snags/ha)	0.019	0.005	1.02	90.0	100.0
Distance to water (m)	0.0006	0.0005	1.001	60.0	50.0

important, suggesting that use of fewer bats in model development would have led to incorrect interpretation of the usefulness of various habitat characteristics to long-legged myotis, as indicated by the grand model.

Parameter estimates frequently changed their sign (15.4%), relative to grand models, when only five bats were used in model development. The frequency with which parameter estimates changed sign decreased to 1.5% when 20 bats were used, suggesting that increasing sample size reduces error in the interpretation of relationships between specific characteristics and roosting habitat of bats. Ten characteristics (50%) that we evaluated demonstrated changes in sign when only five bats were used in model development, compared with the grand models. However, only two characteristics (5%), elevation and distance to the nearest tall tree, changed sign when data from 20 bats were used. Without exception, parameter estimates that were different from zero possessed standard errors that were larger in models based on 5 bats than in similar models based on 20 bats, suggesting that increasing sample size of radio-tagged bats improved precision of estimates used in model development.

Discussion

The roost-landscape model was the most parsimonious choice for best model based on AIC_c scores, Akaike weights (w), and summary statistics using the full data set of radio-tagged bats. This finding demonstrates the importance of both tree- and landscape-related features in roost-site selection of adult female long-legged myotis and is largely consistent with patterns for this species observed in other geographic locations (Baker and Lacki, 2006; Ormsbee and McComb, 1998). Furthermore, the list of habitat features comprising the roost-landscape model was derived from studies involving a range of species of bats (Kalcounis-Rüppell et al., 2005), and we believe that selection of this model as the best indicates that day-roost selection of long-legged myotis is typical of forest-living bats. We agree with Kalcounis-Rüppell et al. (2005) that this common ground may be helpful in developing generalized guidelines for management of bats roosting in forested habitats.

Analysis using bootstrap sampling demonstrated that models based on only five bats were inconsistent in terms of AIC_c scores and AIC_Δ values compared to grand models. Furthermore, variation in stability and relative importance of individual characteristics was also evident when a small number of bats was used. When sample size increased to 20 bats, bootstrap analysis showed more consistency in rankings of models relative to the grand models and resulted in improvement in stability of sign and consistency of relative importance of habitat characteristics. We believe our analysis demonstrates that sample size of radio-tagged bats can impact stability and interpretation of habitat models for forest-living bats.

We surveyed roosting-habitat models developed for forest-living bats in North America (n = 16) that were published between 1998 and 2006 and found that an average of 13.1 ± 1.2 (*SE*) radio-tagged bats was used to develop each model. This estimate excluded Rabe et al. (1998) and Miles et al. (2006) because of data sets pooled across species and sex classes, respectfully. Our findings suggest that some published models are not likely to be robust due to small sample sizes of bats, and such models may poorly represent the cues that bats are actually using when selecting roosting sites (Miller et al., 2003). We recognize that much effort is required to radio-track bats, and this has contributed to the frequency of published studies based on small sample sizes of bats (Barclay and Kurta, 2007).

Although the roosting-habitat models that we surveyed typically relied on few bats, these models were derived from characteristics of 46.1 ± 8.8 roosts, which appeared adequate for developing models using multiple characteristics of the habitat (Johnson, 2002). Regardless of size, though, a large sample of roosts cannot ensure that the models produced are a true representation of the population of interest unless the sample of bats is sufficiently large to represent population-level variation in roost selection (Miller et al., 2003). For long-legged myotis in the present study, mean number of roosts per model was 19.2 ± 2.3 based on 5 bats and 67.2 ± 1.9 based on 20 bats. This resulted in an average number of roosts per radio-tracked bat of 3.8, 3.4, and 3.5 for models based on 5, 20, and all bats, respectively. Although adding individual bats to any study of roosting habitat likely will increase number of roosts for analysis only in small increments, use of more individuals likely will result in incorporation of a greater range of behavioral choices by members of the population of interest.

The decrease in rate of correct classification for random snags with increasing sample size of bats was unexpected, and an explanation for this outcome is not readily apparent. We suggest that an increase in number of roosts also leads to a greater range of habitats associated with roosts in the data, making it more difficult for models to distinguish random snags from roosts.

Our bootstrap analysis was based on a random re-sampling of bats from a common pool of individuals. Thus, it was likely that replicate models based on 20 bats had more of the same bats in common than models based on only 5 bats. This can lead predictably to different models incorporating some of the same roosts, resulting in greater similarity among models based on 20 bats relative to models based on 5 bats. Regardless, comparability of these models with the grand models is still dependent on whether the groups of 5 or 20 bats represent the range of variation exhibited by the entire pool of radio-tagged bats. Because bats used in radio-tracking studies typically are captured at sites where activity and netting success are high, such as water holes or flyways (e.g., Baker and Lacki, 2006; Johnson et al., 2007), it is plausible that animals comprising a small sample of bats that are captured close to one another are more likely to occupy similar roosts than members of a larger pool of bats obtained from a range of sites. Thus, a lack of independence can influence selection of models based on a small sample of bats, as well as models based on a large number of bats, as was the case in our bootstrap approach. We believe that our analysis demonstrated sufficient differences between the two groupings, when compared to the grand models, to suggest that sample size of bats should be a concern for those planning to evaluate roosting habitat characteristics of forest-living bats using radiotelemetry.

Considerable progress has been made in developing models of habitats used by forest-living bats (Brigham, 2007), and shifts in emphasis toward measuring microclimate inside roosts will only improve our resolution of the roosting requirements of bats (Boyles, 2007). Models based on use-availability criteria continue to be popular despite concerns associated with cases in which probability of use is not small and where available (i.e., random) habitats can be occupied (Kalcounis and Brigham, 1998; Keating and Cherry, 2004). Issues of habitat use notwithstanding, our results indicate that inferences drawn from an insufficient sample can be equally problematic in furthering our understanding of how and why bats choose roosts in forests.

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Silvering—A New Color Abnormality in the Little Brown Bat, *Myotis lucifugus*

Olivia M. Münzer and Allen Kurta

Department of Biology, Eastern Michigan University, Ypsilanti, Michigan 48197
E-mail: omunzer@emich.edu

The color of mammalian hair and skin depends upon the presence or absence of melanin, a pigment that occurs as granules in the cortex and medulla of hair and in the epidermis. Variation in coat color between species is determined primarily by genes that alter the presence, number, shape, arrangement, or position of the pigment granules, and abnormal coloration within a species usually results from defective functioning of one or more of those genes (Searle, 1968). Most observations of color abnormalities in bats concern either an excess (melanism) or a lack of pigment (albinism and leucism) throughout the shaft of individual hairs (e.g., Brack et al., 2005; Buchanan, 1985; Herreid and Davis, 1960; Trapido and Crowe, 1942; Uieda, 2000; Walley, 1974). Herein, we report a new abnormality for the little brown bat, *Myotis lucifugus*, affecting pigment in only a portion of the shaft.

An unusually colored little brown bat, a female, was captured on 13 February 1998, during a census of hibernating bats inside Tippy Dam, near the town of Wellston (44.25972°N 85.93917°W), Manistee County, Michigan (Kurta and Teramino, 1994; Kurta et al., 1997). Body hairs of a normal little brown bat are bicolored, appearing black along most of the shaft and light-to-dark brown on the distal few millimeters. Although hairs of the abnormal bat were black at the base, they were white at the tip instead of brown (Fig. 1). White tips were present on all hairs of the body except those of the face, the feet, and a narrow band where the dorsal surface of the wing and tail membranes joined the body. Color of the naked flight membranes and ears appeared normal (brownish-black), and standard linear measurements of the body were within the usual range for little brown bats in Michigan.

This abnormality in the little brown bat is similar to the silvering effect seen in many rodents, carnivores, and lagomorphs (Dunn and Thigpen, 1930; Little, 1958; Searle, 1968). Silvering does not affect pigmentation of the skin but usually results in a mixture of hairs on the body that are totally white, totally pigmented, or pigmented with white tips. Like albinism, silvering appears to be a recessive trait. However, silvering affects early melanoblast differentiation, thereby reducing the number of melanin granules, whereas albinism results in complete absence of melanin (Markert and Silvers, 1956; Little, 1958; Searle, 1968).

Easterla and Watkins (1968) apparently observed the same abnormality in a juvenile evening bat (*Nycticeius humeralis*). However, silvering in that individual was limited to dorsal hairs from the ears to the tail. Similar genes may have been the original cause of the white-tipped (frosted) fur of silver-haired bats (*Lasionycteris noctivagans*), eastern red bats (*Lasiurus borealis*), and other lasiurines.

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Figure 1. A female little brown bat with silvering. Hairs along the dorsal midline were parted to show the black base of the hairs.

Current Status of White-nose Syndrome in the Northeastern United States

Jacques Pierre Veilleux

Department of Biology, Franklin Pierce University, Rindge, NH 03461
E-mail: veilleuxj@franklinpierce.edu

The Problem

During winter 2006–2007, a mysterious die-off affecting hibernating bats was reported from four hibernacula in eastern New York. An estimated 8,000–11,000 bats died, with the highest mortality experienced by little brown myotis (*Myotis lucifugus*) and northern myotis (*M. septentrionalis*). Some dead and dying bats, as well as live animals, had a white, powdery substance concentrated around their nose and mouth, and because of this, the condition became known as white-nose syndrome or WNS. The white substance initially was identified as a fungus within the genus *Fusarium*. However, additional dead or dying bats examined at the National Wildlife Health Center did not yield *Fusarium*, suggesting that this fungus may be indirectly related to the deaths. At some affected hibernacula, bats were flying outside during the day, with additional dead and dying bats on the ground. Some bats appeared both emaciated and dehydrated. No other affected hibernacula were found in New York or neighboring states during population surveys in winter 2006–2007.

Nevertheless, surveys conducted during winter 2007–2008 identified additional affected sites in the Northeast, with bats presenting physical and behavioral symptoms similar to those in 2006–2007 (Fig. 1). In addition, dead or dying bats were observed still hanging from the walls and ceilings of the hibernacula. Visual observations and preliminary analyses using thermal imaging at affected and unaffected hibernacula suggested abnormal behavior by bats during arousal. For example, many targeted bats at both affected and unaffected sites did not arouse during a 2-h period of disturbance, including periods of research activity directly beneath the bats.

As of March 2008, 24 affected hibernacula have been identified in four states: New York (15 sites), Vermont (4), Massachusetts (4), and Connecticut (1). Although precise mortality estimates are not yet available for winter 2007–2008, field observations from New York, Vermont, and Massachusetts suggest that tens of thousands of individuals from five different species have died so far. The little brown myotis has suffered the most, with northern myotis and the Indiana myotis (*M. sodalis*) also experiencing relatively high mortality. Several eastern small-footed myotis (*M. leibii*) and eastern pipistrelles (*Perimyotis subflavus*) have died as well. Additionally, one big brown bat (*Eptesicus fuscus*) with a white muzzle was collected from a hibernaculum in western Connecticut during March 2008 and may represent the first case of WNS for this species. Hence, every species known to hibernate in the Northeast appears to be affected. White-nose syndrome, however, was not found during winter surveys conducted in 2006–2007 and 2007–2008 in neighboring states, including Maine, New Hampshire, New Jersey, and Pennsylvania.

Epidemiology

To date, no definitive causal agent of mortality associated with WNS has been identified. Necropsies of bats with and without symptoms of WNS from affected and

Figure 1. *Myotis lucifugus* with White-nose Syndrome, January 2008. Used with permission of Al Hicks.

non-affected sites, respectively, have been performed. Most affected bats have little-to-no remaining subcutaneous white fat. Some afflicted bats exhibit signs of pulmonary inflammation, mild-to-moderate pneumonia, and hemorrhaging in the lungs.

Culturing of bacteria and fungi from affected bats (particularly from skin samples) at the National Wildlife Health Center indicates high inter-individual variation in microfloral diversity. At this point a single fungal species has not been implicated conclusively as the cause of WNS. Microscopy of the skin surface indicates presence of fungal hyphae, and histological examination of the skin shows hyphal penetration into the dermis and sebaceous glands, although inflammatory responses are minimal. Viral analyses have not yielded positive pathogenic effects or viral isolates. Although endo- and ectoparasites have been observed in afflicted bats, these organisms also do not appear to have caused a strong immune response.

Some researchers hypothesize that a pathogen (or pathogen complex) is causing an immune response in hibernating bats exhibiting WNS. Affected individuals may be increasing their body temperature to initiate the immune response, leading to an increased metabolism of stored fat. Individuals with critically low fat reserves and/or body water may arouse during mid-winter and leave the hibernaculum to look for food and/or water and subsequently die during the search.

Current Efforts

White-nose syndrome is associated with a series of high-mortality events in the northeastern United States, and a direct cause of the mortality has not been identified. However, a collaborative effort involving a range of groups has been initiated to find the causal agent(s). The collaboration includes federal agencies (U.S. Fish and Wildlife Service; U.S. Geological Survey, National Wildlife Health Center), state agencies (New York State Department of Health, New York State Department of Environmental Conservation, Vermont Fish and Wildlife Department), universities (Boston University, Bucknell University, Cornell University, Colorado State University), and private organizations (Disney's Animal Kingdom). Furthermore, both Bat Conservation International[1] and the Center for North American Bat Research and Conservation at Indiana State University[2] have established funds for supporting research aimed at understanding the cause and impact of white-nose syndrome.

Meanwhile, the U.S. Fish and Wildlife Service has made two interim recommendations that might be helpful in limiting spread of the problem. First, only biologists who are actually working on WNS should enter sites in the Northeast where the syndrome has been identified. Second, anyone entering a cave or mine, in the Northeast or in adjacent regions, whether WNS is present or not, should decontaminate their clothing and gear before and after visiting the site[3]. In addition, anyone entering hibernacula in the Northeast should contact the appropriate state wildlife agency prior to entry to determine whether any additional restrictions exist.

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Web sites listed in text above:

[1] http://www.batcon.org
[2] http://www.indstate.edu/ecology/centers/bat.htm
[3] http://www.fws.gov/northeast/whitenosemessage.html
[4] http://www.fws.gov/Midwest/Endangered/mammals/inba/BatAilment.html

ERRATUM—EDITOR'S CORRECTION

Please note that the volume number printed on the front cover of the 2007 Winter issue of *Bat Research News* was in error. The 2007 Winter issue was **Volume 48: No. 4**, not Vol. 44 as appeared on the issue's cover. The correct volume number did appear throughout the rest of the issue (in the headers, inside front cover, and table of contents), but the Editor (i.e., Margaret Griffiths) obviously had a "senior moment" when preparing the front cover. I do apologize for this error. Margaret

RECENT LITERATURE

Beginning with the next issue of *Bat Research News* (Vol. 49: No. 2, Summer 2008), authors are requested to send reprints or PDF files of their published papers to the **new** 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

Bat Skeletal Growth: Molecular and Environmental Perspectives. John W. Hermanson and Cornelia E. Farnum, editors. S. Karger AG, Basel, Switzerland. 88 pages, 2008. ISSN 1422–6405.

This publication is a special topic issue of *Cells, Tissues and Organs* (Vol. 187, No. 1), and consists of both reviews and original papers covering the embryonic development and biomechanics of bats focusing on the extraordinary adaptation of the mammalian forelimb into the wing of bats. The papers were written by accomplished specialists in the field and cover the subject from the genetic control of wing development to the environmental factors that select for particular wing forms.

In the first paper, Karen Sears examined the molecular determinants of bat wing development. She summarized the evolutionary steps of the formation of the wing as 1) retention of interdigital webbing; 2) elongation of skeletal elements; and 3) reduction of wing skeletal elements. For each of these, the genetic mechanisms that underlie the development of the forelimb in other mammals are compared to those that lead to the forelimb specializations in bats. Her hypotheses on elongation of skeletal elements mesh nicely with the later papers in the series by Farnum et al. on the role of chondrocytic growth and differentiation in the formation of bat wings. This paper draws clear comparisons between bats and other mammals and is very accessible to the nonspecialist.

The review of the "Morphogenesis in Bat Wings" by Rick Adams carries on from his extensive research on bat wing development and evolution. His paper examines the developmental patterns of the evolution of wings in mammals, and links this to the selective pressures on growing bats to the ontogeny of flight and its effect on patterns of foraging. Adams presents evidence that growth of wings is controlled more by the functional shapes and sizes of the elastic wing membranes than by the lengths of bony elements. He leads this idea into the concept of the ontogenetic niche, those niche spaces occupied by juveniles as their size and shape changes on the path to adulthood. Although his explanation of concepts is clear, some of the figures could give greater support to his arguments if they were more thoroughly explained. This may have resulted from the use of some figures from previous papers in isolation from their original presentation. Regardless, Adams' review weaves complex concepts into a fabric that elegantly links developmental biology with population ecology.

Hermanson and Wilkins examined skeletogenesis in their paper "Growth and Development of Two Species of Bats in a Shared Maternity Roost." Their study capitalized on the rare opportunity to study skeletal ontogeny in two species under similar environmental conditions. Their suggestion that a more advanced timing of ossification in the hindlimb of *Tadarida brasiliensis* in comparison to *Myotis austroriparius* may relate to a reduced rate of neonatal mortality makes an interesting comparison to Adams' ideas on the ontogenetic landscape. As with all of the papers in this volume, the quality of illustrations is very good. However, one typographical error was noted in the legend of Fig. 5 of this paper. Comparison of specimens at 1–2 weeks prior to birth should be "a and b" rather than "a and d" as listed in the figure legend.

Two papers in this volume by Farnum, Tinsley and Hermanson examined differences in forelimb versus hindlimb skeletal development in *Eptesicus fuscus* and then compare autopod growth in *E. fuscus* to that of *Mus musculus*. In both cases, the papers are based on original data and follow one of the themes of this volume, examination of bone elongation that underlies the development of the wings of bats. In both papers the adaptation of chondrocytes was targeted to elucidate the mechanisms of rapid elongation of wing elements. A major finding of both papers related to the importance of the timing and degree of chondrocytic hypertrophy in wing growth.

The final paper in the series departed from the theme of ontogeny to examine the biomechanics of the bat wing skeleton and placed their data in a phylogenetic context. Swartz and Middleton collected morphometric data from 271 species of mammals, including nonvolant species. They found that the bones of the forelimbs are both longer and have a greater diameter than in nonvolant mammals in contrast to hindlimb bones that are significantly shorter and narrower. The need for flexibility in wing bones was found to be met by unusually small degrees of mineralization in more distal bones of the wings. Interestingly, mineral content of bones decreased progressively in bones of the wings, from proximal to distal. The value of this paper is enhanced by the extensive online appendices that provide readers with phylogenetic and morphometric data used in the analyses.

Taken together, these six papers provide a great insight into the developmental basis of the evolution of wings in bats. The quality of the illustrations is very high. The original papers present extensive data that can support many lines of ongoing research. The authors cite each other's work extensively, which contributes to the cohesiveness of the volume. All of the papers explore ways in which bats take the mammalian morphological blueprint to its extreme and in many ways push the limits of adaptation of mammalian morphological adaptation.

Winston C. Lancaster, Department of Biological Sciences, California State University Sacramento, Sacramento, California 95819-6077; wlancaster@csus.edu

ANNOUNCEMENT

Announcement from *Bat Research News*

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

FUTURE MEETINGS and EVENTS

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

18–22 August 2008
The IV Brazilian Mammalogy Conference will be held in the city of Sao Lourenco, Brazil. Please see http://www.sbmz.org/cbmz2008 for further information.

1 June 2008 through 4 January 2009
The Organization for Bat Conservation (OBC) and the Cranbrook Institute of Science will showcase a collaborative live bat exhibit, "Bats: Myths and Mysteries," the main focus of which is OBC's live bats. The exhibit begins 1 June 2008 and runs through 4 January 2009 at the Cranbrook Institute in Bloomfield Hills, MI. Components from the "Masters of the Night," the recently retired traveling museum exhibit, will also be part of the exhibit. For more information, please visit: http://www.batconservation.org or http://www.cranbrook.edu

1–2 August 2008
The 7th Annual Great Lakes Bat Festival will be held at the Cranbrook Institute of Science in Bloomfield Hills, MI. Janell Cannon, the award-winning author of "Stellaluna," will kick off the Bat Festival on August 1st, 2008, at 7 p.m. (**pre-registration and tickets** required for this event only). On Saturday, August 2nd, the Festival is open to all (no tickets or pre-registration necessary) from 10 a.m. through 11 p.m. Please see http://www.batconservation.org for more information and event schedules.

22–25 October 2008
The 38th Annual North American Symposium on Bat Research (NASBR) will be held in Scranton, Pennsylvania. For information, please see the NASBR Web site: http://www.nasbr.org/ or contact the organizers of the meeting Gary Kwiecinski (ggk301@scranton.edu) or Roy Horst (rhorst@twcny.rr.com).

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

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

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

Bat Biologists

BHE Environmental, Inc., an environmental consulting and engineering company providing services nationwide, has openings in our Cincinnati office for full-time and seasonal bat biologists.

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BAT RESEARCH NEWS

VOLUME 49: NO. 1 **SPRING 2008**

Table of Contents

Front Cover

The photograph of a little brown bat (*Myotis lucifugus*) was taken in January 2008 by Al Hicks, New York Department of Environmental Conservation. The little brown bat is afflicted with white-nose syndrome, which is associated with the deaths of thousands of bats in the northeastern United States again this year. A paper describing this serious problem is published in this issue.

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BAT RESEARCH NEWS

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Publisher and Managing Editor: Dr. Margaret A. Griffiths, CB 257, 700 College Place, Lycoming College, Williamsport PA 17701; TEL 570-321-4399, FAX 570-321-4073; E-mail: griffm@lycoming.edu OR mgriff@illinoisalumni.org

Editor for Feature Articles: Dr. Allen Kurta, Dept. of Biology, Eastern Michigan University, Ypsilanti MI 48197; TEL 734-487-1174, FAX 734-487-9235; E-mail: akurta@emich.edu

Editor for Recent Literature: Dr. Jacques P. Veilleux, Dept. of Biology, Franklin Pierce University, Rindge, NH 03461; E-mail: veilleuxj@franklinpierce.edu; TEL 603-899-4259, FAX 603-899-4389

Editor for Conservation/Education: Patricia A. Morton, The Nature Conservancy, Mukwonago River Watershed Project Director, N8957 Pickerel Jay Road, East Troy WI 53120; TEL 262-642-7276; E-mail: pmorton@tnc.org

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

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

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Roosting by a Lactating Hoary Bat (*Lasiurus cinereus*) in an Intensively Managed Loblolly Pine (*Pinus taeda*) Landscape in Mississippi

Darren A. Miller and Adam C. Miles[1]

Southern Timberlands Research and Development, Weyerhaeuser Company, P.O. Box 2288, Columbus, MS 39704

[1]*Present address: Botany Department, University of Hawaii at Manoa, 3190 Maile Way, Room 101, Honolulu, Hawaii 96822*

E-mail: darren.miller@weyerhaeuser.com

Although widely distributed throughout Canada and the United States, the hoary bat (*Lasiurus cinereus*) is uncommon to rare in the eastern United States (Reid, 2006), including Mississippi (Mississippi Museum of Natural Science, 2008). Virtually nothing is known about roosting ecology of this species within intensively managed pine (*Pinus*) landscapes, which comprise a primary forest type in the Southeast (Wear and Greis, 2002). In this note, we describe use of a loblolly pine tree (*Pinus taeda*) as a diurnal roost by a lactating hoary bat within an intensively managed pine landscape in east-central Mississippi.

During summer 2004, we captured bats using 4-tiered mist nets that were set over water (Avinet, Inc., Dryden, New York), in Kemper Co., Mississippi. Netting occurred in a 24,000-ha landscape that consisted of mostly contiguous, loblolly pine forest. Approximately 85% of the study area was under intensive management by Weyerhaeuser Company for production of sawtimber.

On 21 June 2004, we captured a lactating hoary bat with a mass of 28.5 g and a forearm length of 55 mm. We secured a 0.45-g radio-transmitter (Micro-Pip, Biotrack Ltd., Wareham, Dorset, United Kingdom) to the animal and used a receiver (TRX-2000S, Wildlife Materials, Inc., Carbondale, Illinois) and 3-element Yagi antenna to locate its day roost. We tracked the hoary bat to a live loblolly pine tree, ca. 1.1 km from the capture location, where she roosted for four consecutive nights before the transmitter failed. We confirmed use of this tree by observing evening emergence and estimated that the bat was roosting in pine foliage at a height of ca. 18 m with a southeasterly aspect (130º).

The roost tree had a diameter at breast height (dbh) of 51 cm and a height of ca. 28 m. Canopy closure, measured with a spherical densiometer, was 89%. The roost was located in a 202-ha, 36-year-old stand of planted loblolly pine; the stand had been thinned in 1982 (ca. 371 overstory trees/ha) and in 1996 (ca. 173 trees/ha). The area immediately surrounding the roost tree had an overstory basal area (loblolly pine) of 25.3 m^2/ha and contained 221 overstory trees/ha, with an average dbh of 38.1 cm and height of 25 m. The midstory was composed primarily of hardwood trees with a basal area of 0.8 m^2/ha and 348 midstory trees/ha. Midstory trees averaged 5.4 cm in dbh and 4.4 m in height.

Even though the hoary bat was roosting in an even-aged stand, the roost tree was 25% larger in diameter and 11% taller than surrounding overstory trees. Previous work has shown that bats generally prefer to roost in trees larger in diameter and taller than those that are available (Kalcounis-Rüppell et al., 2005), including hoary bats (Perry and Thill, 2007). Similar to earlier observations of hoary bats (Carter and Menzel, 2007), the animal that we observed was roosting in live foliage. Roost height, canopy cover, and aspect also were within the range reported for hoary bats in other regions (Carter and Menzel, 2007; Perry and Thill, 2007). The current observation and recent publications (Miller, 2003; Perry and Thill, 2007) provide further evidence of reproduction by hoary bats in the Southeast, despite the paucity of summer records from this region (Cryan, 2003). Further study is needed to determine the extent that hoary bats use managed forests.

Funding was provided by Weyerhaeuser Company. We thank J. Coyle for field assistance. We appreciate comments from M. C. Kalcounis-Rüppell, R. Perry, and S. Castleberry.

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Predation by a Rat Snake (*Elaphe climacophora*) on a Foliage-roosting Bat (*Murina ussuriensis*) in Japan

Hirofumi Hirakawa and Dai Fukui

Forestry and Forest Products Research Institute, Hitsujigaoka 7, Toyohira, Sapporo 062-8516, Japan
Email: hiroh@affrc.go.jp

This paper describes predation by a Japanese rat snake (*Elaphe climacophora*) on a radio-tagged Ussurian tube-nosed bat (*Murina ussuriensis*). The radio-transmitter that we used (Blackburn Transmitters, Nacogdoches, Texas) was 15-cm long, including the antenna, and the main body of the transmitter had dimensions of 12 by 6 by 4 mm. We attached the transmitter to a female tube-nosed bat (body weight: 7.9 g) on the evening of 24 July 2007, at the Hitsujigaoka Experimental Forest, Sapporo, Hokkaido, Japan (43º00' N, 141º24' E). Beginning the next day, we tracked the bat during the daytime to locate its day-roosts.

The signal was located in the forest canopy every day through 31 July. On 1 August, at 1215 h, we found the signal coming from a Japanese rat snake, which we spotted on the trunk of a linden (*Tilia maximowicziana*), ca. 2 m from the ground. The linden was ca. 60 cm in diameter and 15 m in height. The snake was ca. 1.5-m long.

After being observed, the snake climbed the trunk and disappeared into the crown of the tree. The signal indicated that the snake was moving in the canopy, and at 1450 h, it was in the canopy of a stand of Sakhalin fir (*Abies sachalinensis*), ca. 70 m from the linden. At 1740 h, it was in the same stand but ca. 40 m from its previous position and 110 m from the linden. The canopy, however, was too thick to observe the snake. At 2145 h (2.8 h after sunset), the signal was stationary.

At 1040 h on the next day, we found the transmitter suspended from a branch of a Sakhalin fir at 4.2 m above the ground and not far from the snake's position on the previous night. The transmitter was covered with dark brown material that included a dense mat of hair, presumably bat fur. Dry mass of the recovered transmitter was 0.47 g, although it originally weighed 0.24 g. Rat snakes, in general, do not regurgitate indigestible foods, and the condition of the recovered transmitter suggested that it, along with the bat, had passed through the digestive tract of the reptile (S. Takenaka and H. Moriguchi, pers. comm.).

Even though we detected the transmitter in the snake on 1 August, the act of predation likely occurred before that date. On 28 July, the bat roosted in a dead, curled leaf of a castor-leaved aralia (*Kalopanax pictus*), 8.5 m above the ground, and on 29 July, at 1440 h, the stationary signal was coming from almost the same site to which we had radio-tracked the bat on 26 July. On 30 and 31 July, we located the signal in the forest canopy as usual, but we had difficulty in determining the position of the bat, especially on 31 July. Usually, we can narrow the location of a transmitter in the canopy of the forest to the crown of a single tree, but on those days, we were unable to do so because, on reflection, the source of the signal apparently was moving, suggesting that the bat and transmitter were already inside the snake, perhaps as early as 30 July.

The following circumstances suggest that the snake attacked the bat in the daytime while the bat roosted in the foliage of the canopy. Due to a cool climate, Japanese rat snakes in this area are usually active only during daytime, even in summer (S. Takenaka, pers. comm.). Like other species of rat snake, the Japanese rat snake is a good climber and often stays in the canopy to forage or bask in the sun (Uchiyama et al., 2002). Female Ussurian tube-nosed bats typically roost in the canopy in summer (Hirakawa, 2007), and three canopy roosts confirmed in our radio-tracking study so far (including the one described above) were all in dead foliage.

Snakes often prey on bats (Esbérard and Vrcibradic, 2007; Shätti, 1984). Some biologists find bat carcasses in captured snakes (Davis, 1951; Jones, 1960; Krutzsch, 1944; Ridlehuber, 1981; Silver, 1928; Stager, 1942), whereas other workers witness attacks or after-attack behaviors. Most examples of attack-related behaviors concern bats in caves, including predation on bats clinging to the ceilings or walls (Barr and Norton, 1965; Easterla, 1967; Lemke, 1978; Mankins et al., 1965; Twente, 1955) or those passing through an entrance constriction or a bat gate (Hammer and Arlettaz, 1998; Hardy, 1957; Kuramoto et al., 1969; Rodríguez-Durán, 1996). In contrast, predation on bats outside caves, and especially in trees, rarely is documented. Rat snakes have preyed upon a hoary bat (*Lasiurus cinereus*) in a garage (Wiseman, 1963) and on a Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) in an attic (Bennett et al., 2004). Cary and Clawson (1981) filmed a rat snake rolling downhill with a bat (possibly, an Indiana bat, *Myotis sodalis*) in its coils and later devouring it. Hopkins and Hopkins (1982) reported a nectar-feeding bat falling prey to an unidentified constrictor while the bat was foraging around the flowers of a tropical tree, and Esbérard and Vrcibradic (2007) observed a common tree boa (*Corallus hortulanus*) grab a white-lined bat (*Platyrrhinus lineata*) from beneath the leaf a banana tree (*Musa*).

Our observation is unique in that a radio-tracked bat was preyed upon by a snake and further suggests that even foliage-roosting bats are vulnerable to predation by arboreal snakes. Although Jones (1960) found three Ussurian tube-nosed bats in the stomach of a rat snake (*Elaphe schrencki)* in Korea, he did not know how the bats were captured. Perhaps they too were taken from foliage.

We are grateful to S. Takenaka, Hokkaido Tokai University, and H. Moriguchi, the Japan Snake Institute, for advice.

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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.

Suggested Milk-replacement Formula for Insectivorous Bats

In 2007, bat rehabilitators in the United States reported problems with the health of hand-reared orphans, which seemed related to the commercial milk replacements that are widely used by wildlife rehabilitators for many species of mammals. In response, Bat World Sanctuary commissioned an independent analysis of milk-replacement formulas that commonly are used for raising insectivorous bat pups. Samples were sent to several labs, including Expertox in Texas, Environmental Testing Laboratories in New York, Animal Nutrition and Health in Arizona, and Analytical Sciences Laboratory in Idaho. The analyses indicated the presence of heavy metals and some inaccuracies in the specified levels of nutrients. These surprising results, coupled with widely publicized contamination of domestic animal feeds in the United States, raised serious questions about the safety of manufactured feeds for animals. Bat World Sanctuary, therefore, sought a safer alternative that was developed at our request by nutritional scientist, Dr. Mark Finke, Ph.D., who has experience in formulating diets for obligate insectivores. We thank Dr. Finke for his careful attention to the nutritional needs of growing bats and his willingness to work through a paucity of literature regarding the nutritional composition of milk produced by insectivorous bats.

His suggested formula requires fresh organic goat's milk or canned evaporated goat's milk (Meyenberg, Turlock, California), a specific commercial milk-based powder (Similac Go & Grow Milk-Based Powder, Abbott Laboratories, Abbott Park, Illinois), and organic or unrefined corn oil. To mix and store about 120 ml (4 U.S. ounces) of formula, use a small food-storage container with a tight-fitting lid. To the container, add 100 ml (3.5 ounces) of fresh goat's milk or Meyenberg goat's milk that has been reconstituted with an equal amount of water according to directions on the can. Add 17.2 g (2 level scoops using the instrument provided with the Similac) of milk-based powder and 7.5 ml (0.5 tablespoon) organic or unrefined corn oil. Shake to mix thoroughly. After mixing, store the formula in the refrigerator, and discard any unused material after 24 hours. Wash the container thoroughly, and rinse well before mixing new batches of formula.

Calculated values of nutrients for the formula (as mixed) are energy, 1.75 kcal/ml; water, 71.2%; protein, 4.4%; lipid, 15.2%; carbohydrate, 11.1%; calcium, 0.24%; phosphorus, 0.15%; vitamin A, 3,740 IU/kg; and vitamin D, 525 IU/kg . On a dry-mass basis, these values are energy, 6.6 kcal/g; protein, 15.2%; lipid, 43.5%; carbohydrate, 38.6%; calcium, 0.82%; phosphorus, 0.51; vitamin A, 12,995 IU/kg; and vitamin D, 1820 IU/kg.

We have not yet tested this formula, but are optimistic that it will meet the needs of fast-growing bats and provide a superior level of nutritional support. We welcome feedback from rehabilitators and anyone else hand-rearing insectivorous bats.

Leslie Sturges
Bat World Sanctuary, 217 North Oak Avenue, Mineral Wells, TX 76067

Abstracts of Papers Presented at the

13th Australasian Bat Society Conference

Charles Sturt University, Thurgoona, NSW, Australia
26–28 March 2008

The following abstracts are listed in alphabetical order by first author. Contact information for authors who attended the ABS meeting can be found in the list of meeting participants, which immediately follows the abstracts. Unless otherwise noted, Australia is the country for all affiliations and addresses listed in the abstracts and list of participants.

A very special note of thanks goes to the Australasian Bat Society (ABS) and the organizers of the conference, Craig Grabham and Lindy Lumsden, for allowing *Bat Research News* to publish the meeting abstracts. The abstracts and list of participants were compiled and submitted by Lindy Lumsden. During the preparation of the abstracts for publication in *Bat Research News*, the Editor, Margaret Griffiths, made editorial and formatting changes. Any errors that may have been introduced during this preparation are inadvertent, and she asks that you please accept her sincerest apologies.

The Malagasy *Miniopterus*

Belinda R. Appleton[1] and S. M. Goodman[2,3]; [1]University of Melbourne, Parkville, VIC 3010; [2]Field Museum of Natural History, Chicago, Illinois 60605, USA; [3]Vahatra, BP 738, Antananarivo (101), Madagascar

Madagascar is renowned for its high levels of biodiversity and endemism. Madagascar's substantial period of continental isolation has long been used to explain these attributes, especially at taxonomic ranks at and above the genus level. It is widely thought that colonizations of animals and subsequent radiations have led to the development of a largely endemic fauna. Further hypotheses focus on the species radiations within the island and describe retreat dispersion watersheds and centers of endemism in an attempt to provide a framework for biogeographical study in Madagascar. This work focuses on the Malagasy species from the widespread genus *Miniopterus*. Our work shows that all forms of *Miniopterus* found in Madagascar are endemic to the island. The work also reveals numerous previously unrecognized species, bringing the number of Malagasy *Miniopterus* species from four to a minimum of ten. Most of these species are currently undescribed.

Bat Roost Boxes: Maintenance Issues
Robert Bender; Ivanhoe, VIC 3079

At Organ Pipes National Park on the northwest fringe of Melbourne, a roost box project has been ongoing since late 1994. Initially 10 boxes were installed, which has now grown to 37, and are mainly of the Stebbings design from the UK. Various problems have arisen of boxes needing to be replaced, timber warping or cracking, attachment screws corroding or being pushed out by the tree, hinges corroding, or other animal species attempting to enlarge entrances. Invasions by bees, paper wasps, and especially ants are discussed. Apart from invertebrates, sugar gliders, ringtail possums, and feral rats have sometimes caused problems. I will present the costs of installing and maintaining boxes, and also the required duration of commitment needed for box maintenance—at least a century, with frequent visits to check on condition of boxes, which our group does monthly. Preliminary results from a project on the Yarra River in Ivanhoe, in which bats first appeared in February 2005, are presented for comparison.

Bat Roost Boxes: Seasonal and Annual Usage Patterns
Robert Bender; Ivanhoe, VIC 3079

The Organ Pipes National Park roost box project has been ongoing now for over 13 years, which may provide a good simulation of usage patterns of natural roosts over this time. Several long-term experiments have been conducted by varying entrance slit dimensions and thickness of timber and orientation of box. We now have a set of boxes used year-round, some boxes predominantly used in warmer months, some in colder months, and some surprising patterns. Annual usage patterns show bats favor individual boxes intensively some years, then avoid them in following years, although a few seem irresistibly attractive and are much used every year. There will be a preliminary discussion of what underlies these patterns with a preliminary comparison to a similar project on the Yarra River bank in Ivanhoe, which has only 3 years of results.

The Droopy Bats of Southeastern Australia
Chris Corben[1] and Harry Parnaby[2]; [1]Columbia, Missouri 65201, U.S.A.; [2]Department of Environment and Climate Change (NSW), Hurstville, NSW 2220

Gould’s Wattled Bats, *Chalinolobus gouldii*, in southeastern Australia seem to include two distinctive call variants. In Tasmania, montane areas of Victoria and southern Queensland, some bats produce echolocation calls that terminate in a pronounced, downwards droop in frequency. Calls of these “Droopy Bats” are generally easily distinguished from those of normal Gould’s Wattled Bats, and the acoustic differences are much greater than between the morphologically distinctive genera *Falsistrellus* and *Scoteanax*. In the late 1980s, Droopy Bats were incorrectly attributed to *Falsistrellus*. Subsequently, it has been widely assumed that they are a variant of Gould’s Wattled Bat. Recent field observations of Droopy Bats have shown them to be consistent with Gould’s Wattled Bat in flight action, shape, and color, and it seems inevitable they would be identified as such in the hand. Droopy bats are found in only a small proportion of the total distribution of Gould’s Wattled Bat. The two call variants are largely separated geographically, but occur together where their distributions meet. The simplest explanation is the presence of two cryptic species. Otherwise, some as yet unknown mechanism would need to be postulated to maintain these distinctions in the absence of consistent differences in environmental conditions. We encourage others to investigate this issue.

Understanding the Effects of Heat Stress in Flying Foxes (*Pteropus* spp.) Supported by Case Studies at Blackbutt Colony, 2006 and 2007

Timna Dean; Charles Sturt University, Wagga Wagga, NSW 2678

To better understand the effects of heat stress on the flying fox colony of Blackbutt Nature Reserve, Newcastle, New South Wales, data were obtained from two consecutive disasters to examine the relationships between gender, age, and species of the affected population. In addition, the cases are supported by literature to examine lethal temperature; the physiological processes of body temperature, heat stress, temperature regulation, heat transfer within the body, and heat loss mechanisms; and the behavioral signs and assisted field/captive techniques employed during the period of the disasters. In conclusion, the age of the flying fox is the most significant method of examining the affected population, for pups and juveniles made up the majority of casualties in 2006 and 2007, with no obvious gender preference. No species significances could be determined, as there was an unknown proportion within the colony prior to the disaster. The methods employed by the wildlife carers attending the disaster were supported by physiological literature as discussed, with supporting photographs illustrating the extent of the 2006 disaster, including behavioral signs, assisted techniques and post-disaster data collection methods of the affected flying foxes.

The Rise and Fall of the Critically Endangered Southern Bent-winged Bat *Miniopterus schreibersii bassanii*

Chris Grant; SA Murray-Darling Basin NRM Region, Department for Environment and Heritage, Berri, SA 5343

Miniopterus schreibersii bassanii (Southern Bat) is a cave-dwelling bat found in South Australia and western Victoria. It is a subspecies of the more widely distributed *Miniopterus schreibersii* (Large Bent-winged Bat). This subspecies has recently been listed as Critically Endangered under the EPBC Act. The principal reason of the increased status is a dramatic decline in the population at the larger of its two breeding caves. The current knowledge of this subspecies will be summarized, and potential reasons for the population decline explored. This paper will provide background information for a workshop to be conducted at this Conference to determine what action needs to be taken to conserve this subspecies.

Bats Collected during a Mammal Survey of the TransFly Ecoregion of Southern New Guinea

Steven G. Hamilton and Karen Firestone; University of NSW, Sydney, NSW 2052

The TransFly Ecoregion of New Guinea is recognized as among the most distinctive of biotic regions in Australasia, characterized by a mixture of open, seasonally dry savanna woodlands and grasslands alongside wetter rainforests. Resembling areas of Northern Australia with which it shares a portion of its biodiversity, broad areas of the TransFly remain unsurveyed for mammals. Preliminary results are presented on the bats recorded during a mammal survey conducted for WWF PNG in 2006. A harp trap and mist nets were used for the first time in this region near the village of Serki in Western Province of Papua New Guinea. Two hundred and thirty bats were captured, comprising 21 species from the families Pteropodidae (7), Molossidae (2), Vespertilionidae (9), and Hipposideridae (3). General aspects of the survey, range extension records, and significant collections of species poorly represented in collections are reported.

The Diversity of Insectivorous Bat Assemblages within a Subtropical Urban Landscape

Clare Hourigan[1], Carla Catterall[1], Darryl Jones[1], and Martin Rhodes[2]; [1]Griffith University, Nathan, QLD 4111; [2]University of Queensland, St. Lucia, QLD

We investigated the bat diversity of four major habitat types within a large Australian subtropical city to determine whether species richness differed significantly between habitat types, as suggested by previous findings. Forty sites representing remnant bushland, parkland, low density residential, and high density residential habitats were surveyed using bat detectors on six non-consecutive occasions. Fourteen bat species were recorded. Mean species richness was lowest in high density residential sites, but significantly higher in low density residential sites than remnant bushland areas. Evenness profiles were similar across habitats, and were not strongly dominated by a few species. These findings contradict those of other studies on bat diversity, and highlight the need for caution in making generalizations based on the existing information from temperate regions.

A 20-year Harp Trapping Study at Organ Pipes National Park

Robert Irvine[1] and Robert Bender[2]; [1]Sunbury, VIC 3429; [2]Ivanhoe, VIC 3079

Insectivorous bats were surveyed using harp traps at Organ Pipes National Park from 1988 to 2008. Six species were trapped: *Chalinolobus gouldii*, *C. morio*, *Nyctophilus geoffroyi*, *Vespadelus darlingtoni*, *V. regulus*, and *V. vulturnus*. A total of 93 trap-nights on 13 occasions was completed catching a total of 830 bats. The purpose of this study was an attempt to track bat population changes prior to bat boxes being installed and annually thereafter. In parallel with this harp trapping, a maximum of 40 bat boxes had been installed within the same area and provided roosting for a maximum of 270 bats at one time. These repetitive trappings were kept as consistent as possible including location, type, number of trap-nights, and time of year. Uncontrollable environmental variables such as temperature, humidity, wind, rainfall, river level, and moon phases were recorded. Biases in harp trappings regarding favoring certain species were considered to remain consistent over the study period. Results showed the same six species over the 20 years of this study but the percentage of the predominate box-roosting species *Chalinolobus gouldii* increased.

What Constitutes Adequate Survey Effort for Bats?

Bradley Law[1] and Katie Cabezas[2]; [1]NSW Department of Primary Industries, Beecroft, NSW 2119; [2]Macquarie University, NSW

Traps and ultrasonic detectors are standard tools to survey and monitor trends in bat populations. Despite their extensive use, little is known about what constitutes adequate survey effort to confidently conclude a species absence from a study area or to produce precise estimates of activity levels for rigorously documenting trends over time. We present some recent examples of studies that investigate these questions. First, the Golden-tipped Bat is infrequently

detected using harp traps, but it is a potential candidate for monitoring in State Forests. In Chichester State Forest, 11 sites were chosen in riparian rainforest, with one trap set per site over six nights. Seven individuals were trapped over the 66 trap-nights, resulting in a low detection probability of P = 0.137 (using the Maximum Likelihood Estimation method). To optimize a reliable monitoring program for a species with such a low detectability would require 23–26 repeat visits per site. This is clearly impractical, but it tells us that such species are likely to be better suited to targeted research than long-term monitoring. A second example involved setting multiple Anabat detectors for multiple nights to estimate the minimum number of nights required to yield precise estimates of bat activity. Preliminary analyses reveal that increasing the number of sampling nights results in increased precision when estimating activity, but that this can be moderated by increasing the number of detector sites in an area.

Bats of South Australia's Murray Region—A Free Poster

Aimeé Linke; Mid Murray Local Action Planning Committee Inc., Cambrai, SA 5353

The Mid Murray Local Action Planning Committee in collaboration with the Bats for Biodiversity Project, has run the Community Bat Monitoring Program since 2003. During the course of the Program, it became evident to us that many members of the community had little appreciation of the diversity of microbats in their region. We therefore decided to design and print a poster, which would illustrate the regional bat biodiversity, and make the posters freely available to the community. The poster "Bats of South Australia's Murray Region" features photographs of the 16 microbat species of the region, and includes some text with general information about bats. Photographs and text were compiled in collaboration with the South Australian Museum. The poster design and content were funded through the South Australian Murray Darling Basin Natural Resources Management Board's Community Grants, and the printing of 2000 posters was funded through the Department of Environment and Heritage. The aim of this poster is to raise awareness of the bat species of the region and hopefully assist in understanding their role in biodiversity and the need to protect and conserve their habitat.

The Ecology and Conservation of the Enigmatic Eastern Long-eared Bat (*Nyctophilus timoriensis*) in Victoria

Lindy Lumsden; Arthur Rylah Institute, Heidelberg, VIC 3084

The Eastern Long-eared Bat *Nyctophilus timoriensis* (southeastern form) is a rare species that is widely distributed from southeastern Queensland, through inland NSW into northwestern Victoria and eastern SA. It is classified as Vulnerable both nationally and in each state in which it occurs. In Victoria it is extremely rare, with only six records for the state prior to 2007. A study was begun in 2007 to increase knowledge of its specific habitat requirements, roosting and foraging ecology, and threats to its long-term conservation. This was centered on the Nowingi area, where an individual was trapped in 2004, and the adjacent Hattah-Kulkyne National Park. Extensive trapping effort was undertaken (539 harp trap-nights and 206 mist-net hours), during which 963 bats of 11 species were caught. There were 19 captures of Eastern Long-eared Bats representing 15 individuals: one male was caught four times. The majority of individuals trapped were males (12 males to 3 females). Twelve individuals were fitted with radio transmitters, and tracked to 29 roost sites. Most roosts were in dead spouts on mallee eucalypts, with some under bark or in fissures of dead Buloke or Belah trees. These roosts provided little or no buffering against extreme ambient temperatures. All roosts, except one, were in long-unburnt habitats that had an abundance of hollows in the general area. All individuals roosted solitarily. Individuals moved large distances on a nightly basis. Roost sites were 1.87 ± 1.63 km (range 0.34–7.06 km) from the capture point. Individuals used a number of different roost sites, often moving to a new roost each day. In contrast to other species of long-eared bats where consecutive roosts are usually close together, Eastern Long-eared Bats moved large distances between roosts: 2.00 ± 1.86 km (range 25 m–5.88 km). The capture of 15 individuals during this study has significantly increased the number of Victorian records of this species. It is believed that the long-unburnt vegetation in this area, which is situated within a large intact area of vegetation, is likely to be the key factor influencing the comparatively high numbers found in this area.

Roost Selection by Bats in Woodchipped Forests

Dan Lunney[1], Peggy Eby[1], Shaan Gresser[1], Harry Parnaby[1], David Priddel[1], Robert Wheeler[1], Alison Matthews[2], and Chris Corben[3]; [1]Department of Environment and Climate Change, Hurstville, NSW 2220; [2]Department of Environment and Climate Change and Charles Sturt University; [3]http://www.hoarybat.com

This research focused on species dependent on old-growth forest elements. The aim was to determine the roosts selected by Gould's Long-eared Bat and the Little Forest Bat in forests that had been logged for woodchips 25 years earlier. The bats were caught in harp traps, radio-tracked to roost trees, and a comparison was made between trees used and trees available. Both bat species were selective in the species, size and condition (live/dead) of their roost trees, and in landscape characteristics, such as logging history, topography, and aspect. Gould's Long-eared Bat selected, as maternity roosts, cavities in large (DBH: mean 73.6 cm) live trees, located in coupes in unwoodchipped forest on slopes with eastern or southern aspects. Adult males showed a preference for roosting under exfoliating bark of dead wattle. Both male and female Little Forest Bats selected cavities in large (DBH: mean 68.7 cm) trees. Their roosts were preferentially located on south and east facing gullies and mid-slopes. Neither species used live trees < 50 cm DBH, although they dominated the forest. While roost preferences are complex, there is a consistent pattern of dependence on cavities found in dead or decaying trees. This and earlier studies offer no evidence that regrowth vegetation in intensively managed forests provides roosting habitat for tree-roosting bats. Rather, conservation of these species depends on preservation and recruitment of old growth elements of forests.

Recovery of the Grey-headed Flying Fox: An Overview of the Department of Environment and Climate Change's Efforts in NSW (2001–ongoing)

Kylie McClelland; NSW Department of Environment and Climate Change, Sydney South, NSW 1232

The Grey-headed Flying Fox *Pteropus poliocephalus* is a wide-ranging species, spanning Queensland, New South Wales, and Victoria, and is listed as a vulnerable species at both the state (NSW and Victoria) and national level. Being a highly mobile species, it moves across its range in response to natural resource availability, and plays a critical ecological role as a pollinator and seed disperser of our native forests. The primary threat to the Grey-headed Flying Fox is habitat loss or modification, but other threats include killing in commercial crops; harassment at roosts; potential competition and hybridization from Black Flying Foxes; negative

public attitudes and conflict with humans; electrocution on power lines, entanglement in netting and on barbed-wire; climate change; and disease. It is unique as a threatened species in that it is also recognized as an agricultural pest, and faces increasing conflict with humans at the urban interface. The listing of the Grey-headed Flying Fox as a vulnerable species under the NSW Threatened Species Conservation Act 1995 in May 2001 instigated the formation of the NSW Flying Fox Consultative Committee and the strengthening of the statewide flying fox conservation program. This presentation provides an overview of the flying fox research and project work coordinated by the NSW Department of Environment and Climate Change since the listing of the Grey-headed Flying Fox as a threatened species in NSW, and how science is being used to inform the conservation of this species. Projects discussed include preparation of the national recovery plan; establishing the flying fox camp database; population surveys and an inland distributional survey; attitudinal surveys; research on foraging habitat, roost site selection and flying fox damage in orchards; and development of the NSW flying fox camp management policy.

Reproductive Management of Captive *Pteropus* Species

Debbie Melville[1], Elizabeth Crichton[1], Gemma O'Brien[2], and Steve Johnston[1]; [1]University of Queensland, Gatton, QLD; [2]University of New England, Armidale, NSW

Pteropus (flying fox) species around the world are on the verge of extinction, primarily due to habitat destruction. The establishment of ex situ conservation programs, such as the development of captive breeding colonies have the potential to help save these species. Captive colonies can serve as important insurance reservoirs of genetic diversity. However, the polyandrous mating system of pteropids means that there is a level of uncertainty surrounding paternity of the offspring. One way to overcome this uncertainty is to utilize assisted breeding technologies, such as artificial insemination (AI) in the reproductive and genetic management of these captive populations. Assisted breeding technologies can also play a primary role in improving our general comprehension of pteropid reproductive biology and should be used as reproductive and genetic tools in conjunction with habitat protection and education campaigns. The development of AI requires the cryopreservation of sperm. Cryopreservation involves cooling, freezing, and thawing the sperm, a process that can cause damage to the plasma membrane and acrosome. Damage or loss of the latter is of particular concern as pteropid sperm have a large anteriorly projecting acrosome that is extremely sensitive and prone to damage. To ensure that the majority of sperm remain alive, retain their acrosomes, and maintain their motility during cryopreservation, the correct protocol must first be established. This involves the development of species-specific diluents and cryoprotectants, and the determination of appropriate rates of temperature change during the cooling, freezing, and thawing processes. My PhD research is investigating ways of improving pteropid sperm cryopreservation protocols, with the aim of utilizing protocols developed using common species of pteropids to aid in the conservation of these endangered species. This would allow the genetics of males from endangered species to be conserved and potentially returned to the population long after that individual male has died. Furthermore, it would allow for the collection of semen from wild males to be stored or used in AI programs for captive breeding populations, and it would eliminate the need to transport live flying foxes between captive populations.

New Records and Extensive Range Extension for the Critically Endangered Bare-rumped Sheath-tailed Bat *Saccolaimus saccolaimus* (Chiroptera: Emballonuridae) Including Genetic Analysis, Notes on Field Identification, and Description of Echolocation Call

D. J. Milne[1], F. C. Jackling[2], and B. R. Appleton[2]; [1]Department of Natural Resources, Environment and the Arts, Palmerston, NT 0831; [2]University of Melbourne, Parkville, VIC 3010

This study combines field survey, morphological and genetic analyses to reveal several new records, as well as large extensions to the known Australian distribution of *Saccolaimus saccolaimus*. The morphological similarities to *S. flaviventris* are addressed and genetic, morphological, and echolocation analyses are used in an attempt to provide diagnostic characters to identify the two species. Approximately 200 individuals were identified at seven new localities, and our genetic and morphological analyses indicate there are likely to be more due to misidentified specimens in museum collections. *S. saccolaimus* is currently listed nationally as critically endangered due to the rarity of observations. In light of the new information and the uncertainties we've identified, 'data deficient' is considered to be the most appropriate classification for this species. We recommend genetic testing of all Australian *Saccolaimus* specimens within museum collections to determine the species true extent and conservation status.

Batting in Borneo

Jen Parsons[1], Chris Corben[2], and Simon Robson[1]; [1]James Cook University, QLD 4811; [2]http://www.hoarybat.com

In December 2007, five staff and 26 students from James Cook University headed off to the wilds of Sabah, Borneo, for a field-based learning experience and an opportunity to catch some great bats. Based in the lowland primary dipterocarp forest of the Danum Valley Field Centre, we used a four-bank harp trap, mist nets, and Anabat CF1s + HP PDAs to capture bats and record echolocation calls. Over seven nights we caught 34 individuals from 13 species of both Microchiroptera and Megachiroptera and recorded the calls of 20 species (only 6 of which could be confidently assigned to a species). Only megachiropterans were caught in the mist nets and both mega- and microchiropterans in the harp trap. Four-bank harp traps appear to offer greater capture success than two-bank traps: we often observed bats successfully flying past the first three banks, only to become entrapped by the fourth. Our goals for this annual field course are to continue to add to our knowledge of the bats present in the region, enhance the call library, and introduce many more students to the world of batting.

Australian Bats on Wikipedia

Michael Pennay; Department of Environment and Climate Change, Queanbeyan, NSW 2620

Wikipedia is a free nonprofit internet-based encyclopedia that is collaboratively written by volunteers—anybody can contribute. Wikipedia has grown rapidly since it started in 2001 and is now accessed by 8–9% of Web users globally on a daily basis. It currently ranks as the 8th most visited Web site in the world based on global traffic. As such Wikipedia probably offers one of the simplest and most accessible ways for information about Australian bats to be conveyed throughout the world. Unfortunately, at the moment only a very small number of Australian bat entries have any information whatsoever, and the great majority of these are 'stubs'—the

Wikipedia equivalent of a vacant space just waiting to be filled. Because anybody can contribute to and edit Wikipedia pages, filling these stubs provides a great opportunity for Australian bat enthusiasts to contribute to the 'global commons' by adding information to species about which they know. To demonstrate how it can be done (and to learn myself) I have filled out a real stub on Wikipedia as an example (http://en.wikipedia.org/wiki/Little_Forest_Bat). Hopefully this poster will encourage more people to take up the challenge.

Gods, Vultures, Starvation, Suicide, and a Pickle Jar, the Beginning and the End of *Vespadelus vulturnus*. An Anthology of Mistakes

Michael Pennay; Department of Environment and Climate Change, Queanbeyan, NSW 2620

While investigating the background history of the Little Forest Bat (*Vespadelus vulturnus*) for a publication, I discovered the bat's history holds a number of sometimes tragic stories and mistakes, including some substantial errors we're all guilty of perpetuating. This talk introduces the characters and stories and describes some of the mistakes uncovered, including the discovery that for 30 years nobody has realized that the type specimen of *Vespadelus vulturnus* is in fact a different species. I explain how the error was made and what it means.

Variations in Hollow Availability for Three Species of Eucalypts in Semi-arid Woodlands of Central-western NSW

Laura Rayner[1], Murray Ellis[2], and Jennifer Taylor[1]; [1]ACU, North Sydney, NSW 2059; [2]DECC Scientific Services, Hurstville, NSW 2220

Hollow-bearing trees provide roost sites for at least 13 species of bats from the woodlands of the wheat-sheep belt in central-western NSW. However, hollow-availability has been greatly reduced by broad-scale clearing for agriculture, compromising the long-term survival of hollow-dependent fauna in the area. Limited information exists about hollow availability in eucalypt species of the NSW wheat-sheep belt. Additionally, variation in hollow characteristics among tree species inhibits the application of existing data from other species. This study compares hollow availability among three dominant eucalypt species: *Eucalyptus melliodora* (Yellow Box), *Eucalyptus microcarpa* (Grey Box), and *Eucalyptus populnea* subsp. *bimbil* (Poplar Box). We have established 142 one-hectare sites in a highly cleared (< 20% native woody vegetation cover remaining) agricultural landscape. Sites range in tree density from no eucalypts on-site to whole remnants and are on roadsides, stock routes, and stream margins. Initial data from 26 sites compare hollow abundance and hollow type in relation to tree species, trunk diameter, tree height, crown size, tree form, and condition. We also compare hollow-availability in single-trunked and multiple-trunked trees, coppicing versus non-coppicing trees, and live versus dead tree segments. Of all trees assessed (DBH > 15 cm), 74% of *E. microcarpa*, 63% of *E. populnea* subsp. *bimbil*, and 48% of *E. melliodora* were found to be hollow-bearing with hollow-production thresholds of 164, 171, and 186 mm, respectively. All species have shown an increase in hollow abundance with increasing DBH, while *E. melliodora* had many fewer hollows at a given trunk diameter than *E. microcarpa* and *E. populnea* subsp. *bimbil*. Overall, sites had very low numbers of hollow-bearing stags (< 4%).

Pit-tagging Lesser Short-tailed Bats: Developing an Ethical Technique for Monitoring 2005–2008

Jane Sedgeley and Colin O'Donnell; Southern Regional Science Centre, Department of Conservation, Christchurch, New Zealand

No abstract is available for this paper, which was substituted for a last minute withdrawal at the Conference.

Artificial Bat Habitats in Western Australia

Joe Tonga; Natsync Environmental, East Fremantle, WA 6158

Natsync Environmental has been designing, producing, and installing artificial homes for native animals for the past ten years. We have been trialing microbat homes for the past five years. We started with building the conventional timber boxes and progressed to PVC. Our objectives were to design, build, and install a bat home that had the following attributes: 1) a long life—microbats are notoriously slow in taking up residence in timber boxes, a home can deteriorate in the elements waiting for inhabitants, and plantation plywood will only last eight to ten years even when coated with good quality paint; 2) temperature stability—provide a home that has various temperature gradients that fulfill the biological requirements of microbats; 3) the ability to house different species of microbats; 4) is designed to become nursery colonies; 5) a generous landing pad; 6) is easy for the bats to move around; 7) is resistant to *Apis mellifera*; 8) is totally weatherproof; and 9) requires minimal installation. In summary we found that: 1) conventional timber, single-cavity, bat roosting boxes rarely attract microbats in the Perth suburbs of Western Australia—within 12 months they fill up with *Apis mellifera*; 2) installation techniques currently used on trees are totally inadequate, and thus we have developed a system that moves with the trees; 3) temperature is critical—all locations studied have extremely high temperatures in summer; 4) new design of sand-filled PVC appears successful and attract local bats in middle suburbia in 15 months; and 5) bat houses mounted on sheds or old buildings attract inhabitants faster than on trees.

Bat Community Responses to Logging in Jarrah Forests, Southwestern Australia

Paul Webala[1], Stuart Bradley[1], Michael Craig[1], and Kyle Armstrong[2]; [1]Murdoch University, Murdoch, WA 6150; [2]Molhar Pty Ltd, Como, WA 6152

To determine whether timber-harvesting practices in jarrah forests of Western Australia negatively impact forest bat communities, we investigated bat activity in unlogged, logged, and regrowth forests. Our aim was to test hypotheses that bat diversity was lowest in gaps and that species negatively affected by logging were less frequent in gaps, compared to regrowth and unlogged forest. We used Anabat Detectors to compare relative use and foraging activity by bats (bat activity) at four sites in each of unlogged forest, gaps, and regrowth (12 sites in total), with detectors placed both on tracks and off-tracks at each site. Preliminary results showed that logging history had no impact on bat activity, when on and off-track data were pooled (Global $R = 0.02$; $P = 0. 414$). However, off-track sites grouped separately from on-track sites in the MDS and bat communities were significantly different (Global $R = 0.55$; $P = 0.002$). Thus, activity on tracks did not significantly vary with logging history, showing that use of forest tracks by bats is unaffected by logging. At the species level, no bat responded to logging history. However five species, excluding *Tadarida australis* and *Mormopterus* spp., showed significant differences in

activity between on- and off-track sites. These five species showed similar activity in logged, regrowth, and unlogged forests on tracks but on-track activity differed significantly from off-track activity. Tracks are thus important in ameliorating the impacts of logging on bats in selectively timber-harvested forests and should be maintained for the long-term persistence of bats.

List of Attendees

13th Australasian Bat Society Conference
Charles Sturt University, Thurgoona NSW, Australia, 12–14 April 2007

Jerry Alexander	Department of Sustainability and Environment, PO Box 303, WODONGA VIC 3689, Jerry.Alexander@dse.vic.gov.au
Belinda Appleton	Department of Genetics, University of Melbourne, Royal Parade, PARKVILLE VIC 3010, b.appleton@unimelb.edu.au
Paul Barden	19 Sammi Court, COOLUM BEACH QLD 4573, e-m-s@optusnet.com.au
Grant Baverstock	55 Noyes Road, LETHBRIDGE VIC 3332, bavs@pipeline.com.au
Robert Bender	Friend of Organ Pipes National Park, 185 The Boulevard, IVANHOE VIC 3079, rbender@netlink.com.au
Gillian Bennett	PO Box 157, YAMBA NSW 2464, stinger@ceinternet.com.au
Rachel Blakey	Biosis Research, rblakey@biosisresearch.com.au
Kathleen Blount	Sydney Wildlife World, 54 Woodbine St, NORTH BALGOWLAH NSW 2093, kblount@sydneyaquarium.com.au
Steve Bourne	Naracoorte Caves National Park, World Heritage Fossil Site, Department for Environment and Heritage, PO Box 134, NARACOORTE SA 5271, Bourne.Steven@saugov.sa.gov.au
Linda Collins	PO Box 1133, WAIKERIE SA 5330, lindacollins1@bigpond.com
Chris Corben	404 Melbourne St, Columbia MISSOURI 65201 USA, corben@hoarybat.com
Elizabeth Crichton	5123 Izard St, Omaha NE 68132 USA, bethiberg@aol.com

Amy Currey	NGH Environmental, PO Box 5464, WAGGA WAGGA NSW 2640, amy@nghenvironmental.com.au
Timna Dean	WIRES Riverina and Charles Sturt University, 1/11 Matheson Place, ESTELLA NSW 2650, tdean@csu.edu.au
Amie Douglas	24 Fairview Street, TRARALGON VIC 3844, amie_douglas@yahoo.com.au
Angela Duffy	Department for Environment & Heritage, GPO Box 1047, ADELAIDE SA 5001, duffy.angela@saugov.sa.gov.au
Murray Ellis	Department Environment & Conservation (NSW), PO Box 1967, HURSTVILLE NSW 2220, murray.ellis@environment.nsw.gov.au
Alex Emmins	Mannum to Wellington Local Action Planning Inc. (Fauna Care & Release Inc.), 74 Thiele Road, MURRAY BRIDGE SA 5253, groovay_89@hotmail.com
Nathan Garvey	Biosis Research, PO Box 389, PORT MELBOURNE VIC 3207, ngarvey@biosisresearch.com.au
Craig Grabham	GHD, Level 8, 180 Lonsdale Street, MELBOURNE VIC 3000, craig.grabham@ghd.com.au
Chris Grant	SA Murray-Darling Basin NRM Region, Department for Environment and Heritage, 28 Vaughan Terrace, BERRI SA 5343, grant.chris2@saugov.sa.gov.au
Rob Gration	80 Hobson St, NEWPORT VIC 3015, rgration@yahoo.com.au
Belinda Gunn	Goolwa to Wellington Local Action Planning Association, PO Box 674, STRATHALBYN SA 5255, belinda.gunn@samdbnrm.sa.gov.au
Judith Hallinan	Wildlife Assistance and Information Foundation Inc., 58 Wideview Road, BEROWRA HEIGHTS NSW 2082, judy@waif.org.au
Steve Hamilton	Biological, Earth and Environmental Sciences, University of NSW, SYDNEY NSW 2052, s.hamilton@student.unsw.edu.au
Jessica Herring	Biosis Research, 8 Tate Street, WOLLONGONG NSW 2500, jherring@biosisresearch.com.au

Luke Hogan	EPA, 80 Meiers Rd, INDOOROOPILLY QLD 4068, luke.hogan@epa.qld.gov.au
Kaye Holdsworth	Professional Australian Wildlife Services, 601 Paterson Road, WOODVILLE NSW 2321, wildcare@hotkey.net.au
Bill Holsworth	13 Nabilla Crescent, BENDIGO VIC 3550, wholsworth@bigpond.com
Clare Hourigan	Griffith University, 2 Thompson St, Silkstone, IPSWICH QLD 4304, clhourigan@yahoo.com.au
Robert Irvine	11 Mudie Ave, SUNBURY VIC 3429, robert.irvine@mail.com
Maree Kerr	72 Lee Steere Cres, KAMBAH ACT 2902, cantcatchme@netspeed.com.au
Ian Kitchen	64 Fillmore Rd, DANDENONG NTH VIC 3175, iankitc@hotmail.com
Chris Knight	Titley Electronics, PO Box 19, BALLINA NSW 2478, chrisk@titley.com.au
Susan Lamb	Environmental Science, Australian Catholic University, 40 Edward Street NORTH SYDNEY NSW 2060, suztestarossa@yahoo.com.au
Brad Law	NSW Department of Primary Industries, Science & Research, PO Box 100, BEECROFT NSW 2119, bradl@sf.nsw.gov.au
Aimeé Linke	Mid Murray Local Action Planning Committee, PO Box 10, CAMBRAI SA 5353, alinke@internode.on.net
Danielle Lisle	3 Narrabeen St, KEWARRA BEACH QLD 4879, Danielle.lisle@jcu.edu.au
Kim Livengood	Titley Electronics, 404 Melbourne Street, Columbia MO 65201 USA, km_livengood@yahoo.com
Gary Luck	Charles Sturt University, ILWS, PO Box 789, ALBURY NSW 2640, galuck@csu.edu.au
Lindy Lumsden	Department of Sustainability & Environment, Arthur Rylah Institute, 123 Brown St, HEIDELBERG VIC 3084, Lindy.Lumsden@dse.vic.gov.au
Dan Lunney	Department of Environment and Conservation (NSW), PO Box 1967, HURSTVILLE NSW 2220, dan.lunney@environment.nsw.gov.au

Alicia Lyon	Ecological Australia, PO Box 484, COFFS HARBOUR NSW 2450, alicial@ecoaus.com.au
Michal Malinga	Ecotone, Slowackiego 12 Sopot 81871, POLAND, biomm@ecotone.pl
Katie Marshall	Sydney Wildlife World, 40 Nararbeen Park Parade, WARRIEWOOD NSW 2102, fishfish40@hotmail.com
Clare Mason	GHD, PO Box 992, WODONGA VIC 3689, clare.mason@ghd.com.au
Kathryn Mason	SA Murray Darling Basin Natural Resource Management Board, PO Box 2343, MURRAY BRIDGE SA 5253, Kate.mason@samdbnrm.sa.gov.au
Alison Matthews	Charles Sturt University, ILWS, PO Box 789, ALBURY NSW 2640, almatthews@csu.edu.au
Dennis Matthews	37 Second Street, NURIOOTPA. SA 5355, dennis.matthews@bigpond.com
Kylie McClelland	Department of Environment and Climate Change (NSW), PO Box A290, SYDNEY SOUTH NSW 1232, kylie.mcclelland@environment.nsw.gov.au
Anna McConville	RPS Harper Somers O'Sullivan, 241 Dension St, BROADMEADOWS NSW 2303, annamac_80@hotmail.com
Debbie Melville	University of Queensland, 34 Larsen St, LEICHHARDT QLD 4305, d.melville@uq.edu.au
Damian Milne	Department of Natural Resources, Environment and the Arts, PO Box 496, PALMERSTON NT 0831, damian.milne@nt.gov.au
Tony Mitchell	Department of Sustainability & Environment, PO Box 634, ORBOST VIC 3888, tony.mitchell@dse.vic.gov.au
Vaughan Monamy	Australian Catholic University, PO Box 968, NORTH SYDNEY NSW 2059, vaughan.monamy@acu.edu.au
Colin O'Donnell	Department of Conservation, PO Box 38, CHRISTCHURCH, NEW ZEALAND, codonnell@doc.govt.nz
Nancy Pallin	Ku-ring-gai Bat Conservation Society Inc., 45 Highfield Rd, LINDFIELD NSW 2070, npallin@bigpond.net.au
Jennifer Parsons	School of Marine & Tropical Biology, James Cook University, QLD 4811, jennifer.parsons@jcu.edu.au

Tim Pearson	Ku-ring-gai Bat Conservation Society, 2A Critchett Rd, CHATSWOOD WEST NSW 2067, tim_cary@bigpond.net.au
Michael Pennay	Department of Environment and Climate Change (NSW), PO Box 733, QUEANBEYAN NSW 2620, michael.pennay@environment.nsw.gov.au
Laura Rayner	Environmental Science, Australian Catholic University, PO Box 968, NORTH SYDNEY NSW 2059, vballgirl@optushome.com.au
April Reside	3 Klopper Court, BAIRNSDALE VIC 3875, aerbatchick@hotmail.com
Reuben Robinson	NGH Environmental, PO Box 5464, WAGGA WAGGA NSW 2640, reuben@nghenvironmental.com.au
Kathryn Rothe	Mannum to Wellington Local Action Planning Inc. (Fauna Care & Release Inc.), PO Box 2056, MURRAY BRIDGE SA 5253, mwlap@mwlap.org.au
Martin Schulz	Department of Environment and Conservation (NSW), PO Box 1967, HURSTVILLE NSW 2220, martin.schulz@environment.nsw.gov.au
Jane Sedgeley	7 Kowhai Terrace, CHRISTCHURCH, NEW ZEALAND 8022, mohua@xtra.co.nz
Melanie Shears	University of Melbourne, Royal Parade, PARKVILLE VIC 3010, m.shears2@ugrad.unimelb.edu.au
Andy Spate	Optimal Karst Management, 2/10 Victoria Street, HALL ACT 2618, andyspate@aliencamel.com
Sonya Stanvic	WIRES (Blue Mountains Branch), 138 Ridgeway Crescent, SUN VALLEY NSW 2777, sonya@stanvicengineering.com
Melissa Starling	Biosis Research, mstarling@biosisresearch.com.au
Jennifer Taylor	Australian Catholic University, PO Box 968, NORTH SYDNEY NSW 2059, jennifer.taylor@acu.edu.au
Caragh Threlfall	Kensington Campus Sydney, Room 514 Biosciences Bld., University of NSW, NSW 2052, caragh.threlfall@gmail.com
Joe Tonga	Natsync Environmental, 25 Oakover Street, EAST FREMANTLE WA 6158, joe@natsync.com.au
Paul Webala	Murdoch University, South St, MURDOCH WA 6108, paul.webala@gmail.com

Carole West	16 Calwalla Crescent, PORT MACQUARIE NSW 2444, grimalkn@ceinternet.com.au
Anne Williams	Ecotone Ecological Consultants Pty Ltd, 23 Kula Rd, MEDOWIE NSW 2318, ecotonesyd@primus.com.au
Narawan Williams	Ecotone Ecological Consultants Pty Ltd, 23 Kula Rd, MEDOWIE NSW 2318, Narawantwilliams@hotmail.com
Ray Williams	Ecotone Ecological Consultants Pty Ltd, 23 Kula Rd, MEDOWIE NSW 2318, ray@ecotoneconsultants.com.au
Rebecca Wood	Genetics Department, University of Melbourne, Royal Parade, PARKVILLE VIC 3010, r.wood@pgrad.unimelb.edu.au

IN MEMORIAM

Robert David Berry: 1939–2008

Patricia E. Brown

Robert David “Bob” Berry died peacefully in his sleep in Ridgecrest, California, on 17 February 2008. A superb athlete and competitor even at the age of 68, Bob battled a rare form of prostate cancer since June 2007. Throughout his illness, Bob maintained his sense of humor and ready smile. His passing leaves a void in the lives of many friends around the world.

Bob was born on 11 May 1939, in Albany, California. He graduated from the University of California at Berkeley with a bachelor’s degree in mechanical engineering, and while at Berkeley, he entered the co-op program and began his professional life-time association with China Lake Naval Air Weapons Station. He briefly left “the Lake” to obtain a master’s degree from Stanford University and a doctorate from the University of California at Berkeley. Bob’s specialty was control systems.

After his marriage to Patricia Brown in 1981, he shared her research on bats. He and Pat traveled around the United States and the world for research and conferences. Bob’s professional background in computer systems enabled him to become an expert in the analysis of bat echolocation signals. An accomplished pilot, he perfected techniques to locate and track bats via radio-telemetry at night from an airplane. He also specialized in surveys of bats in mines and caves, rappelling into many holes, and he developed a down-the-hole camera to investigate deep mine shafts.

Bob loved to share his technical knowledge with colleagues and students. As a permanent memorial to Bob, Pat wants to establish a Bob Berry student scholarship through the Western Bat Working Group (WBWG), which would support purchase of equipment for students. Pat is pledging $1,000 toward the scholarship fund, if this amount is matched by donations to the WBWG fund by the time of the annual meeting in Austin, Texas, in April 2009.

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

Blip, Ping & Buzz: Making Sense of Radar and Sonar. Mark Denny. The Johns Hopkins University Press, Baltimore, Maryland. 274 pp., 2007. ISBN: 978-0-8018-8665-2 (hardcover). $27.00 USD.

As implied by the subtitle and explicitly stated in the preface, Mark Denny's book describes the concepts and techniques behind radar and sonar. With a Ph.D. in theoretical physics and more than 20 years of experience as a systems design engineer, Denny is eminently qualified to write such a treatise. This book explains the physical principles and processing strategies behind radar and sonar in a lucid, fascinating, and at times quite humorous manner. Indeed, Denny's writing is anything but dry and boring. He adeptly explains complex subject matter and does so with relatively simple language and minimal use of symbolic notation; the mathematics that is used should be understood by anyone with a high school diploma. Moreover, almost every explanation is accompanied with a suitable non-technical analogy, often from a military context. Thus, not only is the book technically sound, but it also is historically interesting. With the obvious similarities between radar, sonar, and echolocation, the physical and theoretical concepts discussed in Denny's book will be of tremendous interest and value to bat biologists wishing to further their understanding of echo processing.

The main text is divided into an introduction, six detailed chapters, and a seventh chapter with some brief final thoughts. Furthermore, at the end, there are 23 notes that provide useful technical detail. I would have preferred to see these notes within the chapters themselves, rather than having to flip back and forth to read them, but compromises are inevitable when writing for a broad audience. The notes are reasonably meaty and comprise more than 20% of the book, yet they too are not demanding in terms of mathematical skills. The notes cover a range of topics, including target ranging and accuracy, directional antennas and beamshape, beamforming, resolving target angle, range and motion, the decibel system, antenna gain, atmospheric attenuation, surface clutter, signal statistics, Doppler shift, correlation processing, wave transmission, digital signals and aliasing, and others.

Chapter 1 uses World War II as the backdrop to describe the development of radar and illustrates the pressures facing Great Britain to develop their Chain Home radar system and integrate it into war command and control communications. I very much enjoyed Denny's writing style and the use of a militarily imperative to introduce technical details (e.g., amplitude monopulse detection and transmitter blanking) of historical importance. Combined with fascinating asides in the numerous footnotes, it makes for a rather charming geek read.

After the historical overview, Chapter 2 introduces the foundations of remote sensing with radar and sonar. This is where topics like decibels, the range equation, surface clutter, and signal propagation and transmission are discussed, including a primer on signal detection theory, although Denny does not use this term.

Now that the reader is armed with the parlance of the trade, Chapter 3 delves into signal-processing strategies. Here, the reader learns how to design antenna arrays and about the benefits of coherent signal processing to compensate for Doppler shift in echoes and to suppress echoes from surface clutter. Denny also discusses how to increase signal-to-noise ratio and boost target strength. Furthermore, the reader learns why coherent processing provides more accurate estimates of target angle, range, and direction in sector scans of the environment and why frequency-modulated (FM) chirp signals are better for target ranging.

Chapter 4 starts halfway through the book, and by now the reader has waded through ca. 90% of the technical notes. In this chapter, Denny returns to the battlefield to inform us about different tactics for deploying radar and sonar (including which signal bands are best in particular situations), electronic warfare (e.g., jamming), electronic countermeasures, anomalous signal propagation, and antisubmarine warfare. Chiroptologists immediately will see similarities between military tactics and the foraging strategies of echolocating bats, and more specifically, how tympanate insects attempt to thwart predatory attacks of bats with acoustically triggered escape behavior.

Chapter 5 tells how we process and display radar and sonar information. Here, Denny discusses how synthetic aperture radar and sidescan sonar work to produce exquisitely detailed images. Biologists must wait until this chapter for Denny's tribute to mammalian biosonar and strategies of echolocation. Denny makes direct comparisons between the strategies employed by radar and sonar engineers for effective sensing to analogous strategies evolved in bats (e.g., transmitter blanking versus the middle ear reflex of bats and radar chirp pulse compression versus FM signals emitted by bats).

Chapter 6 deals with modern applications of radar and sonar, including weather radar, air-traffic control systems, fish-finding sonar, and echocardiology. Denny rounds out his last meaty chapter with more advanced techniques, such as bistatic radar, new designs of antenna arrays, and high-resolution remote imaging. He also discusses sensor constraints for remotely operated vehicles, and ends by opining that the future for advancements in radar and sonar rest in sensor fusion or integration.

In Chapter 7, Denny enlightens his readers about the organizational aspects of the radar and sonar industry and the problems associated with large-scale projects. I was especially pleased, but not particularly surprised, to read that academia does not have an exclusive monopoly on run-of-the-mill managers and mediocre administrators.

I liked the size of the book, and its formatting was fine except for a few minor items. The font used in the chapter titles, headings, and running head was unattractive; I would have preferred more white space in the top margin, and there were a lot of footnotes. The book also contained an unusually large number of acronyms and abbreviations. I appreciate that some were included because of their historical usage, but with so many codenames it's a wonder that anyone could keep them straight. Finally, the way of listing topics in the index was inconsistent. For example, some topics were listed by the acronym, making them easy to locate, whereas other acronyms were spelled out, making them more difficult to find unless you already knew their meaning. For the most part, the figures were fairly clear and helpful. Mark Denny, thank you for writing such an interesting, accessible, and entertaining book.

Paul A. Faure, Department of Psychology, Neuroscience & Behavior, McMaster University, Hamilton, ON L8S 4K1, Canada; paul4@mcmaster.ca

ANNOUNCEMENT

Pandion Systems is embarking on the largest and most geographically expansive bat acoustic monitoring program ever undertaken. A state-of the-art automated data collection system is being deployed throughout North America. This program will generate the single largest acoustic monitoring database. To successfully implement this project, Pandion is seeking several bat ecologists for immediate employment.

Senior Bat Ecologist Position

Pandion is a leader in bat consulting services in the wind industry and is focused on innovative approaches and solutions. This position requires a Master's degree in wildlife biology (or equivalent). Field Experience with bats (e.g., acoustical monitoring, acoustical analysis, designing and conducting bat surveys, including mist-netting, echolocation, mark-recapture, or telemetry studies) is required. Candidates should have a solid background in wildlife ecology, sampling techniques, field data collection, data analysis, and report writing. Experience conducting ecological assessments and threatened and endangered species surveys as well as GIS familiarity is preferred. Candidates must have strong writing and interpersonal skills.

Position requires frequent travel, mainly in the U.S. and Canada, and provides both health and retirement benefits. Salary is dependent on qualifications and experience.

To become part of this ground-breaking project, please contact Jenny Carter at (352) 372-4747.

For more information, please visit: http://www.pandionsystems.com/about_news.htm

Staff Bat Ecologist Position

Pandion is a leader in bat consulting services in the wind industry and is focused on innovative approaches and solutions. This position requires a Bachelor's degree in wildlife biology (or equivalent) plus experience. Field Experience with bats (e.g., acoustical monitoring, acoustical analysis, designing and conducting bat surveys, including mist-netting, echolocation, mark-recapture, or telemetry studies) is required. Candidates should have a solid background in wildlife ecology, sampling techniques, field data collection, data analysis, report writing. Experience conducting ecological assessments and threatened and endangered species surveys as well as GIS familiarity is preferred. Candidates must have strong writing and interpersonal skills.

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FUTURE MEETINGS and EVENTS

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

18–22 August 2008
The IV Brazilian Mammalogy Conference will be held in the city of Sao Lourenco, Brazil. Please see http://www.sbmz.org/cbmz2008 for further information.

1 June 2008 through 4 January 2009
The Organization for Bat Conservation (OBC) and the Cranbrook Institute of Science will showcase a collaborative live bat exhibit, “Bats: Myths and Mysteries,” the main focus of which is OBC’s live bats. The exhibit begins 1 June 2008 and runs through 4 January 2009 at the Cranbrook Institute in Bloomfield Hills, MI. Components from the “Masters of the Night,” the recently retired traveling museum exhibit, will also be part of the exhibit. For more information, please visit: http://www.batconservation.org or http://www.cranbrook.edu

1–2 August 2008
The 7th Annual Great Lakes Bat Festival will be held at the Cranbrook Institute of Science in Bloomfield Hills, MI. Janell Cannon, the award-winning author of “Stellaluna,” will kick off the Bat Festival on August 1st, 2008, at 7 p.m. (pre-registration and tickets required for this event only). On Saturday, August 2nd, the Festival is open to all (no tickets or pre-registration necessary) from 10 a.m. through 11 p.m. Please see http://www.batconservation.org for more information and event schedules.

22–25 October 2008
The 38th Annual North American Symposium on Bat Research (NASBR) will be held in Scranton, Pennsylvania. For information, please see the NASBR Web site: http://www.nasbr.org/ or contact the organizers of the meeting Gary Kwiecinski (ggk301@scranton.edu) or Roy Horst (rhorst@twcny.rr.com).

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 the NASBR Web site for information (http://www.nasbr.org/).

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

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

BAT RESEARCH NEWS

VOLUME 49: NO. 2 **SUMMER 2008**

Table of Contents

Front Cover

Silver-haired bat, *Lasionycteris noctivagans*, by Fiona A. Reid. These attractive bats have black fur that is well-frosted with white and thickly haired tail membranes. The edge of the ears is yellowish. From: A Field Guide to the Mammals of North America north of Mexico, by Fiona A. Reid. 2006. Houghton Mifflin Co., Boston. Illustrations copyright Fiona A. Reid (reproduced with permission from the artist).

BAT RESEARCH NEWS

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BAT RESEARCH NEWS

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Effect of Moonlight on Nocturnal Activity of Two Cuban Nectarivores: The Greater Antillean Long-tongued Bat (*Monophyllus redmani*) and Poey's Flower Bat (*Phyllonycteris poeyi*)

Carlos A. Mancina

Instituto de Ecología y Sistemática, Carretera de Varona Km 3 1/2, Boyeros, Ciudad de La Habana, Cuba
E-mail: mancina@ecologia.cu

Introduction

Several Neotropical phytophagous bats respond to levels of lunar illumination by reducing flight activity during clear nights around the full moon (Esbérard, 2007; Handley et al., 1991; Morrison, 1980); this behavior is known as lunar phobia (Morrison, 1978). Fluctuations in availability of flowers and fruits are not linked to changes in lunar phase; therefore, reduced risk of predation by visually oriented predators, such as owls and mammals, has been used to explain this behavior (Fleming and Heithaus, 1986; Handley et al., 1991; Morrison, 1978). However, some studies have found no influence of moonlight on activity of bats, including insectivorous (Karlssön et al., 2002; Negraeff and Brigham, 1995) and phytophagous species (Thies et al., 2006).

I examined the effect of lunar illumination on the nocturnal activity of two bats: Greater Antillean Long-tongued Bat (*Monophyllus redmani*, 8.5–14.5 g) and Poey's Flower Bat (*Phyllonycteris poeyi*, 16.5–25.5 g). These species are cave-dwelling bats and unspecialized or generalist nectarivores (Silva Taboada, 1979; but see Soto-Centeno and Kurta, 2006), and both are endemic to the West Indies. This study was conducted in the Sierra del Rosario Biosphere Reserve (SRBR) in western Cuba. In this region *M. redmani* and *P. poeyi* are among the most abundant bats caught in mist nets set at ground level (Mancina et al., 2007). At least five nocturnal avian predators inhabit this area, and two species—the barn owl (*Tyto alba*) and stygian owl (*Asio stygius*)—are known to prey on bats (Kirckconnell et al., 1999; Silva Taboada, 1979). In the present paper, I inferred activity levels of bats by mist netting, and I predicted a lower nocturnal activity and, therefore, a lower capture rate of both species of bats on moonlit nights in response to increased predatory activity of nocturnal birds.

Methods

I used data from 76 sample-nights between April 1996 and September 2007 at SRBR (22°45'–23°00' N, 82°50'–83°10' W). The habitat in SRBR is evergreen forest, although only small zones of pristine or little-altered forests remain. Mean annual temperature is 24.4° C, and mean annual rainfall is 201.4 cm (Herrera and García, 1995). Bats were sampled with mist nets at five forest sites, including the core zone of SRBR and several secondary forests; the characteristics of the vegetation of these sites are described elsewhere (Mancina, 2004; Mancina et al., 2007). At each site, bats were sampled during the rainy season (May–November) and dry season (December–April); at least four nights of netting occurred in both the wet and dry seasons at most sites.

I used from four to six 9-m- or 12-m-wide mist nets with 35-mm mesh, set from the ground to a height of 2.5 m, and separated by about 30 m. All nets were open before dusk, operated until midnight, and checked every 30 min. The time of each capture was recorded, and each bat was tagged with a numbered band on a plastic necklace. Sampling effort was standardized each night by multiplying the length of all nets in meters by total number of hours during which sampling occurred. This allowed calculation of a nightly capture rate by dividing the number of captured individuals by sampling effort (m-h). To determine activity patterns with respect to lunar illumination, I compared capture rates between bright nights (n = 34) and dark nights (n = 42). I defined bright nights as the five nights around the full moon and dark nights as the five nights around the new moon; very cloudy nights near the full moon were excluded from analysis. All values are given as mean ± one standard error (*SE*).

Results

Phyllonycteris poeyi had lower capture rates on moonlit nights (0.007 ± 0.001 bats/m-h) than on dark nights (0.017 ± 0.003 bats/m-h), and the overall difference was significant (Mann-Whitney Test: U = 653.5; P = 0.02). Lower capture rates on bright nights were observed at all sites that were sampled (Fig. 1), although these data were not analyzed separately because of a low number of sampling nights at some sites. In contrast to *P. poeyi*, *M. redmani* displayed little variation (U = 502.0; P > 0.5) in capture rate between bright nights (0.025 ± 0.004 bats/m-h) and dark nights (0.026 ± 0.006 bats/m-h).

Discussion

Although I did not quantify food availability, it is unlikely that differing abundance of fruiting or flowering trees among sites or nights affected my results. On SRBR, many plants that are used by bats flower or fruit throughout the year (e.g., blue mahogany, *Talipariti elatum*—Herrera et al., 1988). Furthermore, netting at each site occurred on several nights in both the dry and wet seasons. In addition, both species of bats have similar diets (Mancina et al., 2007), and seasonal changes in food availability (e.g., flowering plants) should have affected the capture rate of both species in a similar manner.

Differences in response to bright nights may be related to differential susceptibility to predation brought about by differences in flight and foraging habits of each species. *P. poeyi* often forages in groups, and I have observed more than 30 individuals flying around a flowering blue mahogany. *P. poeyi* has a low wing-tip index (area of dactylopatagium divided by area of plagiopatagium—Mancina et al., 2004), indicating a limited ability to hover, and this bat typically lands on branches to feed. *P. poeyi* probably has low fidelity to foraging areas and commutes long distances to feed (Silva Taboada, 1979). In contrast, *M. redmani* appears to forage in small groups or as solitary animals. In addition, its low body mass and low wing loading (Mancina et al., 2004) allow high maneuverability, and *M. redmani* almost always hovers when feeding; also its greater maneuverability allows it to more easily visit shrubs in the cluttered understory of the forest, which may lessen its exposure to avian predation (Thies et al., 2006). Furthermore, data from SRBR suggest that *M. redmani* shows fidelity to feeding areas because all recaptures of *M. redmani* occurred at the same site where individuals had been caught previously, with some recaptures occurring as much as 2 years later (C. A. Mancina, unpubl. data). Less maneuverability, greater commuting distances, and low fidelity to foraging sites probably combine to make *P. poeyi* more susceptible to aerial predation than *M. redmani*.

The most likely predators are owls. The barn owl lives in urban and natural habitats throughout the Cuban archipelago (Garrido and Kirckconnell, 2000), and remains of at least 13 species of bats (50% of the total

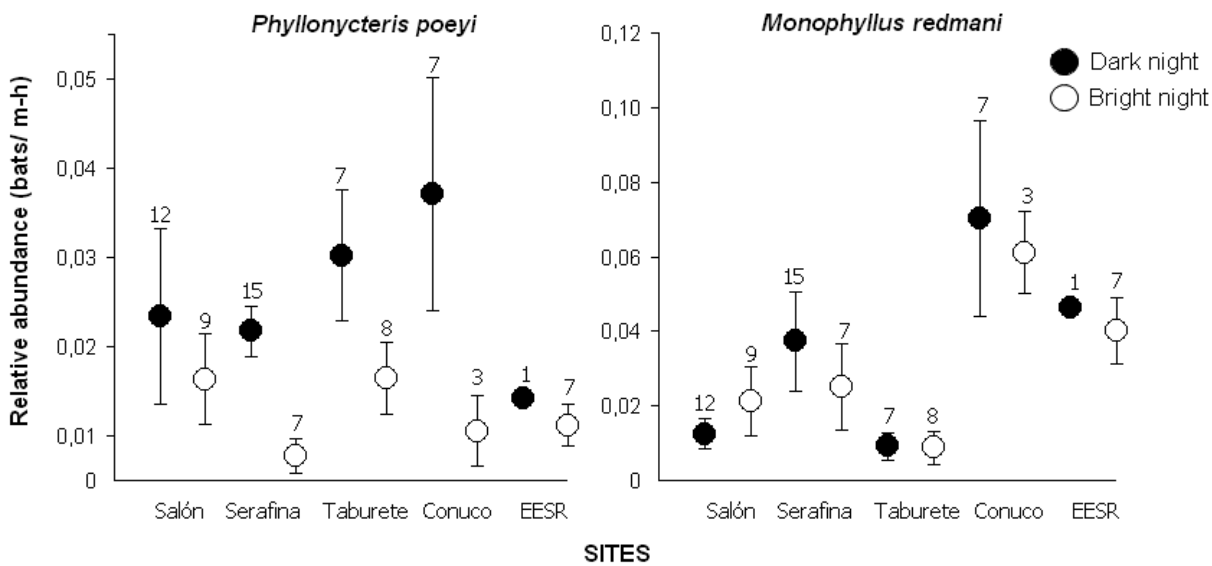

Figure 1. Relative abundance of two nectarivorous bats: Greater Antillean Long-tongued Bat (*Monophyllus redmani*) and Poey's Flower Bat (*Phyllonycteris poeyi*) in five forest sites at the Sierra del Rosario Biosphere Reserve at two levels of lunar illumination. Data are mean ± *SE*; the number of sampled nights is indicated for each site/illumination category.

number present) have been found in pellets of this owl, including all six species of phytophagous phyllostomids (Silva Taboada, 1979). Skulls of *P. poeyi* are more common in pellets from barn owls than are skulls of *M. redmani* in Cuba (Arredondo and Chirino, 2002; Silva Taboada, 1979). Similarly, McFarlane and Garrett (1989) found that another phyllonycterine, the Buffy Flower Bat (*Erophylla sezekorni*) was more common in pellets of barn owls in Jamaica than was *M. redmani*. In addition, *P. poeyi* was the most common species of prey found in 34 pellets from stygian owls obtained from La Güira, Sierra del Rosario, Cuba (Kirckconnell et al., 1999). Gannon and Willig (1997) and Rodríguez-Durán and Vázquez (2001) did not find lunar phobia in the Red Fig-eating Bat (*Stenoderma rufum*) and the Jamaican Fruit Bat (*Artibeus jamaicensis*) on Puerto Rico and suggest that absence of lunar phobia in insular populations of bats could be related to scarcity of nocturnal predators in the Antilles (Rodríguez-Durán and Vázquez, 2001). However, the present report indicates that style of flight and foraging also may impact how bats respond to moonlight.

Acknowledgments

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Working Together to Combat White-nose Syndrome: A Report of a Meeting on 9–11 June 2008, in Albany, New York

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

[1]*Department of Biology, Bucknell University, Lewisburg, PA 17837and*
[2]*Pennsylvania Game Commission, 2001 Elmerton Avenue, Harrisburg, PA 17110*
E-mail: dreeder@bucknell.edu

White-nose syndrome (WNS) was first noted in 2006 in New York State. It was named for a white fungus that grows on the muzzle, ears, and other exposed surfaces of hibernating bats. It is also associated with fat reserves that are depleted by midwinter, a reduced ability to arouse from deep torpor, shifts from typical hibernating sites, daytime flight during winter, and permanent emergence from the hibernacula in midwinter. In severely affected sites, WNS is characterized by mass starvation and death and has resulted in loss of ca. 90% of the bats in certain hibernacula. WNS has been identified now at 18 sites in New York, 5 in Vermont, 3 in Massachusetts, 1 in Connecticut, and possibly 3 locations in Pennsylvania. Bats surviving the winter in Massachusetts, New York, and Vermont were experiencing mortality in their summer habitats, at least through June, and damage to wings and other anomalies (e.g., flaking skin along forearms or multiple small white spots; see Fig. 1), presumably associated with WNS, also have been documented in summer. Thus far, WNS has affected six species (big brown bat, *Eptesicus fuscus*; small-footed bat, *M. leibii*; little brown bat, *Myotis lucifugus*; northern bat, *M. septentrionalis*; Indiana bat, *M. sodalis*; and eastern pipistrelle, *Perimyotis subflavus*), all of which have been identified on state wildlife action plans as species of greatest conservation need. WNS represents a significant and unprecedented problem with likely dire consequences in the Northeast and potentially beyond.

In response to this crisis, a meeting of the primary researchers and wildlife managers dealing with WNS was held on 9–11 June in Albany, New York. The meeting was hosted by New York State Department of Environmental Conservation, and primarily was organized by the U.S. Fish and Wildlife Service and New York State Department of Environmental Conservation, with contributions from Bat Conservation International, Boston University, Cornell University, Pennsylvania Game Commission, Vermont Department of Fish and Game, and U.S Geological Service. The meeting was supported by multiple sources, including a generous contribution from Bat Conservation International. Facilitators were provided by Bat Conservation International and the U.S. Fish and Wildlife Service, and the proceedings from the meeting are currently being produced by the New York State Department of Environmental Conservation and the U.S. Fish and Wildlife Service and will be made available on the service's webpage (see below).

The 3-day meeting was attended by 94 participants from 12 states, 8 agencies of the U.S. government, 8 universities, 4 nongovernmental organizations, and 2 Canadian agencies. In advance of the meeting, selected participants submitted papers that summarized either the state of knowledge from their particular field or the records of bats with WNS from their state or region. During the 1st day, a single session consisted of presentations on bat ecology,

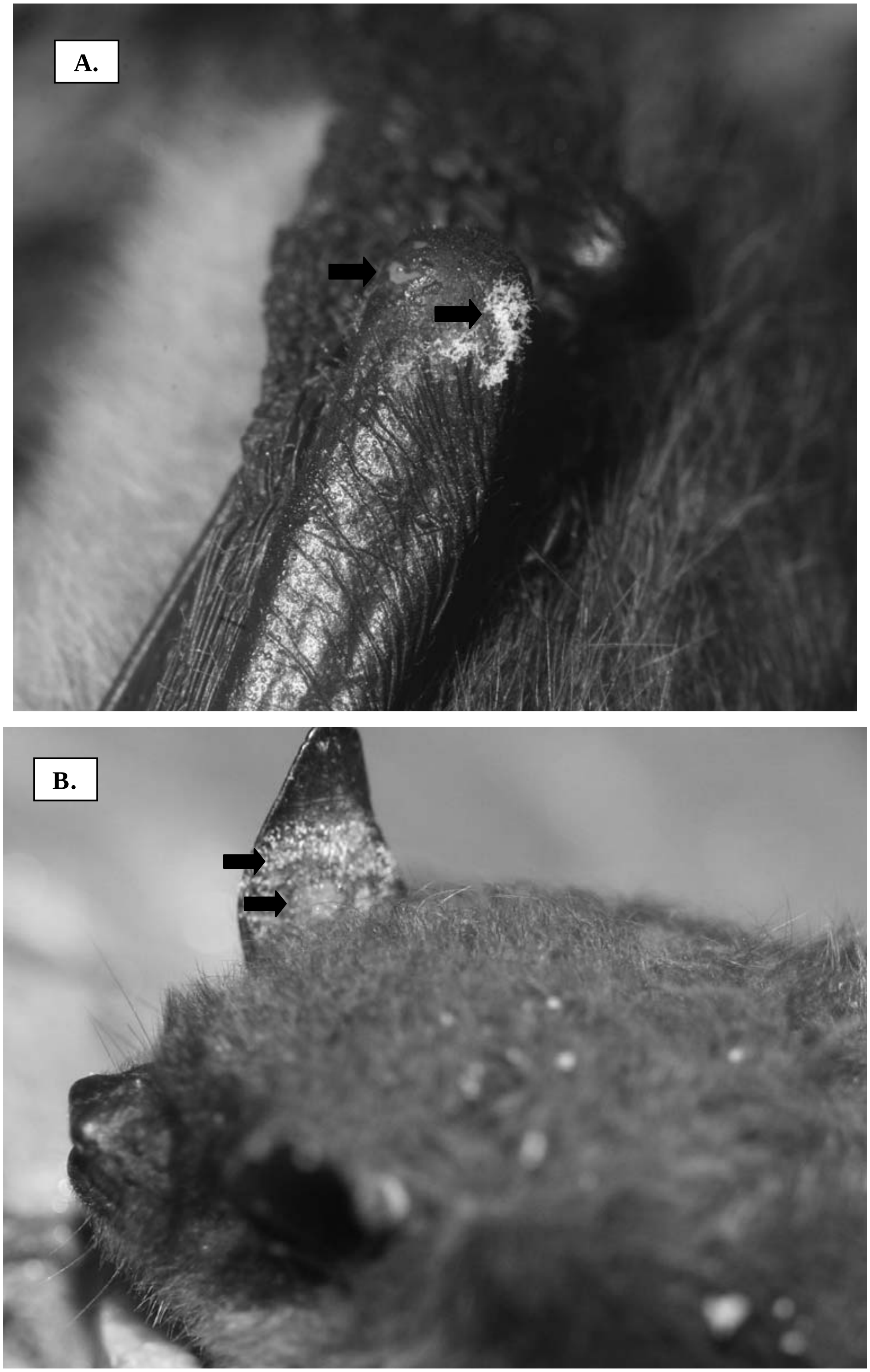

Figure 1. Photos taken of little brown bats in Pennsylvania caves in April 2008.
A) Fungus and lesion on the forearm (Photo courtesy of Charlie Eichelberger, Pennsylvania Natural Heritage). B) Fungus and lesion on the ear (Greg Turner, Pennsylvania Game Commission).

energetics, immunology, toxicology, a history and overview of WNS, perspectives on public health, and updates from pathologists on their findings concerning WNS. Two specialists on bees (J. Pettis of the U.S. Department of Agriculture and D. van Engelsdorp of Pennsylvania State University) discussed strategies for dealing with WNS in a timely fashion and shared lessons from the colony collapse disorder of honeybees.

During the 2nd day, biologists who primarily conduct research and those who primarily work for governmental agencies met separately, with the researchers focusing on developing testable hypotheses regarding the cause or causes of WNS and the managers focusing on developing a coordinated strategic response to WNS among state and federal wildlife agencies. The research group formulated four hypotheses concerning the emergence and spread of WNS.

Hypothesis 1.—Bats are starving to death due to a change in body condition caused by inadequate quantity of depot fat stored prior to hibernation, premature depletion of depot fat, or water imbalance. Implicit in this hypothesis is the assumption that the fungus is an opportunistic infection (as is typical of fungal infections) and represents a symptom, rather than a cause of WNS.

Hypothesis 2.—Mortality is directly due to a pathogen (i.e., fungus, virus, bacteria, or parasite). Although the pattern of emergence and spread of WNS is suggestive of an emergent infectious disease, there is no concrete evidence as of yet of a single causative pathogen.

Hypothesis 3.—Mortality is indirectly caused by environmental contaminants (e.g., pesticide residues or mercury), which in low levels could be altering behavior or physiology. Available evidence does not support the idea that currently present contaminants are directly lethal to bats.

Hypothesis 4.—WNS is caused by the synergistic effects of multiple causal influences. In this scenario, factors such as contaminants, altered patterns of fat deposition or utilization, and a potential pathogen all interact to cause starvation and death. These hypotheses are currently being reworked and expanded as researchers around the country design studies to test them.

The managers' session on the 2nd day focused on strategies for determining the population effects of WNS, conducting surveillance, studying the role of contaminants, examining the role that rehabilitators can play, coordinating WNS-related activities, and coordinating public information and outreach. Primary themes that emerged from the manager's meeting included the lack of funding and time for state and federal personnel to dedicate to this issue, the necessity for continued regional coordination and collaboration among all involved agencies and organizations, the establishment of both field-oriented and coordination work groups, and the need for standardized methodology to facilitate interstate comparisons.

All participants regrouped on the 3rd day in a single session to review the work of the previous 2 days and focus on ways to move forward. A variety of committees were formally established and charged with pursuing areas of future research and management needs and for developing standardized methodology for collection of data.

Priorities established for winter 2008–2009 include, but are not limited to, heightened surveillance at both affected and non-affected sites throughout the Northeast; determining whether bats are entering hibernation with adequate energy reserves; examining arousal patterns and body temperatures during hibernation at both affected and non-affected sites; examining potential differences in metabolism of bats from affected and non-affected sites; further documentation and characterization of the fungus; and, of critical importance, testing whether the identified fungus can cause WNS through direct inoculation experiments.

As a service to biologists, the media, and other interested parties, the U.S. Fish and Wildlife Service maintains a website for information on WNS (http://www.fws.gov/northeast/white_nose.html). Updates on research and useful documents, such as press releases, presentations, and decontamination protocols, are located on this site. Both Bat Conservation International and the Indiana State University Center for North American Bat Research and Conservation have established funds for research on WNS. To donate, please see their respective Web sites: (http://www.batcon.org), (http://www1.indstate.edu/biology/centers/bat.htm).

Lastly, tracking the progression of WNS across the Northeast and documenting the presence of WNS in new areas is of critical importance. Anyone who observes potential signs of WNS while caving or performing research or who observes dead or dying bats is encouraged to report such findings to the U.S. Fish and Wildlife Service (WhiteNoseBats@fws.gov) and appropriate state agencies.

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.

Milk-replacement Formulae: A Cautionary Note

In the summer issue of *Bat Research News*, Leslie Sturges (2008) wrote a letter that suggested use of a homemade milk replacer for rearing infant insectivorous bats. Development of this milk substitute apparently was in response to reports by rehabilitators who are having problems rearing pups and possible contamination of commercial milk replacers. Although concern over contaminated, milk replacers may be valid, just as valid is the concern for simulating bat milk as closely as possible. The milk replacer recommended by Sturges (2008) was a blend of 100 ml of fresh goat's milk, 17.2 g of milk-based powder (Similac Go & Grow Milk-Based Powder, Abbott Laboratories, Abbott Park, Illinois), and 7.5 ml corn oil that yielded 4.4% protein, 11.1% carbohydrate, and 15.2% lipid (wet mass). Except for fat content (15.2%), the suggested milk substitute does not approximate the content of natural milks of insectivorous bats that have been analyzed to date (Table 1). Average protein content listed in Table 1, for example, is 8.4%, and carbohydrate, 3.8%. The proposed formula (Sturges, 2008) provides only half the protein (4.4%) required by insectivorous pups, and the carbohydrate content (11.1%) is three times that of natural milk, which could create serious health issues in pups, such as bloat. The problem with the suggested formula is the Similac. By eliminating Similac and substituting a high-fat, low-carbohydrate milk replacer, such as Zoologic Milk Matrix 30/55 (Pet Ag, Inc., Hampshire, Illinois), composition of the substitute can more closely simulate bat milk. For example, combining 100 ml goat's milk, 19 g Zoologic Milk Matrix 30/55, and 4 ml corn oil yields approximately 15.2% fat and 7.9% protein and reduces the carbohydrate to 4.4%.

As with the milk replacer suggested by Sturges (2008), the one proposed here also comes with concerns. The fat provided in Zoologic Milk Matrix 30/55 is animal-based, and insectivorous bats have problems digesting animal fat. However, when using the Zoologic-based formula, much less corn oil must be added—4 ml instead of the 7.5 ml proposed by Sturges (2008)—and the less oil that must be added to a milk substitute, the more palatable it is.

Finally, it would have been much more helpful to the readers if the specific milk replacers were listed with the contaminants in them. To publish a letter only stating that commercial milk replacers were sent to laboratories and they contained contaminants is not that helpful.

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Susan M. Barnard
Hawthorne, FL 32640
E-mail: batcons@mindspring.com

Table 1. Percent composition of selected components in milk of wild-caught insectivorous bats.

Species and Stage of Lactation	Milk Solids	Fat	Protein	Carbo-hydrate	Reference
Eptesicus fuscus					
Early lactation	27.3	12.8	9.5	3.6	W. R. Hood, unpubl. data
Peak lactation	37.2	21.2	9.5	3.6	
Myotis lucifugus					
Early lactation	26.5	12.4	9.5	3.9	Kunz et al., 1995
Peak lactation	27.1	15.8	8.5	4.0	
Myotis thysanodes	40.5	17.9	12.1	3.4	Jenness, 1974
Myotis velifer					
Early lactation	25.4	11.6	9.2	4.0	Kunz et al., 1995
Peak lactation	32.4	19.9	10.7	4.4	
Tadarida brasiliensis					
Early lactation (1–21 days)	29.1	17.3	8.3	3.6	Kunz et al., 1995
Peak lactation (22–42 days)	36.5	25.8	7.7	3.4	

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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ANNOUNCEMENT

2009 Bat Conservation International Student Research Scholarship Program

Bat Conservation International (BCI) is now accepting applications for its Student Research Scholarships for the 2009–2010 academic year. Students enrolled in any college or university worldwide are eligible to apply for the scholarships. Applications are competitive and will be reviewed by scientists outside BCI. Research should be 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. Some of the scholarships are designated specifically for research conducted in developing countries. **Application deadline** is **15 December 2008**. Information and application form are available at http://www.batcon.org/bcigrants/scholarintro.asp or contact Bob Locke (grants@batcon.org) if you have questions.

FUTURE MEETINGS and EVENTS

1 June 2008 through 4 January 2009
The Organization for Bat Conservation (OBC) and the Cranbrook Institute of Science is holding a collaborative live bat exhibit, "Bats: Myths and Mysteries," at the Cranbrook Institute in Bloomfield Hills, MI. For more information, please visit: http://www.batconservation.org or http://www.cranbrook.edu

22–25 October 2008
The 38th Annual North American Symposium on Bat Research (NASBR) will be held in Scranton, Pennsylvania. For information, please see http://www.nasbr.org/ or contact Gary Kwiecinski (ggk301@scranton.edu) or Roy Horst (rhorst@twcny.rr.com).

25 October 2008
Lubee Bat Conservancy is holding its 4th Annual Bat Festival from 11 a.m.–3 p.m. at 1309 NW 192nd Avenue, Gainesville, Florida. For details about this family event, please see http/: www.lubee.org

16–18 January 2009
The 1st International Symposium on Bat Migration will be held at the Federal Institute for Risk Assessment in Berlin, Germany. Contributions from the fields of behavior, ecology, physiology, and genetics concerning migratory bats are welcome; the conference language will be English. For more information, please contact the organizers, Christian Voigt and Ana Popa-Lisseanu, at batmigration09@izw-berlin.de or check the web page at http://www.izw-berlin.de and click on "Events."

12–13 February 2009
The 14th Annual Meeting of the Southeastern Bat Diversity Network and the 19th Colloquium on Conservation of Mammals in the Southeastern United States will be held in Jonesboro, Arkansas. Information can be found at: http://www.sbdn.org

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.

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

BAT RESEARCH NEWS

VOLUME 49: NUMBER 3 **FALL 2008**

Table of Contents

Front Cover

The cover illustration of *Pteropus livingstonii* is by Alice Hughes, a Ph.D. student at Bristol University. Livingstone's Fruit Bat (also known as the Comoro Flying Fox) has large red eyes and is one of the world's largest bat species (average wingspan 150 cm, length 30 cm, weight 700 g). This species is found only on two of the Comoro Islands and is listed as Critically Endangered. Fortunately, there are a number of captive breeding programs, which have release plans to bolster wild populations of *P. livingstonii*. Land management plans also are being developed in cooperation with the local communities and government that will help protect the habitat in which these beautiful animals live.

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Editor for Feature Articles: Dr. Allen Kurta, Dept. of Biology, Eastern Michigan University, Ypsilanti MI 48197; TEL 734-487-1174, FAX 734-487-9235; E-mail: akurta@emich.edu

Editor for Recent Literature: Dr. Jacques P. Veilleux, Dept. of Biology, Franklin Pierce University, Rindge NH 03461; TEL 603-899-4259, FAX 603-899-4389; E-mail: veilleuxj@franklinpierce.edu

Editor for Conservation/Education: Patricia A. Morton, The Nature Conservancy, Mukwonago River Watershed Project Director, N8957 Pickerel Jay Road, East Troy WI 53120; TEL 262-642-7276; E-mail: pmorton@tnc.org

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

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

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Anomalous Coloring of a Big Brown Bat, *Eptesicus fuscus*

David Jeffcott and Virgil Brack, Jr.

Environmental Solutions & Innovations, Inc., 781 Neeb Road, Cincinnati, OH 45233;
E-mail: vbrack@environmentalsi.com

Abnormally colored bats have been reported for many years (Allen, 1939; Setzer, 1950), but anomalies are more frequently reported over time as more bats are captured by researchers (e.g., Brack et al., 2005; Münzer and Kurta, 2008; Uieda, 2000). Brack et al. (2005) identified partial and complete patterns of white pelage for an Indiana bat (*Myotis sodalis*), and although these patterns are uncommon in the population, they are a reoccurring phenomenon (Barbour and Davis, 1969; Brack and Johnson, 1990; Metzger, 1956; Mumford and Whitaker, 1982).

The analysis by Münzer and Kurta (2008) indicated that most coloring abnormalities in bats are associated with a single color along the shaft of individual hairs, and they reported capture of a little brown myotis (*Myotis lucifugus*) with hairs that had silver tips and a black base. Metzger (1956) reported a *M. sodalis* with hair that was white, except the extreme tips of the guard hairs, which were tinged with brown, and Easterla and Watkins (1968) reported an evening bat (*Nycticeius humeralis*) with silver-tipped hair. Münzer and Kurta (2008) postulated that the typical silvering seen in species like the silver-haired bat (*Lasionycteris noctivagans*) and several lasiurines may have arisen in a manner similar to the aberrant genetic coding responsible for the silver-haired tips in the *M. lucifugus* that they observed.

On 11 July 2008, the pelage of an adult male big brown bat (*Eptesicus fuscus*) that was caught in Stark Co., Ohio, displayed two types of color abnormalities. Typically, the species is described as “buff” or “tawny” on the belly, but the ventral surface of this individual, from the neck backwards, was mostly silver (Fig. 1A). Dorsally, starting on the head between the ears and running the length of the body, some hairs were silver-tipped (Fig. 1B). In many ways, dorsal coloring was similar to that of *L. noctivagans*. The bat appeared healthy and normal in all other ways; wear on the canines indicated that the bat was probably older than one year.

The two types of coloration abnormalities on this bat indicate that if the genetic mechanisms for full versus partial coloration of the hair shaft are different, both can occur in the same individual. The appearance of dorsal silvering on this *E. fuscus* lends support to the hypothesis of Münzer and Kurta (2008) on the origin of typical coloration for *L. noctivagans* and other species.

Eptesicus fuscus is very common and may be the most frequently captured species in the eastern United States. Nevertheless, we could find no other records of aberrant coloration in this species, although the review of Uieda (2000) notes two other species within this genus in which unusual coloring was reported. This individual and other recently captured bats with aberrant coloration stress the need for field researchers to remain vigilant in their identification of bats and point out the possibility that less experienced researchers can be mistaken when identifying even common or distinctively marked species.

Marathon Petroleum Company, LLC, funded field studies, and Sendero Environmental, LLP, provided project oversight. Environmental Solutions & Innovations, Inc. funded development of this

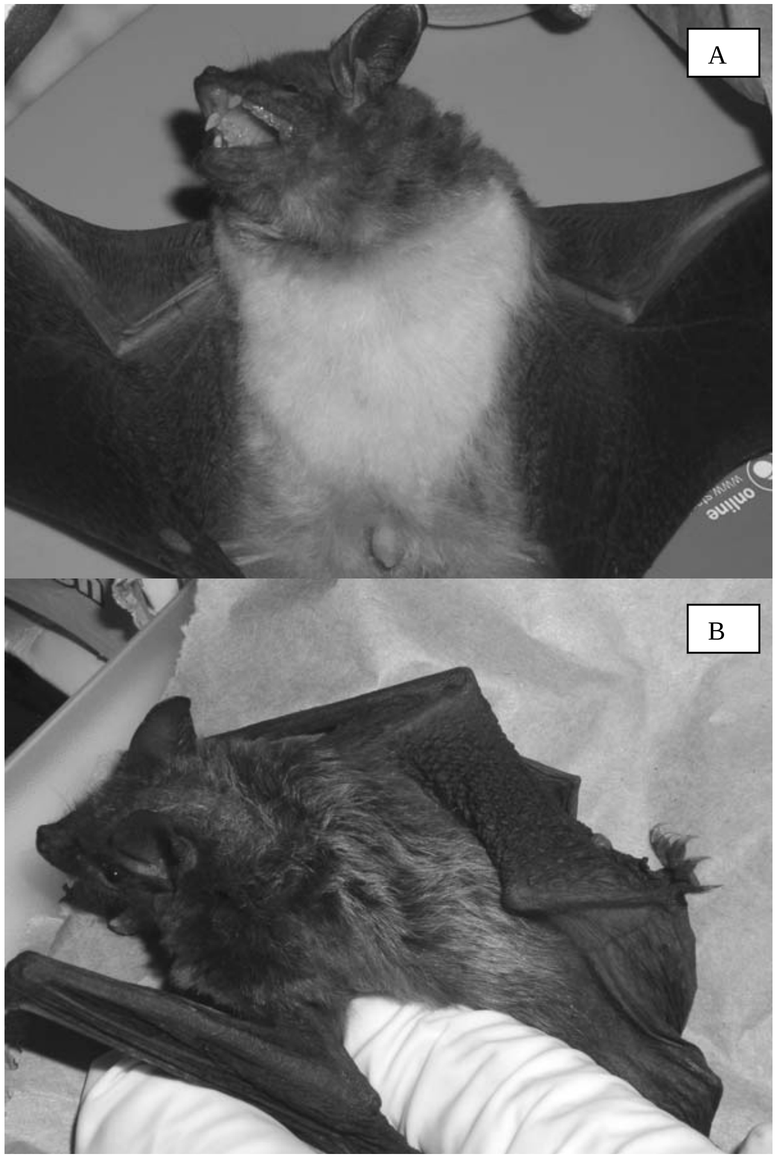

Figure 1. A) Venter and B) dorsum of an adult male *Eptesicus fuscus* captured in Stark Co., Ohio, on 11 July 2008.

manuscript. We thank employees of Environmental Solutions & Innovations who participated in the fieldwork.

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Abstracts of Papers Presented at the

38th Annual North American Symposium on Bat Research
Scranton, Pennsylvania
22–25 October 2008

The following abstracts are from papers presented at the 38th 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 in alphabetical order by first author, and recipients of student awards are indicated by an asterisk (*****) next to the title of the paper. Contact information for authors who attended the 38th Annual NASBR follows the abstracts.

Timing and Pattern of Molt in Kuhl's Bat, *Pipistrellus kuhlii*, in Saudi Arabia
Abdulaziz Alagaili and Douglas A. James; King Saud University, Riyadh, Saudi Arabia; University of Arkansas, Fayetteville, AR

Kuhl's bats (*Pipistrellus kuhlii*) from Unizah province, middle of Saudi Arabia, were studied monthly from May 2005 to August 2006 for timing and pattern of molt. Adults and juveniles have a single molt occurring annually in summer from late April until September with most bats molting in July. Males initiated molt before females, but the sexes terminated molt almost simultaneously. Molting began on the dorsum and then the ventrum once the dorsum was finished. Dorsal molting began both in the center of the pelvic area and the center of the head spreading in all directions from the starting points. The molt then spread toward the shoulders from the pelvic region finishing around the neck and joining there the freshly molted top of the head. The ventral molt began around the nipples, under the neck, and on sides near the wings. Molting near the wings spread in a narrow line, toward the legs. A molting circle also appeared in the center of the pelvic region spreading out laterally as well as toward the uropatagium. Soon new fur on the periphery of the ventrum formed a circle around old pelage replacing it and closing up the circle gradually. All new pelage appeared white at first and then become light brown. Within a few months the new light brown pelage darkened to a cinnamon color. Juveniles molted 2–3 months after birth replacing their dark pelage with a pelage similar to adult new pelage. Patterns of molt in juveniles were similar to the adults. This study, compared to other studies on different bat species, indicates that molt is species specific regarding its timing and pattern.

Bat Activity Levels: How They Differ in Time, Space, and Sampling
Amanda M. Adams and M. Brock Fenton; University of Western Ontario, London, ON

Almost nothing is known about bat population dynamics, as most bats are elusive and difficult to sample. Many bat surveys incorporate both trapping and acoustic recording technology. Both are biased, as trapping is more effective on some species than others and acoustic recording allows bat activity to be quantified, but gives no idea of population size. Many bat species are designated as rare, when a more appropriate term is data deficient. Failure to capture or record a bat species could mean that the species is elusive and therefore hard to sample; conversely, rarity could indicate a low population size, necessitating possible listing as

threatened or endangered and associated conservation action. Because bat species vary in both detectability and abundance, it is unclear how recorded bat activity relates to actual numbers of bats and this relationship likely varies on the basis of both species and habitat. Currently, there is not even an agreed upon level of acoustic activity that constitutes “high” or “low” bat activity. The goal of my PhD thesis is to investigate the ways in which acoustic survey results describe actual bat communities and to make recommendations for future survey designs based on these results. I plan to do this in three ways: 1) I will define different activity levels and quantify how they vary in time and space. I want to know what these levels mean for sampling bat communities; 2) I will quantify the detectability of ‘special’ locations, such as swarming sites and maternity colonies and contrast these sites against more typical scenarios of bat activity; and 3) I will sample communities using a variety of sampling methods, including acoustical transects and trapping techniques, and compare findings. I will use these results to develop a model to identify rare versus elusive species based on community surveys. Bat community structure assessment will occur in three locations: Ontario, Canada; California, USA; and Costa Rica. Based on my research, conservationists and wildlife managers will be able to assign conservation status based on data about actual species rarity and have a better idea of the extent of activity variation to expect. Ultimately this work will aid in conservation efforts and biodiversity assessment.

Changing Climate in Western North American Ecosystems Predict Serious Consequences for Bats

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

Climate warming is occurring at an accelerated rate in western North America. This is particularly true at higher elevations throughout the Rockies Mountains and Pacific Coastal ranges whereby mean monthly temperatures, precipitation levels, and water availability have already been significantly affected. In this talk we provide data suggesting that bats provide an excellent bellwether for measuring ecosystem temperature shifts and loss of water resources because of their reproductive physiology surrounding lactation and water source needs. We measured visitation patterns to an artificial water source of PIT-tagged lactating and nonreproductive female *Myotis thysanodes* and found significance differences between the numbers of drinking passes between these two groups ($N_{lac} = 236$, $N_{nonrepro} = 18$; Wilcoxon rank-sum, $p = 0.0001$), with lactating individuals visiting 13 times more often. From these data we construct a decay model for assessing the effects of climate-induced declines in natural water resources on reproductive success of bat populations in areas of western North America currently experiencing climate warming. We take this analysis further by incorporating overall climate data for Colorado on mean temperature, mean precipitation, and mean stream discharge rates over the months of June, July, and August as well as winter snowpack averages and compare these data with a 12-year cumulative record of captures ($n = 2,123$) and the reproduction status of female bats during that time. Significant declines ($p = 0.001$) are evident in frequency of female reproductive success as correlated with higher monthly mean temperatures, lower precipitation, and lower stream discharges.

A Landscape Level Approach to Abandoned Mine Reclamation in Nevada

John Agee, R. Sherwin, S. Skalak, and C. Ross; Christopher Newport University, Newport News, VA

We surveyed 250 abandoned mines in the Clark County region of southern Nevada between June 2007 and May 2008 as part of a large-scale mine reclamation project. Mines were located on lands managed by the Bureau of Land Management, the National Park Service, and the United States Forest Service. Those mines that were safely accessed were internally surveyed and those mines that we were unable to enter or completely internally survey were surveyed externally. We evaluated each site for actual and potential use by bats and used relative and absolute significance models to identify critical roosting habitat. We gauged actual use through observation of roosting bats, guano, insect parts, and other biological residues, while potential use was inferred through evaluation of a suite of internal and external biotic and abiotic factors. Common species of bats using these mines were *Corynorhinus townsendii*, *Antrozous pallidus, Pipistrellus hesperus, Idionycteris phyllotis*, *Myotis volans,* among others. We used a landscape level approach to further refine recommendations and ensure that we maintained the integrity of the roosting landscape. Closure recommendations were submitted to the Army Corp of Engineers, who evaluated our approach, and final closures are currently being conducted by the Bureau of Reclamation. Of the 250 mines surveyed, 108 of them warranted bat compatible closures. Sixty-three of these sites included maternity use by a variety of species of bats. We are currently designing monitoring protocols that will help us evaluate the short and long term impacts of this project.

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

Louse C. Allen, Isabelle-Anne Bisson, and Thomas H. Kunz; Boston University, Boston, MA; Princeton University, Princeton, NJ

As human populations expand, increased encroachment on natural landscapes and wildlife habitats is likely. We can expect that organisms 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. Species that roost in such places are likely to be exposed to a variety of potential stressors including both chronic and acute exposure to petrochemicals, noise pollution, and vibration. Evidence from previous research, based on measured levels of the hormone cortisol, suggests that bridge-roosting Brazilian free-tailed bats (*Tadarida brasiliensis*) experience lower levels of stress and are in better overall health than their cave-roosting counterparts. This unexpected result suggests the ability of this species to rapidly acclimate to the potential stressors we observed at highway bridges. Heart rate telemetry allows direct and continuous monitoring of an acute response to a stressor and thus is ideal for assessing acclimation to repeated stimuli. Heart rate telemetry has been used on several avian and mammalian species; however, its use on small, free-ranging bats has not been tested. In July 2008 we assessed the suitability of heart rate telemetry in the Brazilian free-tailed bat and evaluated the ability of these bats to rapidly acclimate to environmental stressors in a large highway bridge roost. To measure heart rate, a small (0.06 g) custom-made heart rate transmitter was affixed to each bat (~12 g) and the signal was recorded on an MP3 recorder, while the bat was in the roost and at the onset of nightly emergence. We subjected lactating females (n = 4) to several novel disturbance events (simulated predator) over the course of the experiment (12–36 hours), as well as noted other potentially disturbing stimuli (noise and vibration from passing freight trains) that the roosting bats may experience while roosting in bridge crevices. Results will be presented and be discussed in relation to implications concerning the ecology and management of this species.

Living Under the Bridge: A Comparison of Stress Levels and Health Status in Bridge- and Cave-Roosting Brazilian Free-tailed Bats *Tadarida brasiliensis

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

*** Louise Allen** received the **Titley Electronics Award**

During the past two decades, the Brazilian free-tailed bat (*Tadarida brasiliensis*) has increasingly used bridges as roosts in the southern and southwestern United States. To date, however, little research has examined the health of individuals living in these largely unintended and potentially stressful man-made roosts. This species possesses characteristics that make it an attractive model for the study of stress physiology. It roosts in some of the largest aggregations of mammals on earth and occupies a variety of roost types. Roosts are likely to differ in quality, due to variation in thermal stability, colony size, and levels of disturbance. This study examines variations in glucocorticoid stress hormones (cortisol) in adult female Brazilian free-tailed bats in response to different roost environments. We captured and examined females from late-May until early-October at four different sites (two caves and two bridges) in south-central Texas during evening emergence. We tested the hypothesis that cortisol levels would differ between roost types in response to variations in stress environment. We also captured females at emergence, midnight return, and morning return at one cave and one bridge to test for any differences in the diurnal variation of cortisol at these roost types. Our results indicate that variations in cortisol levels are correlated with reproductive status, body condition, time of day, and site type. Baseline cortisol levels were significantly higher in pregnant females, females in poor body condition, and those captured at emergence. Contrary to predictions, cortisol levels were higher in bats living in caves compared to those living in bridges, indicating lower stress levels in bats at bridges. Our findings are important for determining the health of colonies and individuals subjected to potential stressors and the suitability of bridges as alternate roosts for this species.

Relationship between Bat and Insect Activity in Southern Ontario

M. Reese Arh, John M. Ratcliffe, and James H. Fullard; University of Toronto, Mississauga, ON

Bat activity changes over the course of the summer in temperate areas, where foraging activity (based on trapping and acoustic survey data) is highest in July. Using the residential insectivorous bat community of southern Ontario, we tested seasonal changes in bat diet and activity to relate them to changes in insect composition and abundance in the field. Light traps, water pan traps, and pitfall traps were set weekly at three sites (lakefront, field, and forest). Insect count and identification allowed analysis of insect abundance and changes in diversity at the ordinal level over the summer, at and amongst different sites. Temperature fluctuations and moon cycles significantly explained outliers in our data set. Insect numbers were highest in the forest and lowest at the lakefront. Fecal samples were collected and analyzed from the five residential bat species (*Myotis leibii, M. lucifugus, M. septentrionalis, Eptesicus fuscus,* and

Pipistrellus subflavus). We examined fecal samples and acoustic surveys throughout the summer to determine how bat diet and activity changed with respect to seasonal changes in the level of insects. Percent volume and frequency of insect orders in fecal samples from bats captured using harp traps indicated selective foraging by decreased diet variety during periods of higher insect activity. There were significant diet composition differences between species. We suggest that higher densities of insects lead to more selective foraging by bat species whereas more generalist foraging occurs at the beginning and end of the summer when insects are less diverse. Throughout the summer the highest number of calls occurred between 11 pm to 1 am. Bat and insect activity were highest in July (24,102 calls over five nights) and lowest in September (3,106 calls over six nights) but were not significantly correlated to moon phase or temperature. There was no difference between bat activity and site. We suggest that foraging patterns of bats follows the increase and subsequent decrease in insect abundance. Bat activity and selectivity in foraging directly relates to insect activity and diversity.

Wing Folding and the Functional Morphology of Chiropteran Digit Articulations
Maria T. Armour; Post College of Long Island University, Brookville, NY

Bat wings are fascinating topics for studies of form and function, because although the wings of all bats must abide by the same aeromechanical demands placed on them during flight, the morphology of these structures exhibits significant interspecific variability. Previous phylogenetic studies have identified differences in wing folding at the family level, but this is the first broad-scale study focused on variability at the species level. I examined wing folding-related characteristics across 300 bat species, covering 18 families. I studied digital osteology (in a subset of thirteen species) with the goal of identifying aspects of joint morphology involved in the variable wing folding patterns I observed. Not surprisingly, extreme variation is present in the morphology of the articulating points of the handwing bones among bat species. This study also resulted in several new observations related to the morphology of the articulating points along the handwing's third digit. The data collected have enabled me to approach several questions including: how do skeletal elements of the handwing vary among species, and are there morphological suites of characters arising independently in different lineages? The results of this study support my hypotheses that the handwing's joint composition varies across wing folding states.

Patterns of Bat Activity at Proposed Wind Energy Facilities
Edward B. Arnett, John P. Hayes, Manuela Huso, and Michael Schirmacher; Bat Conservation International, Austin, TX; University of Florida, Gainesville, FL; Oregon State University, Corvallis, OR; Bat Conservation International, Somerset, PA

Pre-construction surveys at proposed wind facilities have been conducted and most commonly employ mist nets and acoustic detectors to assess the presence and activity of local bat species. However, using this information to predict bat fatality and, thus risk at a site, has proved to be challenging. Currently there are no studies linking pre-construction monitoring data with post-construction fatality, a fundamental link necessary for understanding potential risk of wind farms to bats. In summer and fall 2005–2007, we studied patterns of bat activity at proposed wind facilities in the eastern United States. Our primary objectives were to: 1) determine level and patterns of activity of different species' groups of bats using the proposed wind facility prior to and after construction of turbines; 2) correlate bat activity with weather and other environmental variables; and 3) determine if indices of pre-construction bat activity can be used to predict post-construction bat fatalities at proposed wind facilities. We recorded echolocation calls of bats with Anabat II zero-crossing ultrasonic detectors deployed on meteorological (met) towers and 22 m tall, portable, telescoping towers to vertically array detectors for acoustic sampling. Meteorological data were collected every 10 minutes and averaged to give nightly average wind speed and temperature at each met tower; wind speed was measured at 50 m and air temperature was measured at 3 m at all towers. The best models selected using AIC were consistent among the three years, in spite of large differences in overall activity and in period of time during which data were available. The expected number of bat calls at a tower in a 10-h period (approximately one night) generally increased with increasing temperature, while activity decreased with increasing wind speed in all three years. Although our data set yielded high statistical power, the best statistical models accounted for only about 0.5% of the deviance in any of the three years, indicating that although there appeared to be some detectable relationship between activity and meteorological variables, most of the variation in activity remained unexplained.

Bats of St. John and St. Thomas, U.S. Virgin Islands: Priority Conservation Measures for Species of Greatest Concern

Jean-Pierre Bacle, Kevel C. Lindsay, and Gary G. Kwiecinski; Island Resources Foundation, St. Thomas, U.S. Virgin Islands; University of Scranton, Scranton PA

An ongoing three-year study of the bats of St. Thomas and St. John, U.S. Virgin Islands, confirms the presence of six species—*Artibeus jamaicensis*, *Molossus molossus*, *Brachyphylla cavernarum*, *Noctilio leporinus*, *Tadarida brasiliensis*, and *Stenoderma rufum*. To date, over 1200 bats were netted at 78 sites, during 4 different seasons, representing a range of habitat communities and physiographic conditions. Of the six species, the latter four represent only 17% of the total captures. Of these, three species are currently listed as endangered under the Virgin Islands Indigenous and Endangered Species Act: *Brachyphylla cavernarum*, *Noctilio leporinus*, and *Stenoderma rufum*. The U.S. Virgin Islands, currently with a population density of 846 people per square mile, is faced with a rapid state of development as evidenced by new coastal resorts, shopping malls, road construction, and widespread housing developments. This surge in development within limited land surface (St. Thomas: 32 square miles; St. John: 19 square miles) has contributed to the fragmentation and degradation of a number of habitats that bats use for roosting and foraging. Of greatest concern are the most vulnerable species: *Brachyphylla cavernarum*, *Noctilio leporinus*, *Stenoderma rufum*, and *Tadarida brasiliensis*. Because of the limited numbers and roosting and foraging habitats for these four species, the study identifies the main threats facing these species, and proposes priority conservation and mitigation measures necessary for their sustainability.

Patterns of Activity and Fatality of Migratory Bats at a Wind Energy Facility in Southwestern Alberta

Erin F. Baerwald and Robert M. R. Barclay; University of Calgary, Canada

Growing interest in alternative energy sources has led to a proliferation of wind energy facilities in recent years. Southern Alberta currently has 16 wind farms with ~400 total turbines

producing ~400 MW, and numerous other projects in various stages of development. Bat fatalities at wind energy facilities have offered the potential for insights into bat migration because the majority of such fatalities involve migratory bats during fall migration. Historically, corrected bat fatality rates in southern Alberta were low, approximately 1 bat/turbine/year, but corrected bat fatality rates as high as 30 bats/turbine/year have now been recorded. Some of the variation can be explained by differences in turbine height, with higher fatality rates at taller turbines, and the location of the wind energy facility in relation to migratory routes. In addition to broad-scale variation, there is also fine-scale variation in migratory-bat activity and fatality, both temporally (night to night) and spatially (turbine to turbine). I explored fine-scale variation in fatality rates and the activity of migratory bats at a wind energy facility in southwestern Alberta, Canada from 15 July to 30 September 2006 and 2007. I acoustically monitored echolocation activity of bats with a combination of calibrated Anabat II (with a Compact Flash ZCA Interface Module (CF ZCAIM)), and Anabat SD1 bat detectors installed on meteorological towers (met towers) and turbine nacelles. I conducted carcass searches daily at 10 randomly selected turbines and weekly at the remaining 29 turbines. I examined patterns of migratory-bat activity and fatality and the relationships between activity and fatality with weather variables, turbine location, and detection height. Timing of migratory-bat activity and fatality were comparable to other North American sites. Migratory-bat activity differed with detection height and weather variables such as wind speed, ambient temperature, and fraction of the moon illuminated. Migratory-bat fatalities varied with activity, turbine location, and weather variables such as wind speed, change in barometric pressure, and fraction of the moon illuminated.

Geographic Variation in Activity and Fatality Rates of Migratory Bats at Wind-Energy Facilities in Southern Alberta

Erin F. Baerwald and Robert M. R. Barclay; University of Calgary, Canada

Growing interest in alternative energy sources has led to a proliferation of wind energy facilities in recent years. Southern Alberta currently has 16 wind farms with ~400 total turbines producing ~400 MW, and numerous other projects in various stages of development. Bat fatalities at wind energy facilities have offered the potential for insights into bat migration because the majority of such fatalities involve migratory bats during fall migration. Historically, corrected bat fatality rates in southern Alberta were low, approximately 1 bat/turbine/year, but corrected bat fatality rates as high as 30 bats/turbine/year have now been recorded at some newer, taller turbines. Using acoustic monitoring and carcass searches, I examined variation in fatality rates and bat activity levels across southern Alberta. To investigate geographical variation in bat activity, I acoustically monitored bat activity from 15 July to 15 September 2006 and 2007 at seven proposed or existing wind energy installations across southern Alberta (~200 km between the most westerly wind energy facility and the most easterly). Activity of migratory bats varied among sites, suggesting that, rather than migrating south randomly or evenly over a wide East-West area, bats concentrate along select routes. Activity rates of both *Lasiurus cinereus* and *Lasionycteris noctivagans* were higher near the foothills to the west than on the prairies further east, at least partly due to the availability of a roosting habitat. Activity levels also varied between heights. To investigate variation in bat fatality rates among wind energy installations, I compiled fatality data collected between 2001 and 2007 from six wind energy facilities and conducted carcass searches at two wind energy installations in 2006 and 2007. Fatality rates differed among the eight sites, partly due to differences in turbine height, but also due to differences in migratory bat activity at 30 m and the interaction between bat activity at 30 m and turbine height. Sites with high activity at 30 m but relatively short towers had low fatality rates, and sites with low activity at 30 m but tall towers also had low fatality rates. If a site has low levels of bat activity, then bat fatality rate will also likely be low and tower height does not appear to influence that.

Size Matters More than How You Use It: Modeling the Effects of Varying Bat Wing Morphology and Kinematics

Joseph Wm. Bahlman, Kenneth S. Breuer, and Sharon M. Swartz; Brown University, Providence, RI

Flapping flight is a complex form of locomotion where a variety of kinematic and morphological variables contribute to the aerodynamic force that supports and maneuvers the body. To truly understand bat flight, we need to understand the effect of each of these kinematic and morphological variables. In live bats, however, we cannot isolate the effect of individual variables because we cannot control their kinematics. One solution to this problem is to use physical and computational models where kinematics and morphology can be systematically modulated. Although we cannot make models that exactly duplicate the complex kinematics and morphology of bats, creating a model that combines aerodynamic theory with information on bat wing motion and morphology provides useful approximations of bat flight performance. We created a computational model of flapping flight that assumes rigid wings that extend on the downstroke, retract on the upstroke, and have the mass distribution of realistic bat wings. The model also accounted for the cost associated with moving the wings; calculations of inertia and flight power requirements were based on published literature. Within the model we varied two kinematic parameters, wingbeat frequency and amplitude, and two morphological parameters, aspect ratio and surface area. We then calculated the amount of lift generated by and power required to flap the prescribed wings in the prescribed motion. Both lift and power increased with increasing values of each parameter, but they increased at different rates. Augmenting each parameter to achieve a 5% increase in lift required different amounts of power; increasing wingbeat frequency required the greatest increase in power (32%), with lower required increases in power arising from increases in wingbeat amplitude (22%), surface area (14%), and aspect ratio (9%). The decreases in power required were similar for the modeled 5% decrease in lift. Our results from this model indicate that it requires less energy to flap larger wings more slowly than it does to flap smaller wings more quickly. In terms of evolutionary change, this model suggests that when selection favors energetic efficiency, bats should evolve larger wings with a higher aspect ratio and use a lower wingbeat frequency and amplitude.

Evidence for Repeated Independent Evolution of Migration in Bats

Isabelle-Anne Bisson and Richard A. Holland; Princeton University, Princeton, NJ; University of Leeds, Leeds, UK

The evolution of migration represents one of the most poignant questions in evolutionary biology. Although studies on the evolution of migration in birds are well represented in the literature, migration in bats has received relatively little attention. Yet, more than 30 species of bats migrate annually from breeding to non-breeding locations. Our study is the first to test theories on the evolutionary history of migration in bats using a phylogenetic framework. In addition to providing a review of bat migration in relation to existing theories on the evolution of migration in birds, we use the Jones et al. (2002) supertree to formulate and test hypotheses on the evolutionary history of migration in bats. The results suggest that migration in bats has evolved independently in several lineages, likely as the need arises to track resources (food, roosting site) but not through a series of steps from short to long distance migrants, as has been suggested for birds. Nor do they indicate that migration is an ancestral state, suggesting that migration is a relatively recent trait in bats. This is the first study to provide evidence that migration has evolved independently in bats. If migration evolved as a need to track seasonal resources or seek adequate roosting sites, climate change may have a pivotal impact on bat migratory habits. Our study provides a strong framework for future research on the evolution of migration in chiropterans.

Bat White Nose Syndrome: An Emerging Fungal Pathogen?

David S. Blehert; National Wildlife Health Center, USGS, Madison, WI

White Nose Syndrome (WNS) is a condition associated with an unprecedented bat mortality event in the northeastern United States. Since the winter of 2006–2007, bat declines ranging from 80–97% have been observed at surveyed hibernacula. Affected hibernating bats often present with visually striking white fungal growth on their muzzles, ears, and/or wing membranes. Histopathological analyses conducted in multiple laboratories confirmed that 90% (105 of 117) of necropsied bats submitted from WNS-positive sites exhibited an associated cutaneous fungal infection. Direct microscopy and culture analyses demonstrated that the skin of WNS-affected bats is colonized by a psychrophilic (cold-loving) fungus that is phylogenetically related to *Geomyces* spp., but with conidial morphology distinct from characterized members of this genus. The isolates were initially cultured at 3° C and grew optimally between 5° C and 10° C, temperatures consistent with the core temperatures of hibernating cave bat species within the WNS-affected region. The upper growth limit for the fungus was approximately 22° C. There is currently a growing body of circumstantial evidence supporting an association between WNS and cutaneous infection by a *Geomyces*-like fungus. Given the hundreds of thousands of hibernating bats found throughout the WNS-affected region, this condition represents an unprecedented threat to bats of the northeastern United States and potentially beyond.

Seasonal Variation in Habitat Occupancy by Hawaiian Hoary Bats

Frank Bonaccorso, Marcos Gorresen, Christopher Todd, Christina Cornett, and Corinna Pinzari; U. S. Geological Survey, Hawaii National Park, HI

In order to provide effective conservation management for mobile animals such as bats, potential seasonal movements and habitat shifts must be understood. 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 move through the considerable gradients of elevation and habitat with seasonal patterns on the island of Hawai'i, we deployed arrays of automated ultrasound detectors coupled to memory storage devices at a large number of sites. We recorded bat detections and applied occupancy analysis to quantitatively estimate bat occurrence. Detector arrays were deployed along gradients of elevation on leeward and windward sites. Recorded bat calls were processed with Analook software and occupancy was estimated with Presence 2. Bat occurrence was low in the windward lowlands December through March and dramatically increased between April and October. Bat activity peaked in the windward highlands from January through March. Detections were infrequent at dry high elevation sites and consistently present at moderate levels throughout monitoring at a low elevation leeward site. Seasonal shifts in occupancy are most pronounced between sea level and 1600 m on the windward side of the island of Hawai'i. Hawaiian hoary bats move to higher elevations in winter possibly to use torpor during winter storms when foraging for aerial prey is difficult. Our ultrasound detection monitoring is continuing for a second annual cycle at an increased number of locations to provide wildlife managers with additional information about summer and winter range habitat use by this bat species.

The Influence of Temperature and Solar Radiation on Tree Roost Selection of Big Brown Bats, *Eptesicus fuscus*, in Cypress Hills

Kristin J. Bondo; University of Regina, Regina, Saskatchewan

Microclimate inside roosts and amount of solar radiation falling on trees have been proposed as factors driving roost switching behavior and roost tree selection by many species of forest-dwelling bats. However, how solar radiation actually influences tree cavity temperature at the roost and landscape levels is unknown. I tested whether a roosting group of *Eptesicus fuscus* in Cypress Hills, SK used the warmest trees receiving the highest amounts of solar radiation. I measured solar radiation and temperature simultaneously in trembling aspen cavities used by bats and those available to them. To determine if tree cavity temperature could be predicted by its location on the landscape level, I compared temperatures inside tree cavities based on their aspect and solar radiation values generated by GIS. Mean, maximum, minimum temperature and mean rate of change inside used and available roosts did not differ significantly. Total solar radiation and the level of radiation reaching the cavity entrance did not differ significantly between used and available trees. Roost cavities did not differ in mean temperature according to the aspect of the terrain. Trees receiving high amounts of solar radiation as predicted by GIS did not differ significantly from trees receiving medium amounts of solar radiation. Total solar radiation did not differ significantly in areas predicted by GIS to receive high or low-to-medium amounts of solar radiation. Ambient temperature (T_a) was strongly correlated with roost temperature between 0700 and 1600 ($r^2 = 0.976$, $t = 19.0$, $p = 0.000$). In summary, my results indicate tree cavity microclimate at latitudes above 30° varies little and is determined by T_a. I argue that bats likely select cavities with large volumes that can hold a lot of individuals and adjust group size to meet energetic demands. My data are not consistent with the idea that bats switch roost trees based on microclimate. They more likely switch to avoid build up of ectoparasites, guano, and/or to facilitate knowledge and information transfer among potential roost trees.

Understanding the Trade-off: Environmental Costs and Benefits of Industrial Wind Energy Development with Focus on the Eastern United States

Daniel D. Boone and Rick Webb; Virginia Wind

By the end of 2008, about 20,000 MW of utility-scale wind turbines will supply nearly 1.5% of U.S. electricity demand. The U.S. Department of Energy released a report in Spring 2008 that calls for 20% of our nation's electricity to be supplied by industrial wind energy facilities by 2030. Such a huge and rapid increase in wind energy development is expected to require construction of up to 400,000 MW of huge wind turbines. In addition, Canada is planning to erect tens of thousands of industrial wind turbines over the coming decades in order to achieve similar renewable energy goals. The economic and environmental costs and benefits of such a massive expansion of wind energy facilities in North America need to be better understood, particularly since significant differences in the level of impact/benefit likely would occur within and among regions according to the siting and extent of development. This presentation will provide an overview of the broad range of potential adverse environmental impacts that may accrue from the anticipated expansion of wind energy development—from bat mortality to impacts upon other wildlife and their habitat. In addition, the claimed environmental benefits of wind energy development will be examined and assessed, focusing on the reduction in the annual rate of air pollution emissions from conventional power plants (including CO_2). Other "public policy" aspects of wind energy development will be briefly assessed, including questionable claimed benefits such as our nation's dependence on imported oil would be significantly reduced.

Impacts of Agricultural Intensification on Bat Activity and Insect Diversity on Western Pennsylvania Farms

Brittany N. Bovard and Michael R. Gannon; Pennsylvania State University Altoona College, Altoona PA

Although extensive research has been done on the impact of agrochemical use on insects and birds, few studies have focused on its effect on bats. Bats are the primary predators of night flying insects including many agricultural pests; however, little research has addressed bat management or conservation in Pennsylvania and the role of bats in insect control on farms within the Commonwealth. Because nearly one third of land use in Pennsylvania is farmland and all of the bat species within the Commonwealth are insectivorous, farms are the most logical place to begin assessing the impact of the application of agricultural pest control chemicals and its implications on bat conservation. In this study we compare bat activity on an organic and a conventional farm in Pennsylvania that were similar in total area and crop types. Two sites were chosen on each farm—a pond site and a crop site. Bat activity was measured by counting bat passes recorded on an ultrasonic bat detector. Insect availability was assessed using sweep nets and heath traps. Differences in bat activity and insect diversity and abundance is quantified to assess whether agrochemical use may affect insect prey density and foraging activity of bats.

Foraging Behavior and Diversity of Bats in a Pecan Agroecosystem in Texas

Elizabeth C. Braun de Torrez and Thomas H. Kunz; Boston University, Boston, MA

In central Texas, agriculture has significantly modified the native woodland savanna, and pecan cultivation has replaced diverse riparian woodlands. Pecan orchards, ranging from lightly managed native groves to commercial plantations with heavy pesticide use, cover over 240,000 acres in Texas. The integration of pecan orchards within riparian plant communities, their structural complexity, and the mosaic of management intensities make pecans a model system to study as an alternative habitat resource for bats. The pecan nut casebearer moth (*Acrobasis nuxvorella*) and the hickory shuckworm (*Cydia caryana*) are the most devastating predators affecting pecans. Pecan growers have long thought that bats reduce the need for pesticides through consumption of these pests, but no comprehensive studies have explored this suggestion.

In our study, we documented habitat use by bats within the pecan agroecosystem to evaluate: 1) the role of pecan groves as a source of riparian woodland habitat for bats; 2) the influence of management intensity on bat activity; and 3) dietary content of bats foraging in the orchards. Sites were divided into three categories: 1) managed native pecan groves *without* pesticide use; 2) commercial plantations *with* pesticide use; and 3) unmanaged juniper/mesquite woodlands. At each site, bat activity and diversity was monitored three times with mist nets and Anabat detectors. Guano was collected from beneath the roost and from captured bats for dietary analysis. Five bat species were found in the pecan agroecosystem (*Tadarida brasiliensis*, *Myotis velifer*, *Nycticeius humeralis*, *Lasiurus borealis*, *Perimyotis subflavus*). Preliminary results suggest that bat activity is higher in native orchards and commercial plantations than in unmanaged woodlands and that native orchards have higher activity than commercial plantations. Species richness is equal across management types but alpha diversity and evenness is highest in the native orchards and lowest in the unmanaged woodlands. In the unmanaged woodlands, activity and diversity increases with proximity to the river, while distance from the river has no effect in the orchards. More analysis remains, including acoustic and fecal analysis, but preliminary results point to interesting conclusions regarding habitat selection by bats in pecan orchards. This initial study lays the foundation for further work in which we plan to examine bat-mediated trophic interactions within pecan orchards and their cumulative ecological and economic impact on pests of pecan nuts.

Application of Stable Isotope Analysis to Determine the Migratory Patterns of Female Indiana bats *Myotis sodalis*

Eric R. Britzke, Susan C. Loeb, and Maarten J. Vonhof; Britzke and Associates, Forrest City, AR; Southern Research Station, Clemson, SC; Western Michigan University, Kalamazoo, MI

Knowledge of the movements of bats between their summer and winter range is important for any conservation efforts to be effective. Although female Indiana bats (*Myotis sodalis*) have been documented to migrate up to 450 km, our understanding of bat migration is still extremely limited. Previous work has demonstrated a relationship between latitude and the stable hydrogen isotope ratio in bat hair (δD_h) that was collected while in their summer range. We used this relationship to determine the movements of female Indiana bats from hair samples taken at hibernacula throughout the range of the species. We analyzed 306 hair samples taken from 15 caves in 8 states. We compared the range in δD_h from each cave population to values from summer maternity range to assess the relative area of the range that is used by bats from each hibernaculum. We also used regression analysis to predict the latitude of the maternity range used by bats sampled during hibernation. Caves varied substantially in δD_h range, suggesting big differences among caves in the movement distance traveled by the bats that hibernate there. This variability in movement distances among sites was not associated with the population size of the cave or its geographic location. Currently, the importance of hibernacula for species conservation is largely determined by population size. However, ranking of importance of hibernacula should be reevaluated to incorporate the migratory movements of the bats at these caves, as high levels of migratory diversity may be present within small populations at some sites.

Genetic Variation and Structure in the Endangered Mexican Long-nosed Bat *Leptonycteris nivalis*: Mitochondrial and Nuclear Perspectives

Carson M. Brown, Loren K. Ammerman, Rodrigo A. Medellin, Arnulfo Moreno-Valdez, and Russell S. Pfau; Angelo State University, San Angelo, TX; Universidad Nacional Autónoma de México, Distrito Federal, México; Universidad Technológica de Ciudad Victoria, Tamaulipas, México; Tarleton State University, Stephenville, TX

The endangered Mexican Long-nosed Bat (*Leptonycteris nivalis*) is a nectar-feeding phyllostomid that occurs in high-elevation, semi-arid, pine-oak woodlands of central and northern Mexico and two localities within the southwestern United States. Female *L. nivalis* migrate during summer; they follow blooms of paniculate *Agave* spp. to the northern reaches of their distribution where parturition occurs. This species is thought to have experienced recent declines; however, evidence on the trends of *L. nivalis* numbers is scant and little is known about its migratory patterns. We collected wing punch tissue samples from *L. nivalis* throughout its range. Genetic analysis of mitochondrial DNA (mtDNA; control region) and nuclear DNA (amplified fragment length polymorphisms, AFLP) revealed an absence of genetic structuring within *L. nivalis*. Nucleotide (n = 0.013) and haplotype (h = 0.810) diversity values for genetic data are comparable to other species of migratory bats, and were moderately high for a species believed to have undergone a recent, drastic decline. Patterns of mtDNA sequence variation (*Tajima's D* = -1.054; P > 0.10, *Fu's F* -16.53, and mismatch distribution) and a star-like AFLP neighbor-joining tree topology suggest a historic population expansion. The geographic distribution of mtDNA control region haplotypes does not support the hypothesis of female philopatry. In addition, direct evidence of movement from El Infierno Cave, Nuevo Leon and Emory Cave, Texas as observed by the recapture of individuals with wing punches, provides further support against philopatry in *L. nivalis*. Population size was estimated based on mark-recapture data; these estimates for migratory females and their offspring were comparable to cave exit counts at Emory Cave from previous studies, suggesting that all reproductive *L. nivalis* females may migrate as a single colony. If this is the case, then *L. nivalis*, as a species, would be extremely vulnerable to disturbance at any one roost along their migratory route.

Townsend's Big-eared Bats *Corynorhinus townsendii* on Santa Cruz Island, California: Preserving Historic Structures as Critical Habitat for a Rare Species

Patricia E. Brown, Robert D. Berry, Cathy Schwemm, and Tim Coonan; UCLA and Brown-Berry Biological Consulting, Bishop, CA; University of California, Santa Barbara; Channel Islands National Park, Ventura, CA

A maternity colony of Townsend's Big-eared Bat (*Corynorhinus townsendii*) roosts in the adobe at Scorpion Anchorage on Santa Cruz Island, which is in the Channel Islands National Park. This building appears to be extremely important for the maintenance of this population. Because the adobe is an historic structure, this situation presents challenges for preserving and interpreting a cultural resource that is also critical bat habitat. Efforts to preserve the building may have disturbed the bats, as could future plans for interpretive use of the adobe. *Corynorhinus townsendii* typically roost in caves or cave-like structures and are very sensitive to human disturbance. The species has declined in numbers across the western United States, particularly in coastal California. Several causative factors have been identified, and roost disturbance or destruction appears to be the most important. The authors have monitored the population in the Scorpion adobe since 1994. Since 2005 the population has declined by almost 50%. A 1994 telemetry study determined that these bats foraged up to five kilometers from the coastal roost in native vegetation in an area with many small natural caves. Although these caves were used for night roosts, the bats exhibited high fidelity to the adobe. Thermal data-loggers were placed for a year in the adobes at Scorpion and Smuggler's Cove, and in coastal and inland caves. The Scorpion adobe provides a warmer environment during the maternity season, and this may be a reason for the bats' preference. The purposes of the current research are to monitor the resident bat population at Scorpion Ranch; to survey for additional colonies on SCI; to provide recommendations for protecting the colony from disturbance; and to develop guidelines for alternative roosts in the event the colony is evicted from the Scorpion adobe.

Correlating Roost Habitat Availability and Local Population Densities: A First Step Toward Determining Carrying Capacity for Spix's Disk-winged Bat, *Thyroptera tricolor,* in Southern Costa Rica

Michael R. Buchalski, Gloriana Chaverri, and Maarten J. Vonhof; Western Michigan University, Kalamazoo, MI

An understanding of the resource requirements determining carrying capacity for a given species is essential for predicting the effects of habitat loss on abundance. For habitat specialists, it is reasonable to consider the resource of specialization as a limiting factor with regard to carrying capacity. Many bat species demonstrate narrow resource requirements with regard to roosting habitat. This is particularly true for Spix's Disk-winged Bat, *Thyroptera tricolor*, which is morphologically adapted to roost inside the rolled, developing leaves of plants in the order Zingiberales. With an ultimate objective of modeling population dynamics and experimentally testing the effects of habitat loss on *T. tricolor*, this pilot study attempts to determine if variation in rolled leaf density leads to corresponding variation in bat abundance. Mark/recapture data were used in conjunction with program MARK to estimate local population abundance at five sites for each of 15 survey efforts. The POPAN configuration of the Jolly-Seber model was used to calculate a maximum likelihood estimation of abundance based on observed capture histories. Model appropriateness was evaluated through goodness of fit testing (i.e., AIC weights and likelihood ratio tests), and standard errors for abundance estimates were determined using the Delta method. The degree of linear relationship between estimates of abundance and observed rolled leaf densities was assessed via regression and Pearson-product moment correlation analysis. This study is an important first step towards applying ecological models of population dynamics to local populations of bats, with an ultimate goal of predicting the effects of habitat loss.

Pathologic Investigations into the Cause of White Nose Syndrome during Winter 2008

Elizabeth L. Buckles, Carrol Meteyer, and Melissa Behr; Cornell University, Ithaca, NY

White Nose Syndrome (WNS) is a mysterious condition associated with unprecedented mortality in hibernating bats from the Northeast. Significant mortalities were first noticed during the winter of 2007 and again in 2008. Hallmarks of WNS include alterations in hibernation patterns, inappropriate activity of bats during hibernation, increased mortality in the hibernacula, and visible growth of a white fungus on muzzles of affected bats. It is this latter condition from which the syndrome gains its name. In order to determine the cause of mortality in these bats, a

comprehensive disease investigation was launched during the winter of 2008. Dead and moribund bats were collected from multiple sites in New York, Massachusetts, Connecticut, New Hampshire, and Pennsylvania. The carcasses of over 100 bats were examined by veterinary pathologists at three separate institutions. Examinations included gross evaluation of organs, body condition, and extent of fungal growth on the bats. Additionally, tissues were examined histologically, and appropriate samples processed for fungal, bacterial, and viral culture. The majority of examined bats were *Myotis lucifugus*, but submissions also included one *Eptesicus fuscus* and *Myotis septentrionalis*. Bats were emaciated, and the majority of the bats had fungal growth either on their ears, muzzles, or wings. In some cases, fungal growth was associated with no lesions, while in others fungal growth was associated with areas of dermal necrosis and inflammation. An unusual fungus has been cultured from these bats, but it is not known if this fungus is a primary cause of mortality or an opportunistic invader. It is known that the observation of fungus on hibernating bats is unusual. Investigations into identifying predisposing factors for the development of WNS, and for clarifying the role that this unusual fungus plays in mortality are ongoing.

Spring Indiana Bat *Myotis sodalis* Migration Telemetry in Pennsylvania

Calvin M. Butchkoski and John D. Chenger; Pennsylvania Game Commission, Harrisburg, PA; Bat Conservation and Management, Inc., Carlisle, PA

Since the year 2000, studies have been conducted in Pennsylvania to locate Indiana bat summer habitats by radio-tagging and following female Indiana bats (*Myotis sodalis*) as they exit known hibernacula in the spring. Prior to this work only one summer maternity roost was known in the state. Techniques used include ground tracking with specially equipped vehicles, tracking with specially equipped aircraft, and the combination of both techniques. Four hibernacula were investigated on seven occasions, with five of the seven investigations being successful in locating summer habitats. Of the 46 bats radio-tagged, 19 (41%) were found in 9 summer sites, including 2 roosts in Maryland, which were 135 and 148 km from their hibernaculum.

Overview of the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) and Preliminary Results of Bat Monitoring at Habitat Creation Sites

Allen Calvert, Susan Broderick, and Theresa Olson; U.S. Bureau of Reclamation

The Lower Colorado River Multi-Species Conservation Program (LCR MSCP) is a 50-year cooperative Federal-State-Tribal-County-Private effort to manage natural resources of the LCR watershed, provide regulatory relief for use of water resources, create native habitat types along the LCR, and monitor 26 covered species. Monitoring provides data to the adaptive management process to insure that the best science is used in decision-making. Four covered bat species are being managed and monitored: Western Red Bat, *Lasiurus blossevillii*; Western Yellow Bat, *Lasiurus xanthinus*; California Leaf-nosed Bat, *Macrotus californicus*; and Townsend's Big-eared Bat, *Corynorhinus townsendii*. Post-development monitoring of covered bat species is being completed in five areas: Beal Lake riparian restoration area within Havasu National Wildlife Refuge (NWR) near Needles, CA; 'Ahakhav Tribal Preserve near Parker, AZ; Palo Verde Ecological Reserve north of Blythe, CA; Cibola Valley Conservation Area near Cibola, AZ; and Imperial Ponds Conservation Area within Imperial NWR north of Yuma, AZ. Monitoring includes both acoustic and capture surveys. Acoustic surveys are performed quarterly using Anabat detectors. Bat detectors are placed within diverse, created land cover types in order to detect habitat preferences of the different bat species. A long-term passive Anabat station was established at one site in April of this year. Capture surveys are conducted five times between late spring and early fall, and methods include the use of harp traps and mist nets. Capture surveys are used to acquire reference calls, determine age, sex and reproductive status of bats, and to discover if any species are missing from the acoustic surveys. Acoustic surveys have been performed since the fall of 2006. Capture surveys were conducted minimally in 2007 and a full survey season was completed in 2008. A total of 16 species have been recorded acoustically, and 9 species have been captured. Both techniques have revealed a species from a site that had been previously unknown using the other technique. Together, the two survey techniques provide a good picture of bat use of each habitat creation site. These are preliminary data that will be used during the adaptive management process to further direct the monitoring of current habitat creation areas and to determine how to make created sites more suitable for bat use in the future.

Do All Three Vampires Duet? Comparing Structure and Function of Social Calls in *Desmodus, Diaemus,* and *Diphylla*

Gerald G. Carter, Angelica Menchaca, and Rodrigo Medellin; University of Western Ontario, London, ON, Canada; UNAM, Mexico City, Mexico

Adult white-winged vampire bats *Diaemus youngi* exchange social calls in simple antiphonal duets. After a bat emits a loud double-note social call, a conspecific will match that call type within about 1/3 of a second. These exchanges allow individual vocal discrimination and may be analogous to the contact calls between mothers and pups ("directive" and "isolation" calls) in other bat species. To determine if these adult social calls function to maintain contact with certain individuals, we recorded antiphonal calling under two social environmental conditions: unstable and stable. In unstable social environments, locations of four isolated bats shifted randomly. In stable conditions, four isolated bats were disturbed in the same manner, but were then returned to their original positions. We predicted that bats would call more in an unstable social environment in order to track the locations of certain conspecifics. Results for this experiment are forthcoming. We next investigated whether common vampires *Desmodus rotundus* or hairy-legged vampires *Diphylla ecaudata* produce similar vocal exchanges. Using an Avisoft CM16 and ultrasoundgate synchronized to an IR video camcorder, we recorded echolocation pulses, isolation calls, distress calls, and other social calls from wild *Desmodus* and *Diphylla*. We found no evidence of antiphonal duets in *Desmodus* or *Diphylla*, although adult *Diphylla* produce similar structured social calls to *Diaemus* when isolated. We compare structural and temporal differences in social calls between these three genera and discuss their implications for social behavior. Because all three vampires perform food sharing, the individual-specific social calls of *Diaemus* are unlikely to be related to reciprocal food sharing. Instead, we suggest they function for long-distance individual recognition outside the roost. Studies with free-ranging *Diaemus* will be necessary to explain the adaptive function of this act in the wild.

Comparing Adhesive Types for Radio Transmitter Attachment on Eastern Bat Species
Timothy C. Carter, Timothy J. Sichmeller, Amanda. L. Albus, and Matthew G. Hohmann; Ball State University, Muncie, IN; Southern Illinois University of Carbondale, IL; US Army ERDC-CERL, Champaign, IL

Radio transmitters are a valuable tool used in bat studies around the world. There are varying methods for attaching the transmitters. A common method is to attach the transmitter between the scapulae with a surgical adhesive. However, within the last year or so the manufacturer of the most popular surgical adhesive (Skin-Bond) has changed its formulation. The newly formulated adhesive acts very differently and some researchers are unhappy with its performance. Our objective was to evaluate the currently available surgical adhesives to determine their performance for attaching radio transmitters to bats. The three adhesives tested included the original formula of Skin-Bond, the new formula of Skin-Bond and the Torbot brand adhesive. In the field, we placed transmitters (n = 60) on three species of *Myotis* tracked in Indiana, Illinois, and Kentucky using the three different types of adhesive. We documented the length of time each transmitter stayed on the bats based on the number of days each bat was tracked. Additionally, in the laboratory, we tested the application, drying characteristics, and holding strength of each adhesive. Data from the field portion of the study were compared to the laboratory results. The characteristics both in the field and laboratory are discussed and recommendations are made.

Tips for Excluding Bats From Buildings
John Chenger; Bat Conservation and Management, Inc., Carlisle, PA

As natural roosts have been disturbed or destroyed, many bats have moved into man-made structures, especially wooden buildings and bridges. At least 17 types of bats in North America are known to inhabit buildings during some stage of their life cycle, including several federally endangered species. The cumulative effect of such an increasing number of maternity roosts in conflict with private and public buildings, presents an increasing conservation problem when bats must ultimately be relocated. Because bats are very site loyal and tenacious in their abilities to re-enter improperly bat-proofed buildings, many homeowners resort to less than ideal methods for bat removal. Proper bat exclusions start with witnessing the emergence, planning work for the right time of year, using the right materials, and offering bats remaining in a building the opportunity to escape but not re-enter. Homeowners must be educated that a few bats in a house does not necessarily constitute a health hazard, and waiting to bat-proof a building until after the maternity season may minimize encounters with live bats in the living spaces, which might otherwise occur if an exclusion project is rushed into practice during the mid-summer. With the systematic inspection and sealing of exterior crevices, it is possible to bat-proof nearly any building, preventing future bat use, and successfully eliminating bat-human conflicts. By pairing exclusions with bat house construction, homeowners can continue to benefit from prodigious insect-eating activities of nearby bats without having to share their living quarters with them.

Unraveling Complex Food Webs with Molecules: Ontario's Generalist Predator *Lasiurus borealis* and its Arthropod Prey

Elizabeth L. Clare, Paul D. N. Hebert, Erin E. Fraser, and M. Brock Fenton; University of Guelph, Guelph, ON, Canada; University of Western Ontario, London, ON, Canada

One of the most difficult interactions to observe in nature is the relationship between a generalist predator and its prey. When direct observations are impossible, we rely on post-consumption dietary analysis. For insectivorous bats, this traditionally employs morphological identification of wings at feeding sites or digested insect remains. Because these bats rapidly and thoroughly chew their food, species-level identification of prey is extremely difficult and investigations of diet rarely provide identifications beyond order or family. Despite these obstacles, the evolution of insect hearing and bat echolocation is a frequently cited example of predator-prey co-evolution. Many insect species have simple ears that react to the hunting calls of bats and elicit an avoidance flight response, and some have evolved additional defenses such as toxins and sound emission. In turn, bats may modify their sound production to shift outside the insect's range of hearing. In this investigation, we explore residual mtDNA (DNA barcodes) in fecal pellets as a means to identify the prey of *Lasiurus borealis* captured at Pinery Provincial Park in Ontario and to test three predictions: 1) populations of *L. borealis* eat mainly moths; 2) they do not eat insects that hear their approach; and 3) their diet does not include Arctiid moths, which possess additional defenses. We obtained sequences from 89% of the insect fragments sub-sampled and 78% of these were identified to species (125 species of insect and 2 species of spider) through comparison to the BOLD reference database. Most identified prey were Lepidoptera (16 families represented), although we also identified species of Coleoptera, Diptera, Ephemeroptera, and Hymenoptera, and possibly Trichoptera, Neuroptera, and Hemiptera. Bats had a mean of 3.5 ± 0.22 (range 1–7) identifiable species in their guano. We found no evidence of resource partitioning between sexes or ages, or seasonal patterns of capture richness. We identified twice as many (n = 16) families of Lepidoptera as previous morphological studies and all additional families were the rarest representatives in the diet. Notably, 70% of the lepidopteran prey had ears capable of hearing the echolocation hunting calls of *L. borealis* but the moth family Arctiidae, with multiple defensive abilities, was nearly absent (only one species detected).

Range, Distribution, and Natural Roosts of Rafinesque's Big-eared Bat in the Coastal Plain of Georgia

Matthew J. Clement and Steven B. Castleberry; University of Georgia, Athens, GA

Prior to this study, knowledge of Rafinesque's Big-eared Bat *Corynorhinus rafinesquii* in the Coastal Plain of Georgia was based on records for 20 individuals in 10 locations. The previous records came from anthropogenic roosts and mist-net captures. We searched for big-eared bats in 2007 and 2008 at eight study sites along six major river drainages in the Coastal Plain with the goal of further elucidating the range, distribution, and natural roosts of big-eared bats. We located roosts through a combination of tree cavity searches along randomly selected transects, *ad hoc* tree cavity searches, and radio-tracking of bats captured from roosts or in mist nets. Transects were placed in three wetland types to clarify the distribution of bats within their range. We collected quantitative data on occupied trees and randomly selected, apparently unoccupied trees. We located 1,856 hollow trees, 192 roosts, and roughly 970 bats at the 8 study areas combined. We found 141 roosts during transect searches, 16 roosts during *ad hoc* cavity searches, and 35 roosts by tracking 34 radio-tagged bats. Three roosts were located in buildings and 189 in hollow trees. Big-eared bats most often roosted in water tupelo (*Nyssa aquatica*; n = 141) or bald cypress (*Taxodium distichum*; n = 12) trees. For the eight sites combined, saturated wetlands contained 0.03 roosts per ha, seasonally flooded wetlands contained 0.57 roosts per ha, and seasonally exposed wetlands contained 1.19 roosts per ha. We performed logistic regressions using variables describing occupied and unoccupied trees, and evaluated the resulting models in an information theoretic framework. The most parsimonious model predicted that big-eared bats are more likely to be found in water tupelo trees with a large cavity and smooth interior walls. These results show that big-eared bats are found throughout the upper and lower Coastal Plains of Georgia; they are found in flooded wetlands more than saturated wetlands; and they prefer water tupelos with a large cavity and smooth interior.

The Coordinated Response for White Nose Syndrome Research and Management
Jeremy T. H. Coleman, Robyn A. Niver, Susi L. von Oettingen, and Laury Zicari; U.S. Fish and Wildlife Service

State, federal, and research scientists are working together to investigate large-scale mortality events in bats that hibernate in the northeastern U.S. First observed at hibernacula near Albany, NY, White Nose Syndrome (WNS) has affected bats in at least four U.S. states, but the impacts of this affliction have spread much farther. At present, the geographic scope of WNS crosses multiple state and federal boundaries requiring the close coordination and collaboration of many different agencies. Moreover, biologists and scientists from health departments, private institutions, universities, and federal labs are actively researching the cause of WNS and working together to contain the potential spread to unaffected areas. The U.S. Fish and Wildlife Service (the Service) has taken the lead in coordinating research and management activities, and has recently secured funding for some of these efforts. Service funds will be available through a competitive grant process. Three additional organizations have also announced grant opportunities for WNS research: the Center for North American Bat Research and Conservation, Bat Conservation International, and the National Speleological Society. Following the successful WNS meeting held in Albany, NY, in June, 2008, the Service worked to formalize the structure of WNS investigation and management by creating a Service-funded coordinator position, outlining an investigation team structure, maintaining a website with up-to-date information, and producing a Memorandum of Understanding between state and federal agencies. The Albany meeting provided direction for the Service and states towards prioritizing research needs and management actions. Research planned for the fall of 2008 and winter 2008–09 will focus on investigating the questions and hypotheses identified at the meeting, and will include studies to: 1) monitor arousal activities of hibernating bats; 2) investigate use of bat body fat resources at affected and unaffected hibernacula; 3) investigate the body condition of bats entering hibernation at affected and unaffected sites; and 4) investigate the nature and physiological impact of the fungus associated with WNS. Additional short-term research activities include: 1) analysis of wing damage observed in summer 2008; 2) standardized population surveys; 3) population modeling for analysis of WNS impacts; 4) captive experiments to investigate the transmission of WNS and the potential for detection procedures; and 5) examination of bat movements and migration in relation to the potential spread of WNS.

The Effects of Urbanization on Bats in the Prairies of Southern Alberta
Joanna Coleman; University of Calgary, Calgary, AB, Canada

Compared to our knowledge of urban ecology in forested biomes, our understanding of how urbanization impacts wildlife in general and bats in particular in grassland ecoregions is rudimentary. Also, by measuring diversity indices and activity levels, traditional urban ecology has focused mainly on community-level responses to urbanization. Besides being one of the few urban ecology studies of Prairie bats, my work goes beyond the conventional approach, being the first to investigate how urbanization impacts bats at the population and individual levels. My overall hypothesis was that urbanization benefits Prairie bats by increasing structural habitat complexity in a fairly homogeneous landscape, and that urban bats benefit from 1) increased availability of roosts and of prey; and 2) reduced use of torpor by reproductive individuals (due to the urban heat-island). Since 2006, I have been acoustically monitoring and mist netting bats at riparian sites inside and outside Calgary, Alberta, Canada to test the following predictions: 1) Urban bats are more speciose and abundant; 2) Urban bats have higher levels of feeding activity; 3) Urban bats are in better body condition; 4) Urban populations contain greater proportions of reproductive individuals; 5) Urban females give birth earlier and their pups grow more quickly; and 6) Urban populations contain greater proportions of volant juveniles. Since 2007, I have also been 1) comparing nocturnal insect availability between urban and non-urban sites, and 2) locating maternity colonies of *Myotis lucifugus* to compare temperatures of urban and non-urban roosts. In 2006 and 2007, I collected 171 nights of acoustic data and captured a total of 1,150 bats, but my acoustic and capture datasets remain incomplete until the end of my 2008 field season. Some preliminary results (subject to change depending on the data I collect this year) contrast with my predictions: 1) Urban bats are more abundant, but less speciose; 2) Urban insects are less abundant and less speciose; 3) The probability of observing feeding buzzes is highest in urban areas, but the frequency of feeding buzzes is not different between urban and non-urban sites; 4) Urban *M. lucifugus* do not contain higher proportions of reproductive individuals; 5) Urban *M. lucifugus* give birth earlier, but urban pups do not become volant earlier; 6) Urban *M. lucifugus* populations contain proportionally fewer volant juveniles.

Why Did the Tree Bat Cross the Turbine?
Paul M. Cryan; USGS Fort Collins Science Center, Fort Collins, CO

Underlying causes of high rates of bat fatality at wind turbines remain a mystery. Worldwide, the majority of bat fatalities observed at wind turbines thus far involve species of bats that roost in trees, and most are killed during late summer and autumn. Why do tree bats play such a major role in turbine collisions, considering they compose only a small proportion of the bat fauna? This talk reviews hypothesized reasons for the disproportionate representation of tree bats among turbine fatalities (e.g., migration, roosting, feeding, mating, etc.) and looks at existing information relevant to these hypotheses. I will highlight the challenges associated with testing hypotheses of cause and emphasize the importance of establishing the reasons for what may be a fatal attraction between tree bats and wind turbines.

Hypothesized Causes of White Nose Syndrome

Paul M. Cryan, Thomas H. Kunz, and Merlin D. Tuttle; USGS Fort Collins Science Center, Fort Collins, CO; Boston University, Boston, MA; Bat Conservation International, Austin, TX

White Nose Syndrome (WNS) was first reported as a condition in hibernating bats in New York State during the winter of 2006–2007, and has now been associated with unprecedented mortality of hibernating bats in four adjacent states during the winter of 2007–2008. Despite the best efforts of a diverse group of bat biologists, pathologists, virologists, mycologists, toxicologists, and wildlife rehabilitators, the etiology of WNS remained unclear during the winter and spring of 2008. In response to this challenge, an emergency meeting was convened in Albany, New York during June 2008. Primary objectives of the meeting were to review existing information on WNS and to develop expert opinion on the most productive course forward to determine causes, consequences, and possible solutions to this condition. To date, evidence indicates that affected hibernating bats were emaciated and dehydrated, and had depleted fat reserve at the time of death—a finding indicative of starvation. Analysis of carcasses recovered in winter has failed to reveal any consistent pathological evidence attributable to the direct effects of a pathogen or contaminant. Based on observations that affected bats were starving, the group assembled in Albany stressed the importance of testing two fundamental hypotheses: 1) bats arriving at hibernacula have insufficient fat to survive until spring; and 2) bats with sufficient arrival fat suffer early depletion during hibernation. Causes of such energy deficits could include the indirect effects of pathogens, contaminants, or environmental change. The first evidence of a cryophilic (cold-loving) fungus as the culprit behind WNS was presented and its potential role in disrupting the energy balance of hibernating bats was presented. The assembled group also further postulated that undetected pathogens, contaminants, compromised immune systems, ecological changes, or some synergistic combination of factors could be the cause of WNS and that, until an obvious cause is identified, such hypotheses should be rigorously pursued.

A Quantitative Approach to Historical Ecology of the West Indies: *Artibeus jamaicensis*

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

We investigated the role of climate change in facilitating the expansion of *Artibeus jamaicensis* in the West Indies. Using a database of locality records and a high-resolution current climate database, we produced an environmental niche model of the species' distribution using the maximum entropy algorithm. Sixty percent of the localities were used as training data, and the remainder as test data, with background points extracted from a database of Neotropical localities, as recommended in published tests. The resulting niche model was projected onto Last Glacial Maximum (LGM) layers generated using two different global climate models. Thresholds of habitat suitability for continuous logistic output were set at the minimum training presence (lowest threshold) and the mean predicted suitability (highest threshold). Both climate models showed similar within-island paleodistributions, with larger area of suitability (1.4X) inferred for the St. Kitts bank under the MIROC climate model. Suitable area was inferred to be between 1.9X (St. Kitts bank) and 3.1X (Saba) larger in the LGM than at present. Low-threshold predictions implied greater decline in suitable area since the LGM on Saba (3.1X) than high-threshold predictions (1.9X) under the CCSM climate model, with negligible differences in comparisons for other climate model/threshold/island combinations. Our results consistently showed larger areas of suitable habitat during the Last Glacial Maximum than at present. The availability of habitat, coupled with the wide environmental tolerance of this species enabled its relatively recent expansion to the West Indies.

Habitat Preference of Insectivorous Bats across an Agricultural Landscape Depends on Habitat Type and Temporal Variation

Noa Davidai, John K. Westbrook, Tom Hallam, and Gary F. McCracken; University of Tennessee, Knoxville, TN; Areawide Pest Management Research Unit, USDA, College Station, TX

Brazilian free-tailed bats (*Tadarida brasiliensis)* form extremely large colonies in caves within and around an agricultural area called the Winter Garden region in south-central Texas, although their numbers have been consistently and continuously declining. These bats forage nightly and consume massive amounts of insects, including the corn earworm (*Helicoverpa zea*), a noctuid moth responsible for over a billion dollars of annual losses and costs for control each year in the U.S. This study analyzed foraging bat activity across this large spatial scale to understand the factors determining the bat's foraging habitat preference. Using Anabat II bat detectors, nightly bat foraging activity was surveyed across the landscape for the duration of 2007. In addition, nightly insect abundances and climatic data were collected. Though preliminary analysis shows no overall direct correlation between increases in bat activity and peaks in moth abundance, there is a Lotka-Voltera type relationship between bats and moths that is strongly affected by time. In addition, preliminary analysis shows a significant difference between relative bat activity in crop and non-crop habitat types and this relationship is also strongly affected by time, but, contrary to expectation, bat activity seems to be higher in natural areas than in crop habitat areas. This could indicate a need for restoration of natural areas within and around the agricultural region.

Activity Patterns and Maternity Roost Selection of Indiana Bats in Relation to Potential Wind Farms in Northern Missouri

Shelly N. Dey and Lynn W. Robbins; Missouri State University, Springfield, MO

Wind turbines are an excellent source of renewable energy; however, large numbers of dead bats are being reported in association with the turbines. Because the endangered Indiana Bat (*Myotis sodalis)* has maternity roosts in northern Missouri, there are concerns that wind farms may potentially have a negative effect on this species. We conducted mist net surveys (focusing on *Myotis sodalis*) in conjunction with Anabat detector surveys from May 2007 to August 2007 and again from May 2008 to August 2008 in three northern Missouri counties where wind farms have been proposed. Fifteen (one juvenile male, fourteen female) *Myotis sodalis* of various reproductive stages were fitted with radio transmitters. They were tracked from the site of capture to primary and/or alternate roost trees. Each bat was tracked for an average of three days and/or nights. Activity behavior (length of total travel, direction of travel, etc.) was recorded and was highly variable. Some bats traveled two-plus miles to and from the roost site and or capture site, while other bats captured at the same time and place traveled less than one mile. We can speculate that they were foraging during the time of travel. Roost selection was also highly variable, but most roost sites were in dead trees with peeling bark (26.7% Elm, 20% Oak, 40%

Shagbark Hickory, 6.6% Maple, and 6.6% other) with an average height of 43.8 feet. One pregnant female roosted in an old barn where the majority of the bats were *Myotis lucifugus*. Indiana bats seemed to travel along forested corridors and streams, and roosts were in trees and/or structures that had exposure to sunlight.

Silvicultural Disturbance Influences Bat Activity and the Occurrence of Nocturnal Insects in the Central Appalachians of Eastern North America

Luke E. Dodd, Lynne K. Rieske-Kinney, and Michael J. Lacki; University of Kentucky, Lexington, KY

The use of forest habitats by foraging bats and how this habitat use is influenced by the insect prey base is poorly understood. Silvicultural treatments implemented during the dormant season of 2006–2007 created a gradient of disturbance from cleared to undisturbed forest, replicated at each of four sites across the central Appalachians. We monitored bat activity and insect occurrence at each site during the 2007 growing season. Bat activity was monitored using acoustic surveys. Bat detectors were placed in all plots to allow synchronous assessment in a study area; surveys were conducted across 36 nights. Nocturnal insect activity was assessed concurrently using light traps, malaise traps, and funnel traps over 16 nights. Bat activity (echolocation pulses/night) was higher in plots with greater disturbance intensity ($p < 0.05$). Insects captured in malaise traps, particularly Diptera, were more abundant in plots with greater disturbance intensity ($p < 0.05$). In contrast, the overall abundance of Lepidoptera captured in light traps, as well as all common lepidopteran families, was lower in plots with greater disturbance intensity ($p < 0.05$). Coleoptera were the primary taxa collected in funnel traps; no difference was noted based on disturbance intensity ($p > 0.05$). Differences in abundance among insect taxa may be related to changes in the host plant base and increases in snags and woody debris. As bat activity did not mirror insect data, hypotheses addressing correlations between bat activity and disturbance intensity must consider foraging success, proximity of roost locations, and differences in occurrence of bat species. Integration of data from the 2008 growing season will allow a more robust analysis of all sampling methods, incorporating effects attributable to position within plots (interior versus edge), as well as potential regional differences. Efforts are ongoing to assess food habits of bats captured in study areas, linking the occurrence of insect taxa with specific bat species. A fundamental understanding of plant and animal relationships are necessary for sound management of our forest resources. Our research offers insight into the spatial relationships between bats, insects, and their forest environment in eastern North America, and has implications for predator-prey relations, forest ecology, and forest stewardship.

Molecular Systematics of the Genus *Nyctinomops

Richard W. Dolman and Loren K. Ammerman; Angelo State University, San Angelo, TX

*** Richard Dolman** received the **Basically Bats Wildlife Conservation Society Award**

The genus *Nyctinomops* comprises four species of bats in the free-tailed family Molossidae: *N. macrotis, N. femorosaccus, N. aurispinosus,* and *N. laticaudatus.* A comprehensive morphometric analysis of the family Molossidae confirmed that all four species should be separated from the New World genus *Tadarida*. To our knowledge, there has been no published phylogeny of the genus *Nyctinomops*. The objective of this study was to use mitochondrial cytochrome-*b* sequence data to test hypotheses of relationship within *Nyctinomops*. A total of 513 bases were aligned and analyzed using maximum likelihood (GTR+G). Sequences from *Cynomops abrasus* and two species of *Tadarida* (*T. brasiliensis* and *T. teniotis*) were used as outgroups. Cytochrome-*b* divergences (Kimura 2 parameter) ranged from 6–11% within the genus. Our results confirm the result based on morphological similarity that the largest member of the genus *N. macrotis* is the basal species. Analysis of cytochrome-*b* data recovered the following relationships with strong bootstrap support: (*N. macrotis* (*N. femorosaccus* (*N. laticaudatus, N. aurispinosus*))). The relationships of the smaller species did not agree with previous morphometric analyses.

Associations between Nitrogen Isotope Ratios and Cranial Morphology in Phyllostomid Bats

Elizabeth Dumont, Katja Rex, and Christian Voigt; University of Massachusetts, Amherst, MA

Phyllostomids exhibit spectacular trophic diversity and many studies have demonstrated a clear link between the morphology of their skulls and traditional dietary categories such as ‘frugivore,’ ‘nectarivore,’ and ‘sanguivore.’ However, with the accumulation of detailed field studies, it has also become clear that the diets of many species are actually quite broad. This raises the prospect that the association between cranial morphology and diet is weaker than we think. To address this possibility, we investigated the strength of the association between cranial morphology and nitrogen isotope ratios. To generate cranial morphology variables, we analyzed size adjusted, linear measurements of the skull from 70 species using principal components analysis. The first two components explained 78% of the variation among the species and were used as independent morphology variables in subsequent analyses. To represent diet, we used nitrogen isotope ratios from 42 species to summarize the relative proportion of plant- and animal-based dietary resources. We evaluated the association between cranial morphology and nitrogen isotope ratios in the context of a dated molecular phylogeny using a generalized least squares (GLS) approach. GLS is a flexible analysis tool that allowed us to correct for the lack of phylogenetic independence within the sample as well as to investigate patterns of character evolution. We found that both cranial morphology variables were significantly associated with nitrogen isotope ratios. We also found that compared to morphology variables, nitrogen isotope ratios have weaker phylogenetic signal and evolved most rapidly on the shortest branches within the tree. These data indicate that the evolution of morphology and diet are indeed linked, but they have not evolved at same rate.

Determining Metabolized Fuel Source during Arousal from Hibernation using Stable Isotope Signatures in Breath

Miranda B. Dunbar, Justin G. Boyles, Matthew Shuler, and Jonathan J. Storm; University of Regina, Regina, SK; Indiana State University, Terre Haute, IN; University of South Carolina Upstate, Spartanburg, SC

Bats rely mostly on a fixed energy source, white adipose tissue (WAT), to survive the hibernation period; however, two other sources, brown adipose tissue (BAT) and food, may lessen use of WAT in specific situations. BAT is used mainly for thermogenesis during arousal

to raise body temperature to euthermic levels, but methods previously used to estimate the time course of BAT metabolism have poor temporal resolution and generally require subjects to be euthanized. Feeding during winter may be possible in some situations, but it is unknown whether bats metabolize food immediately to power euthermy, or if it is converted to WAT for later use. We conducted two experiments with wild *Myotis lucifugus* to test the efficacy of a relatively new technique, stable isotope analysis of excurrent breath, in determining the metabolic fuel powering arousals from hibernation and the subsequent euthermic periods. First, we collected breath samples from 16 bats as they aroused from hibernation to determine if the change between BAT and WAT being metabolized for thermogenesis was detectable in excurrent breath. Second, we fed euthermic bats mealworms with a known isotopic signature to determine if bats can quickly metabolize an exogenous energy source during euthermic bouts. The results of the first experiment suggest the isotopic signatures of WAT and BAT vary enough to be detectable in excurrent breath. The results of the second experiment suggest that despite a known atrophy of the digestive system during hibernation, bats begin metabolizing exogenous fuel sources shortly after feeding and continue to metabolize them for several hours. Stable isotope analysis of excurrent breath appears to be a viable tool in determining the time course of energy expenditure during hibernation and periodic euthermic bouts.

***Thermoregulatory Variation among Populations of Bats along a Latitudinal Gradient**

Miranda B. Dunbar and R. Mark Brigham; University of Regina, Regina, SK, Canada

*** Miranda Dunbar** received the **Bat Conservation International Award**

Most studies of seasonal variation in physiology have sampled from populations within a single geographic area and have not assessed within-season variation. Because environmental factors are correlated with biological phenomena, many of which require physiological adjustments, and habitats vary with geography, we expect variance in hibernation patterns among geographically separated populations. Some hibernators have large winter ranges meaning that populations likely experience area specific levels of environmental stress. Our goal was to measure intraspecific variation in thermal energetics of a non-migratory and migratory species to determine whether there is a continuum based on latitude. We chose big brown (*Eptesicus fuscus*) and eastern red bats (*Lasiurus borealis*) as model species. We sampled bats throughout each species' winter range and measured oxygen consumption and skin temperature over a range of ambient temperatures to assess metabolism. Our data suggest that torpid metabolic rate (TMR) is a function of both temperature and sex and varied with latitude. Bats from southern populations maintained higher body temperatures and have higher TMR at cooler temperatures and lower TMR at warmer temperatures than northern individuals. Also TMR among populations of *L. borealis* varied less dramatically than in *E. fuscus*. Both species exhibited a limited range of physiological plasticity. Collectively, the data demonstrate bats' sensitivity to thermal variation and suggest some level of physiological fidelity to a particular region and/or winter habitat based on the climatic conditions of that habitat. This plasticity reflects a continuum in thermoregulatory response ranging from the expression of classic hibernation in northern populations to a pattern akin to daily torpor in southern populations. Understanding winter requirements of hibernators will allow us to mitigate future threats to ecological systems by accounting for changing environmental conditions.

The Effects of Reproductive Condition on Foraging Behavior and Thermoregulation in *Myotis lucifugus* of Upstate New York

Yvonne Dzal; University of Regina, Regina, SK

Reproduction is energetically costly, especially for pregnant and lactating females. They should adjust foraging behavior and thermoregulation to minimize energetic consumption. Compared to non-reproductive bats, reproductive females should use torpor less due to the constraints of reproduction. When they use torpor, bouts should be shorter and shallower to enable energy savings while avoiding negative effects of torpor on offspring growth and milk production. Compared to pregnant and non-reproductive female bats, lactating bats should forage closer to roosts and return more often to nurse pups. I tested these predictions for individuals from three colonies of building-roosting *Myotis lucifugus* in Upstate New York. I was especially interested in determining whether bats of varying reproductive states used heterothermy regularly, even when there appeared to be an abundance of food. From June to August 2008 I radio-tracked and monitored thermoregulatory behavior of 40 *M. lucifugus*. I found that pregnant and lactating females often entered torpor (reduced skin temperature: T_{sk}) on cool mornings and passively rewarmed in the afternoon. They maintained higher minimum T_{sk} than post-lactating females. Reproductive female bats foraged for longer but traveled shorter distances to foraging areas than post-lactating females; however, pregnant females usually had 2 foraging bouts while lactating females made 2–3 shorter bouts, and post-lactating females went out only once. Although the use of torpor was similar to previous studies of *M. lucifugus*, the differences in foraging behavior have not been reported before, even for *M. lucifugus* in other parts of its range. I hypothesize that foraging by *M. lucifugus* in my study area reflects the highly profitable foraging areas located in close proximity to roosts.

Vertebral Fusion in Bats (Order Chiroptera)

Dawn J. Eichenberger, Shannon Datwyler, and Winston C. Lancaster; California State University, Sacramento, CA

Retention of independent vertebrae (*sans sacrum*) is the ancestral state for mammals. The purpose of this study was to determine the patterns of vertebral fusion in bats and determine if there is an association of phylogenetic relationships and feeding methods to vertebral fusion. Data for vertebral fusion were collected from museum specimens and data for feeding methods and phylogeny were collected from the literature. Vertebral fusion was found to occur in three distinct regions in addition to the sacrum. The phylogenetic analysis indicated that vertebral fusion evolved independently at least four times. Vertebral fusion is not likely an adaptation for feeding methods; although statistically significant, the test could not remove the effect of phylogeny. Vertebral fusion may increase the intrinsic rigidity of the vertebral column, reducing the need for muscular support, and resulting in a relative reduction in weight of the organism. Further studies incorporating muscular and skeletal relationships as well as phylogenetic analysis combining molecular and morphological data may provide an explanation of the presence of vertebral fusion in some families of bats and not others.

Global Completeness of the Bat Fossil Record

Thomas P. Eiting and Gregg F. Gunnell; University of Massachusetts, Amherst, MA; University of Michigan, Ann Arbor, MI

The fossil record of bats is commonly believed to be very poor. However, quantitative analyses of this record have rarely been attempted, so it has been difficult to gauge just how depauperate the bat fossil record really is. Measures of completeness of the fossil record have important consequences for our understanding of evolutionary rates and patterns among bats. In this study, we applied previously developed statistical methods of analyzing completeness to the bat fossil record. The main utility of these methods over others used to study completeness is their independence from phylogeny, a desirable characteristic given the recent state of flux in the higher-level phylogenetic relationships of bats. All known fossil bat genera were tabulated at the geologic stage or sub-epoch level. This binning strategy allowed an estimate of the extinction rate for each bat genus per bin. Extinction rate—together with estimates for preservation probability and original temporal distributions—was used to calculate completeness. Results indicated that, at the genus-level, the bat fossil record is just over 20% complete. Within the order, Pteropodidae and Noctilionoidea are missing most of their fossil histories, while Vespertilionoidea is missing the least. These results suggest that incorporating bat fossils into broad phylogenetic analyses of genus-level relationships may not be particularly useful until the fossil history of bats is more thoroughly documented.

Summary and Analysis of the U.S. Government's Bat Banding Program

Laura E. Ellison; U.S. Geological Survey, Fort Collins, CO

More than two million bands were issued by the U.S. Fish and Wildlife Service's (USFWS) Bat Banding Program (BBP) from 1932–1972. Approximately 1.5 million bands were applied to 36 bat species by scientists in many locations in North America, including the U.S., Canada, Mexico, and Central America. Throughout the program, scientists noticed numerous and deleterious effects on bats, which led the USFWS to issue a moratorium on bat banding and the American Society of Mammalogists to pass a resolution to cease banding in 1973. One of the main points of the memorandum written to justify the moratorium was to conduct a "detailed evaluation of the files of the bat-banding program." However, a critical and detailed evaluation of the BBP was never completed. In an effort to satisfy this need, I compiled a detailed history of the BBP by examining the files and conducting a literature review on bat banding activities during the program. I also provided a case study in managing data and applying current mark-recapture theory to estimate survival using the information from a series of bat bands issued to Clyde M. Senger during the BBP. The majority of bands applied by Senger were to Townsend's Big-eared Bat (*Corynorhinus townsendii*), a species of special concern for many states within its geographic range. I developed a database management system for the bat banding records and then analyzed and modeled survival of hibernating Townsend's big-eared bats at three main locations in Washington State using Cormack-Jolly-Seber (CJS) open models and the modeling capabilities of Program MARK. This analysis of a select dataset in the BBP files provided relatively precise estimates of survival for wintering Townsend's big-eared bats. However, this dataset is unique because of its well-maintained and complete state and because there were high recapture rates over the course of banding; it is doubtful that other unpublished datasets of the same quality exist buried in the BBP files for further analyses. Lastly, I make several

recommendations based on the findings of this summary and analysis, the most important of which is that marking bats with standard metal or split-ring forearm bands should not be considered for mark-recapture studies unless the information sought and the potential for obtaining unbiased estimates from that information vastly outweigh the potential negative effects to the bats.

Wing Surface Tactile Receptors: Electron Microscopy and Flight Behavior

Ben Falk, John M. Zook, Susanne Sterbing-D'Angelo, and Cynthia F. Moss; University of Maryland, College Park, MD; Ohio University, Athens, OH

Hairs on wing membranes of microchiropteran bats are thought to provide feedback on boundary level air flow necessary for estimations of aerodynamic properties of the bat's flexible hand-wings. During aerial prey capture, the pattern of tactile sensitivity of the wings may play an additional role in locating and manipulating prey caught in wing membranes. We examine the structure of these wing-dome hairs with scanning electron microscopy and detail the density and size of these hairs in three species of bats: *Glossophaga soricina*, *Carollia perspicillata*, and *Eptesicus fuscus*. We further examine the purpose and function of these wing hairs through flight behavior analysis of wing-manipulated bats. Baseline data collected from bats before wing manipulations show they can maneuver to avoid obstacles and successfully intercept tethered prey. We explore the specific influence of dorsal and ventral wing hair manipulations on flight control in obstacle avoidance and prey capture tasks. In our experiments, we first categorize the flight behavior of several bats as they fly in a large flight room through a series of obstacles. We use stereo high-speed cameras to track flying bats in 3-D and an array of microphones to track their vocal orientation. We measure flight speed, turning rate, and maneuverability around obstacles. After using depilatory cream to remove specific locations of wing hairs, we continued to monitor the flight behavior. Preliminary behavioral experiments with free-flying bats suggest that flight performance can be degraded by the removal of wing-dome hairs. (Sponsored by AFOSR MURI Biologically Inspired Flight for Micro-Air Vehicles.)

An Overview of an Extraordinary Colony of *Myotis* Bats

Greg A. Falxa; Cascadia Research Collective, Olympia, WA

The largest known colony of bats in Washington State is a mixed-species maternity colony under an abandoned railroad pier 10 km NE of the capitol city of Olympia. The colony consists of approximately 2,000 *Myotis yumanensis* and 1,000 *Myotis lucifugus* adult female bats. Beginning in 2003, a local effort was started to collect data on this colony. Our goal has been to characterize roosting and foraging preferences, and to document behavior that might assist in the conservation of the colony. Regular fly-out counts, roost structure measurements, collection of roost temperature, and documentation of areas of use within the roost were initiated. During each spring and summer, 2003–2008, I radio-tagged several bats from this colony and tracked them during their foraging bouts. From these efforts, a number of unexpected behaviors were documented. Ten of the thirteen bats radio-tracked from this colony regularly traveled over 13 km from their rural roost, to forage at an urban lake in downtown Olympia. This is one of the longest one-way commute distances reported for *M. lucifugus* or *M. yumanensis* bats. Moreover, lactating mothers sometimes made two nightly trips to this lake. In addition to these extraordinary commutes, other unexpected observations were made during these investigations.

The area of the pier where the bats day-roost is not warmer than the outside ambient temperature. The colony's population recently increased 50 percent from one year to the next. The colony is roosting directly over water, but it is the salt water of Puget Sound—a long distance from fresh water. Highly structured routes between the day roost and the distant feeding area have been documented. Fidelity to individual-specific feeding locations and patterns were observed for all of the bats tracked to the urban lake. Although reproductive success and timing of this colony appear to be within the norms for these species, some of their life-history strategies are unlike those generally accepted and reported.

Harmonics in the Echolocation Calls of Bats

Brock Fenton and Mark Skowronski; University of Western Ontario, London, ON

Microchiropteran bats show considerable latitude in the design and structure of their echolocation calls. Changes in timing (duration, interpulse intervals), frequency, and pattern of frequency change over time have been well documented. Although it is clear that bats also vary the harmonic content of their signals, this aspect of call design has received less attention. The purpose of this study was to examine and quantify the incidence of harmonics in the echolocation calls of a variety of bats. We will address the following questions about the incidence of harmonics: 1) variation within and between species?; 2) within and between settings?; and 3) according to social situation? We also will consider how harmonics vary in strength. The data will allow us to speculate about the role that harmonics play in the echolocation calls of bats and their value in classification.

Light Intensity and the Emergence Time of Little Brown Bats in Central Pennsylvania

Kathryn Fidian and Carlos Iudica; Susquehanna University, Selinsgrove, PA

Little brown bats *Myotis lucifugus* are crepuscular-night insect predators and leave there roosting sites nightly in the fall, summer, and spring to forage for their prey. Their main food sources are flying insects, which show an activity peak in the late evening near sun down. For the last two years, a maternity colony of little brown bats along the Susquehanna River in central Pennsylvania has been studied as part of an on-going, long-term monitoring project to determine what factors cause these animals to leave their daily roost site at a specific time each night. In addition to light intensity, we plan to measure—both inside and outside of the barn where they roost—temperature, barometric pressure, humidity, and wind speed. Emergence time will be defined and characterized using biotic and abiotic elements. Data will be collected at different intervals during the day and night, and statistical analyses will be used to determine correlation among variables. Because data collection is ongoing, preliminary results and interpretations will be presented.

Population and Genetic Consequences of Strong Hurricanes for Three Species of West Indian Phyllostomid Bats

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

Strong hurricanes can cause population reductions in West Indian birds and bats, but the genetic consequences of such reductions have not been documented. For three species of phyllostomid bats, we report on the genetic effects of three strong hurricanes that struck the

northern West Indies in 2004. Hurricane Ivan devastated Grand Cayman and severely depressed populations of several bat species. Despite being smaller than pre-hurricane levels, the population of *Artibeus jamaicensis* (the only species we could resample) on Grand Cayman contained greater mitochondrial haplotype diversity but similar microsatellite allelic diversity compared to pre-Ivan levels. We suggest that hurricane-aided dispersal from Cayman Brac introduced two new haplotypes into the Grand Cayman population. In the Bahamas, two other phyllostomids (*Erophylla sezekorni* and *Macrotus waterhousii*) did not suffer population losses or changes in genetic diversity as a result of Hurricanes Frances and Jeanne. Our results suggest that strong hurricanes usually have greater demographic than genetic effects but that hurricane-aided dispersal can occasionally introduce new genotypes or haplotypes into island bat populations.

Winter Forest Bat Activity in South Central Missouri

Josh R. Flinn, Jason T. Layne, Shelly N. Dey, and Lynn W. Robbins; Missouri State University, Springfield, MO

Compared to the information on summer activity of forest bats, winter data are extremely sparse. Even though forest bats may not be as active during the months of December through March, understanding their patterns of activity are important for management and conservation. We present a summary of capture and call sequence data from three winters (2005–2008) of mist netting and passive acoustic detection at Peck Ranch Conservation Area in Carter County Missouri. Mist nets were set over service roads and ponds in oak/hickory and pine forest. Anabat detectors were placed in these same habitats, but also in areas managed for pine regeneration. Four species of tree bats were captured including *Lasiurus borealis* (n = 239), *Lasionycteris noctivagans* (n = 21), *Nycticeius humeralis* (n = 18), and *Myotis septentrionalis* (n = 13). *L. borealis* and *L. noctivagans* were captured in every month, but *N. humeralis* and *M. septentrionalis* were only captured in March. A total of 1,802 call sequences were recorded and identified as these same four species. Daily temperatures were obtained from an online weather database. Maximum daily temperature when bats were captured was higher (mean = 17.7º C) compared to days when no bats were captured (mean = 12.7º C). This information can be used to understand habitat use and migratory activity of these bats.

A Predictive Bat Activity Index Used for Wind Turbine Constraint Mapping

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

The recent push for renewable energy has led to an increase in wind power development, and the impact on bat populations is concerning to biologists. Energy companies may wish to assess potential bat risks when planning new wind power projects, especially if federally endangered species are known to exist on the project area. Although it is currently unclear how pre-construction bat activity relates to post-construction activity and mortality, one approach to limiting impacts may be to construct wind turbines in areas with relatively low bat activity. The goal of this project was to develop a constraint map for wind turbine placement based on predicted bat activity at a proposed wind farm site in northern Missouri. Sixteen detector stations were sampled for seven nights each from August 21–September 25 of 2007 using the Anabat system for passive acoustic monitoring. Detectors and sampling dates were randomized to reduce bias. A bat activity index (AI), defined as the number of one-minute time blocks in a sampling

night that contains at least one bat pass, was calculated for each station. Wooded habitat on the project area was delineated using aerial photo interpretation. A geographic information system (GIS) was used to create a 100-m radius buffer around each detector station and the percent of wooded habitat within that area was determined. Bat activity was then compared to the percentage of wooded habitat using correlation analysis. The mean AI values ranged from 7 to 78 and were positively correlated with percent wooded habitat (Pearson's $r = 0.889$, $p < 0.001$). A grid was overlaid onto the proposed wind project area and the percent wooded habitat within each grid cell was calculated with the GIS. A linear regression function ($Y = 8.45 + 0.798*X$, $r^2 = 0.791$) was used to populate grid cells with values for predicted bat AI where X is the percent wooded habitat and Y is the predicted AI. Proposed wind turbine locations were then overlaid onto the predictive bat activity map. This map is currently being used to identify proposed turbine locations that occur in areas where high bat activity is likely.

Variation in Fur Stable Hydrogen Isotope Values within Summer Populations of Little Brown Bats *Myotis lucifugus* and Eastern Red Bats *Lasiurus borealis*

Erin E. Fraser, M. Brock Fenton, and F. J. Longstaffe; University of Western Ontario, London, ON, Canada

Most North American bat species undergo an annual fall migration, either to swarming sites and hibernacula or to more southern wintering sites, but little is known about their migratory routes. Stable hydrogen isotope analysis provides a useful tool for learning about migrant origin but has been used infrequently in bats. In order to evaluate the potential use of stable hydrogen isotope analysis for migrant origin assignment, it is necessary to quantify the variation in tissue stable hydrogen isotope values, both among and within individuals, at a single location. Similar studies on birds have indicated that this variation may be quite high. We present fur stable hydrogen isotope values taken from residential little brown bats (*Myotis lucifugus*) and eastern red bats (*Lasiurus borealis*) in Pinery Provincial Park, Ontario, from June to September 2007. We quantify variation over time, between species, among age and sex groupings, and between dorsal and ventral samples from the same bat. We compare these values to those of potential drinking water sources and local precipitation.

Flower-visiting Behavior of Pallid Bats *Antrozous pallidus* in Northwestern Mexico

Winifred F. Frick, Paul A. Heady III, and John P. Hayes; University of California, Santa Cruz, CA; Central Coast Bat Research Group, Aptos, CA; University of Florida, Gainesville, FL

Bats are key pollinators of many plant species in tropical and subtropical regions and play an important role in maintaining biodiversity in many ecosystems. In the western hemisphere, evolution of bat nectarivory is considered restricted to a single family, the Phyllostomidae. We investigated flower-visiting behavior of an insectivorous gleaning bat (*Antrozous pallidus*, Vespertilionidae) in bat-adapted flowers of the cardon (*Pachycereus pringlei,* Cactaceae), an abundant columnar cactus in northwestern Mexico that is typically pollinated by lesser long-nosed bats (*Leptonycteris curasoae,* Phyllostomidae). In 2007 and 2008, we recorded flower-visiting behavior of bats using infrared videography on 144 cactus nights across 14 sites in Baja California, Mexico, including one island. Our data demonstrate that pallid bats are common visitors to cardon flowers across the Baja peninsula. We recorded a total 1,198 flower visits by pallid bats at 13 out of 14 locations, which constituted 11% of all recorded bat visits. Pallid bats were the only nocturnal pollinators of cardon flowers in some locations. Pallid bats covered in cactus pollen were commonly captured at study locations in Baja California and observations of pallid bats covered in pollen or fruit smears have been reported elsewhere, but were thought to result from gleaning moths at cactus flowers or fruit. Pallid bats lack obvious morphological specialization for nectar feeding, but we documented pallid bats consuming nectar by plunging their torsos into a flower corolla and lapping nectar. We observed a few rare cases of pallid bats trapping sphinx moths (Sphingidae) inside flowers during predatory attacks, although the vast majority of flower visits were consistent with nectar-feeding behavior (98%). Gleaning from flowers may have served as an evolutionary precursor to nectarivory prior to the evolution of specialized nectar-feeding morphology. Pallid bats exhibit behavioral plasticity in diet that has only been recorded in one other microchiropteran outside the family Phyllostomidae—*Mystacina tuberculata* from New Zealand. Opportunistic foraging behavior in pallid bats provides insights about the origin of novel diet strategies in bats.

Surviving Cave Bats: Auditory and Behavioral Defenses in the Australian Noctuid Moth, *Speiredonia spectans*

James H. Fullard, Matt E. Jackson, David S. Jacobs, Chris R. Pavey, and Chris J. Burwell; University of Toronto, Mississauga, ON, Canada; University of Cape Town, South Africa; Department of Natural Resources, Environment, and the Arts, Australia; Queensland Museum, South Brisbane, Australia

The Australian noctuid moth, *Speiredonia spectans* shares its subterranean day roosts (caves and abandoned mines) with insectivorous bats, some of which prey upon it. The capacity of this moth to survive is assumed to arise from its ability to listen for the bats' echolocation calls and take evasive action but the auditory characteristics of this or any tropically distributed Australian moth have never been examined. We investigated the ears of *S. spectans* and determined that they are amongst the most sensitive ever described for a noctuid moth. Using playbacks of cave-recorded bats we determined that *S. spectans* is able to detect most of the calls of two co-habiting bats, *Rhinolophus megaphyllus* and *Miniopterus australis*, whose echolocation calls are dominated by frequencies from 60–79 kHz. Video-recorded observations of this site roost show that *S. spectans* adjusts its flight activity to avoid bats but that this defense may delay the normal emergence of the moths and leave some "pinned down" in the roosts for the entire night. At a different day roost, we observed one moth's auditory responses to the exceptionally high echolocation frequencies (150–160 kHz) of the bat, *Hipposideros ater*, and determined that *S. spectans* is unable to detect most of its calls. We suggest that this auditory constraint, in addition to the greater flight maneuverability of *H. ater*, renders *S. spectans* vulnerable to predation by this bat to the point of excluding the moth from day roosts where the bat occurs.

The Social Structure of Bat Researchers: It's a Small World after All

Colin J. Garroway; Trent University, Peterborough, ON, Canada

Recently, there has been an increased interest in quantitatively describing bat social systems because how animals interact has important implications for understanding resource exploitation, information spread, and indeed many other fundamental behavioral and evolutionary questions. What's true for bats should be true for bat researchers. Here I construct a social network of bat researchers based upon collaborations on peer-reviewed publications containing the terms 'bat,'

'bats,' or 'Chiroptera' as indexed by the ISI Web of Science beginning in 2003 through to the most recent update in 2008. A social network is a collection of individuals, each of whom associates with a particular subset of individuals. Analogous to bats roosting together in a tree, researchers were linked if they co-authored a paper together and the strength of association between linked pairs of individuals was weighted by the number of papers upon which pairs were co-authors. Network analysis is a powerful tool for quantifying social systems but it has not yet, to my knowledge, been applied to bat or bat researcher societies. As most would guess the collaboration network of bat researchers is quantitatively consistent with the 'small-world' class of networks. Here I will present the statistical properties of this network. Of particular interest might be the mean degree of separation between pairs of researchers, the most collaborative researchers, and the delineation of social groups as defined by network modularity. Further I will model the temporal nature of collaborations and the extent to which collaboration patterns differ from random. I should note that this is in no way a measure of the quality of research or researchers, as I do not incorporate any of the indices that putatively measure researcher impact. Rather I thought it would be fun and perhaps useful and informative to us (bat researchers) because it is about us and because the methods are directly applicable to our research subjects.

Emergence Patterns and Social Structure of Big Brown Bats, *Eptesicus fuscus*

Erin H. Gillam, R. Mark Brigham, and Thomas J. O'Shea; University of Regina, Regina, SK, Canada; U.S. Geological Survey, Fort Collins, CO

Although the vast majority of bat species are colonial, relatively little is known about the short- or long-term social interactions that occur among individuals sharing a roost. Given that bats generally roost in locations where conventional methods of observation are not possible, it is often necessary to employ alternative means of assessing social behavior. The objective of our study was to determine if bats emerge from the roost in a predictable order. This is a method of studying social structure that has not been rigorously explored. Specifically, we compared the nightly orders of emergence by big brown bats, *Eptesicus fuscus*, who carried passive integrated transponders (PIT tags) at eight building roosts in Fort Collins, CO. Records were extracted for a subset of bats and nights from the evening exodus, and Kendall's test of concordance was used to determine if ranked orders of emergence were consistent across nights within a year. We found significant similarities in rank order between nights at all eight roosts, indicating concordant patterns of emergence. There were no significant correlations between average rank and individual bat characteristics, such as age or body size. In four of eight roosts, dates that were very close in time exhibited the greatest concordance of emergence orders, consistent with the possibility of a fission-fusion social structure, which has been reported for tree-roosting *E. fuscus*.

Bats, Bugs, and *Bt*

Thomas Hallam, Kimberly Kennard, Paula Federico, and Gary McCracken; University of Tennessee, Knoxville, TN; University of Georgia, Athens, GA; Ohio State University, Columbus, OH

In the agricultural areas of south central Texas, there are gigantic colonies of Brazilian free-tailed bats (*Tadarida brasiliensis*), copious amounts of agricultural pest insects, and a large plurality of genetically modified (*Bt*) crops. We present 1) a structured systems model of the

agricultural food web and 2) indicate results of related field experiments. The modeling results suggest that should the bats not be present, the number of insects emigrating from *Bt* cotton is decreased considerably over the numbers of insects emigrating from non-transgenic cotton and for *Bt* cotton; predation on moths by the bat population can reduce the number of sprays required from four to two. Results from the field experiments indicate that bats that forage over *Bt* fields may consume *Bt*-resistant insects and, in general, bats show a remarkable ability to track patchy and ephemeral food sources. We conclude that bats increase foraging when insects emerge and that *Bt* only affects bat activity when it has a measurable effect on moth activity.

When Conservation Conflicts with Recreation

Aimee N. Haskew and J. Edward Gates; University of Maryland Center for Environmental Science, Frostburg, MD

Indigo Tunnel, an abandoned railroad tunnel located within the C & O Canal National Historical Park in western Maryland, houses the largest known suspected hibernating colony of eastern small-footed myotis (*Myotis leibii*) in the state. Fall swarming and spring emergence surveys conducted 2006–2008 have consistently captured this species. Mark-recapture estimates calculated in 2007 estimated the population to be around 137 individuals. With the emergence of White Nose Syndrome, Indigo Tunnel may be one of the largest remaining hibernacula for this species. Indigo Tunnel is being considered for Phase IV in the development of the Western Maryland Rail Trail, a recreational hike and bike trail. Modifications to the tunnel from construction and resulting use of the recreational trail could result in the loss of this sizeable colony. Considerable political pressure exists at the local, state, and federal level to go forward with construction of the tunnel.

Olfaction in Bats: The Genomic Consequence of Environmental Niche Specialization

Sara Hayden, Micheal Beakert, and Emma C.Teeling; University College Dublin, Belfield, Dublin, Ireland

Olfactory receptor (OR) genes comprise nearly 1% of the mammalian genome and make up the largest gene family. 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. To investigate the genomic consequence of environmental niche specialization through the acquisition of laryngeal echolocation, a sample of the full repertoire of OR genes were amplified by PCR, cloned, and sequenced in echolocating microbats and non-echolocating megabats. The percentage of functioning and non-functioning OR genes were assessed to elucidate whether a molecular ‘trade-off’ between olfaction and echolocation is apparent in bats. 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. Both echolocating and non-echolocating bats show a difference in the percentage of non-functioning olfactory receptors and distribution of OR genes into OR gene families.

Potential Affects of Climate Change on Bat Populations in the Southern Rocky Mountains: Preliminary Population Modeling

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

The Southern Rocky Mountains may be experiencing some of the most rapid climate changes in North America, resulting in environmental modification with potentially significant influences on animal populations of conservation concern. Bats represent a significant contribution to mammalian species diversity in the Southern Rocky Mountains and globally. However, the precise affects of climate changes on bat population dynamics are unknown. In a related talk at this symposium, Adams shows that the proportion of reproductively active female bats in his study area over 12 years was significantly correlated with annual precipitation, mean summer temperatures, and stream flows. Here, we scale these results of reproductive rate with projected increasing temperatures and incorporate these reproductive rates into a preliminary age-structured stochastic population dynamics model. In this climate change model, bat populations declined to extinction regularly within two centuries. These preliminary results demonstrate how bat populations may respond to increasing temperatures and reduced precipitation associated with climate change in the Southern Rocky Mountains. We anticipate this model framework to be a starting point for more sophisticated species-specific mathematical approaches to modeling the regional affects of climate change on bats and other mammalian populations. Furthermore, quantifying species-specific causative factors influencing reproductive rates in bat species of conservation concern would be relevant for developments in modeling how bat populations in different parts of the world are likely to respond to regional climate changes.

White Nose Syndrome: The History and Current Status of an Unprecedented Threat to Hibernating Bats in North America

Alan C. Hicks, Carl J. Herzog, Ryan Vonlinden, Scott R. Darling, Susanna L. von Oettingen, Robyn A. Niver, and Jeremy T. H. Coleman; New York State Department of Environmental Conservation, Albany, NY; Vermont Fish and Wildlife Department, Rutland, VT; U.S. Fish and Wildlife Service, Concord, NH; U.S. Fish and Wildlife Service, Cortland, NY

White Nose Syndrome (WNS) is an unidentified agent that is killing bats in unprecedented numbers in the northeastern United States. If current trends continue, it will surely eliminate most hibernating bats in a major portion of eastern North America, and may threaten the very existence of some species. The most obvious symptom of WNS is a white fungal growth surrounding the nose of some, but clearly not all affected bats. There are also behavioral changes. Bats appear to be dying because of depleted fat reserves as early as late January. Based on currently available information, WNS was first observed in Howe Cave, Schoharie County, NY on 2/16/06. By April of 2007 it was confirmed in four additional hibernacula within a 15-km radius centered in western Albany County, NY. By the end of April 2008, it had spread to include all 28 hibernacula checked within 130 km of the epicenter, and 5 of 19 sites checked between 130 and 200 km. It is now confirmed in the states of NY, VT, MA, and CT. Winter survey counts of all bat species at six hibernacula showed declines ranging from 81% (Knox Cave, NY) to 97% (Schoharie Caverns, NY) over two years. Both sites where winter surveys have been conducted in each of the two years (Schoharie Caverns and Hailes Cave, NY) suffered first-year losses of more than 50%, and higher percentage losses the second year. WNS has been found in all six hibernating species in the Northeast. *Myotis lucifugus* appears to be the most severely affected, while *Eptesicus fuscus* and *Myotis leibii* appear to be the least affected. Variable mortality rates among hibernacula for *Myotis sodalis* appear linked to humidity. The driest sites (Barton Hill Mine, NY and Williams Hotel Mine, NY) showed no indication of loss over one year. By contrast, among the sites with highest humidity, Hailes Cave lost all 685 and the Williams Preserve Mine, NY lost all but 124 of 13,014 *M. sodalis*.

An Active Infrared Detection and Data Logging System for Automated Counts of Bats at Roosts

Matthew G. Hohmann, Chris Hansen, and Michael G. Just; U.S. Army ERDC-CERL, Champaign, IL; Hansen Hobbies, Champaign, IL; University of Illinois at Urbana-Champaign, IL

Despite the importance of accurate counts and estimates of abundance for informing bat conservation and management, the availability of these data is limited by current techniques. This is particularly true for species that form small, ephemeral colonies under the bark and in crevices of dead or dying trees. We designed, developed and field tested an active, infrared detection and data logging system to automate counts of bats using “rocket-box”-style bat boxes. In its current embodiment, the system records the date and time of bat entrances and exits to/from the boxes using an array of paired, infrared sensors mounted at the entrance of the roost. This “sensor block” is connected via an ethernet cable to a weatherproof ground station. This allows data to be downloaded to a computer without direct contact with the roost or disturbance of the bats. Other design specifications included low power drain, low cost, large data storage capacity, easily modifiable configuration, and field durability. Among other advantages over human observers, the system provides the ability to: 1) develop detailed longitudinal records of roost use and colony size; 2) simultaneously monitor multiple roosts; and 3) easily record observations continuously throughout the night. The system also allows unmarked individuals to be counted, which are otherwise difficult to quantify in PIT tag-based, mark and re-sight studies. This economical and easy-to-use system may be of interest to state or federal agencies with public land management responsibilities and a mission or mandate to characterize or monitor bat populations. Researchers will also likely find the system helpful for population and behavioral studies. State departments of wildlife, municipalities, and nongovernmental organizations might use the system to significantly enhance their bat box conservation and education programs. The system could also fuel interest in bats among the public, as it provides an additional dimension to the growing interest in providing roosting habitat for bats and mitigating impacts to displaced colonies. Design information, example data, and an on-site demonstration will be featured.

Bat Migration Activity at an Important Stopover Site for Migratory Birds

Laura A. Hooton and M. Brock Fenton; University of Western Ontario, London, ON

Several North American bat species make seasonal migrations; however, little is known about timing and stopover behavior during these migrations. Long Point, Ontario is an important stopover site for migratory birds, and research has shown that bats appear to be migrating through Long Point as well. We hypothesized that Long Point is a critical area for migratory 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. 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. Activity was highest during the spring and fall migrations, and activity was higher on Long Point than in the surrounding area. Our research indicates that during migration bats stopover at Long Point and not in the surrounding area, supporting the hypothesis that Long Point is an important stopover area for bats. Future studies of other known migratory bird stopover sites may identify additional bat migration stopover areas.

Mechanisms of Self-organization in Flying Brazilian Free-tailed Bats *Tadarida brasiliensis*

Nickolay I. Hristov, Louise C. Allen, Erin G. Gillam, Margrit Betke, Zheng Wu, and Thomas H. Kunz; Boston University, Boston, MA; University of Regina, Regina, SK

The collective behavior of large groups of animals is an impressive phenomenon that has attracted considerable interest in recent years. Studies of self-organization in insects, fish, birds, and terrestrial mammals have shown that relatively simple rules from the perspective of the individual result in complex patterns of behavior at the level of the group. Remarkably, there has been little similar research to study the group behavior of colonial bats. Nevertheless colonial bats represent an excellent model for the study of self-organization in animal groups. Bats belong to some of the largest aggregations of mammals known to mankind, and unlike other colonial organisms, self-organization in flying echolocating bats appears to be largely based on acoustic cues. We present data from the study of collective behavior in flying Brazilian free-tailed bats (*Tadarida brasiliensis*) using advanced thermal imaging and computer vision analysis. Automatic detection and tracking algorithms were used to quantify the underlying structure and patterns of movement in dense columns of emerging bats. We demonstrate some of the mechanisms that might be responsible for the formation and maintenance of group cohesion both from the perspective of the individual as well as the group.

The Aerodynamic Flight Pattern of Bats

Tatjana Y. Hubel, Sharon Swartz, and Kenneth Breuer; Brown University, Providence, RI

The goal of the study is to investigate the aerodynamics and wing motion of *Cynopterus brachyotis* to ultimately gain a better understanding of the influence of certain flight parameters, such as flapping frequency, amplitude, wing camber, and angle of attack on the aerodynamic performance. A body moving through fluid leaves a characteristic vortex pattern behind. This pattern contains information about the forces acting on the body itself and provides a possibility to observe the force generation of the body using optical non-invasive measurement methods. Our bats were trained to fly in a wind tunnel at speeds between 3 m/s and 7 m/s, and we used time-resolved Particle Image Velocimetry (200 Hz) for the flow visualization. We observed the wake structure perpendicular to the flow stream obtaining the change in circulation (lift) over the wingbeat cycle. Simultaneously, we recorded the wing motion creating the wake structure with four high-speed cameras (200 Hz) and reconstructed the motion by transferring markers painted on the wing membrane, joints, and body of the bats in a 3D coordinate system. The wake at a medium speed of 3.4 m/s shows a pattern similar to one previously identified in the flight of small birds called "ring vortex gait," which contains closed vortex loops separated by an aerodynamic passive phase during the upstroke when no lift is generated. The ongoing work will show 1) how the wake structure and kinematics change over a range of different wind speeds and 2) if there are individual preferences within the species in the flight parameters they choose to increase the flight speed.

Taxonomic and Conservation Genetic Status of *Perimyotis subflavus* in Nova Scotia

Howard M. Huynh, Joseph A. Poissant, Hugh G. Broders, and Donald T. Stewart; Acadia University, Wolfville, NS; Saint Mary's University, Halifax, NS

The eastern pipistrelle, *Perimyotis subflavus*, is at or near the northern extent of their geographic range in Atlantic Canada, with the only known summering population residing in southwest Nova Scotia in Kejimkujik National Park (KNP) and Historic Site. Little is known about *P. subflavus* in this part of their range, and the prospects of this population being geographically disjunct in Nova Scotia may make the species nationally significant. Observed morphological and behavioral traits that appear to be unique in this population highlight a need to characterize the level of population differentiation between *P. subflavus* found in Nova Scotia and the rest of eastern North America. In order to better characterize inter-population variation, vouchered specimens of *P. subflavus* from across their geographic range were examined and measured in several museum collections in northeastern North America; comparative morphometric analysis of craniodental and external body measurements is pending. Tissue samples in the form of blood and wing punches were collected from field-captured individuals in KNP during the summers of 2007 and 2008; samples from other localities were also solicited from specimens housed at several museums. Efforts are underway to characterize the inter-population genetic differences via examination of mitochondrial and nuclear markers. This research emphasizes the importance of determining the taxonomic and conservation genetic status of peripherally isolated populations.

Seasonal Variation of Immune Function in Vespertilionid Bats

Roymon Jacob, John B. Kobilis, and DeeAnn M. Reeder; Bucknell University, Lewisburg, PA

Maintaining a robust defense system is an energetically costly endeavor, and the relative benefits versus costs of this protection vary with life history state and seasonal shifts in resource availability and disease risk. There is a relative paucity of data on how bat immune systems function and how immune competence may vary over the annual season. In this study, we explored the immune competence of vespertilionid bats during different stages of an annual cycle. During winter, big brown bats (*Eptesicus fuscus*) were either housed at ~ 24° C in a flight cage or artificially hibernated at 4° C or 8° C. Preliminary data suggest that overwintering bats maintained at euthermic temperatures have more robust immune responses than bats that are torpid. For example, over a period of three months, no wound healing was observed in bats hibernated at either 4° C or 8° C, while wounds created by 3-mm biopsy punches healed within several weeks in euthermic bats. Bats housed at 8° C aroused more frequently, achieved higher body temperatures during arousal bouts, and spent more time over the study period at euthermic temperatures than bats housed at 4° C. Additionally, preliminary data show that bats housed at 8° C had greater bactericidal activity (a measurement of constitutive innate immunity) than bats housed at 4° C, suggesting greater immune competence in these bats. In summer, both innate and adaptive immune systems of little brown bats (*Myotis lucifugus*) were explored. The natural antibody agglutination assay showed that bats have moderate complement activity but low levels of natural antibodies. Using the splenic T-cell proliferation assay, we found that bat splenocytes were non-responsive to standard stimulates such as Con A, LPS, and anti-bat IgG, but were stimulated by more potent mitogens including PHA, PMA, and A23187. Our results support the notion of a hyporesponsive immune system in bats during summer and immune-suppression during hibernation, with of a role for arousals in regulating immunity. These findings will help us better understand the tradeoffs between immune function and energy expenditure, which will shed light on the susceptibility of bats to emerging diseases such as White Nose Syndrome.

Can Ground-based Weather Data or Insect Abundance Predict Bat Mortality at Wind Energy Facilities?

Joel W. Jameson and Craig K. R. Willis; University of Winnipeg, Winnipeg, MB, Canada

Despite the benefits of wind power, a number of studies have now reported bat mortality at industrial scale wind plants across North America and migratory tree bats account for most fatalities. Nights with low wind speed before or after passing weather fronts appear to be correlated with high mortality in eastern North America but few data on this relationship have been published. Furthermore, little is known about the relationship between flying insect abundance and mortality. We tested the value of ground-based weather data, and data on relative insect abundance, as predictors of bat mortality at a wind plant in southern Manitoba, Canada. We conducted standardized carcass searches on twenty mornings between 16 August 2007 and 11 September 2007 and corrected for searcher efficiency and scavenging. On the night prior to each mortality survey, we took point measurements of ground-based air temperature and wind speed at a site within 1 km of the wind plant using a handheld anemometer/thermometer. At the same site we also quantified insect abundance using spotlight sampling. There was a negative trend relating ground-based wind speed and mortality rate but the correlation was not significant ($p = 0.133$, Pearson $r = 0.70$). However, we did find a significant positive effect of relative insect abundance on mortality ($p = 0.005$). Our data suggest that ground-based, point sampling of weather variables may be inadequate for predicting mortality risk but that measurement of insect abundance may provide an alternative or additional tool for identifying nights when the risk of mortality is high. Wind speed, air temperature, and barometric pressure data recorded at turbine height, for this and other sites, are needed to provide the best test of the hypothesis that weather variables can be used to predict mortality risk.

Summer Energetics of *Myotis lucifugus* in Areas Affected and Unaffected with White Nose Syndrome

Amanda Janicki and Tom Tomasi; Missouri State University, Springfield, MO

White Nose Syndrome (WNS) is a large-scale epidemic that is killing cave-dwelling bats in the northeast while they are hibernating. Since its discovery in four caves near Albany, NY, it has spread at least 250 km to at least three neighboring states. Affected caves are experiencing greater than 90% mortality in one year. With such a rapid spread and a high mortality rate, it is important to determine the cause of this epidemic. WNS is causing bats to deplete all of their fat reserves before hibernation is over, and this could be the result of higher metabolic rates in affected bats. We predict that affected bats will also have a higher metabolic rate prior to hibernation. The metabolic rates of little brown bats (*Myotis lucifugus*) were studied in multiple sites in New York, Pennsylvania, and Missouri during July and August 2008. While the bats where kept in a metabolic chamber, oxygen consumption rates during daily torpor and body temperatures were measured using an oxygen analyzer and iBBats, respectively. As expected, metabolic rates increased with ambient temperature and body temperature, and decreased with relative depth of torpor. After accounting for the effect of ambient temperature, there was no

difference in metabolic rates between sites. However, when data were removed for bats with relatively shallow torpor, Missouri bats showed higher metabolic rates than New York and Pennsylvania bats. There was no difference between sites in relative depth of torpor. Contrary to our prediction, bats in New York that are affected by WNS did not show higher metabolic rates during the summer when compared to possibly unaffected bats in Pennsylvania and unaffected bats in Missouri.

Day Roosts of Male and Female Eastern Small-footed Myotis *Myotis leibii* in the Mid-Atlantic Ridge and Valley Region of West Virginia

Joseph S. Johnson, James D. Kiser, Kristen Watrous, and Trevor S. Peterson; Stantec Consulting, Topsham, ME

The Eastern Small-footed Myotis (*Myotis leibii*) is considered rare throughout its range and is listed as an endangered or threatened species in many states. Because of its rarity and small size, few data or peer-reviewed studies of the species' roosting behaviors are currently available. We radio-tracked five male and five lactating female eastern small-footed myotis during June and early July 2008 to provide more data on day-roosting habitat and roost-switching behaviors, and to examine potential differences in these activities between sexes. Radio-tagged bats were tracked for an average of 6.5 days (range = 4–9), resulting in the location of 32 male and 25 female day roosts. Two types of day roosts were located: ground-level rock roosts (n = 53) and roosts located in vertical cliff-faces (n = 4). Males switched roosts an average of every 1.1 ± 0.04 (se) days (range = 1–2), traveled an average of 41.2 ± 7.8 m between consecutive roosts (range = 1.0–140.0), and roosted an average of 414.7 ± 49.0 m (range = 90.4–881.7) from their capture location. Females switched roosts every 1.1 ± 0.06 days (range = 1–2), traveled an average of 66.5 ± 14.6 m between consecutive roosts (range = 5.1–203.8), and roosted an average of 368.1 ± 24.0 m from their capture sites (range = 98.9–525.3) even when partially solar exposed rocky habitats were present. Males roosted solitarily, and females roosted alone or in groups of up to eight individuals. Ground-level rock roosts were limited to talus slopes or transmission-line corridors with low average canopy cover ($\bar{x}$ = 16.7 ± 1.8%), but located close to patches of vegetation ($\bar{x}$ = 4.2 ± 0.4 m). Roost habitat data will be further analyzed and compared between sexes. These data highlight the importance of both solar exposure and predator avoidance in the selection of day roosts by small-footed myotis. Data also show that small-footed myotis switch roosts more frequently and travel shorter distances than has been observed among other North American *Myotis* species.

Retrofitting Anthropogenic Walls, Underground Structures, Silos, and other Concrete Structures for the Conservation of Bats

Dave S. Johnston; H. T. Harvey & Associates; San Jose State University, San Jose, CA

One of the primary limiting resources for bats is roosting habitat. As human populations grow, natural habitat for bats decreases and man-made structures become increasingly important as roosting habitat. As a municipality ages, older structures often become potential bat roosting habitat when the human population abandons them. However, most of these abandoned structures become a public nuisance and liability for the landowner. The result is that the structures are usually either demolished, or bats are excluded during the restoration process. In a few situations, historic or relic structures are unsuitable for human occupation but good

candidates as bat roosting habitat. When a central California rocket development campus of 259 hectares (approximately 1 square mile) was decommissioned, 30-meter-tall concrete walls, concrete buildings, and a 5-story underground facility were retrofitted for various potential crevice and cavernous roosting habitats for bats. To predict the ideal placement of bat boxes, modeling was attempted using complex equations, but ultimately, experimental designs were used to predict optimal temperatures inside eight different situations for various crevices and bat box designs. For multiple baffle bat boxes, temperatures inside the space closest to the wall were warmest at night, but coolest during the day, and were not expected to reach optimal maternity colony roosting temperatures until ambient daytime temperatures exceeded 38º C. However, temperatures inside the second and third spaces reached optimal temperatures during the day and retained enough heat to maintain warmer than ambient air temperatures at night. A maternity colony of *Myotis californicus* occupied one retrofitted building during the summers of 2007 and 2008, and *Antrozous pallidus*, *Corynorhinus townsendii*, *Tadarida brasiliensis*, and *Myotis yumanensis* also occur in buildings but not as maternity colonies. Additionally, an abandoned concrete silo on the Don Edwards San Francisco Bay National Wildlife Refuge was converted into potential bat roosting habitat complete with a heat pump, solar panels to run the heat pump, and data-loggers to monitor the temperatures at the various bat boxes spiraling down inside the silo and in additional spaces on the outside of the silo. As natural roosting habitat is degraded or lost in metropolitan areas, we must continue to take advantage of opportunities to convert abandoned or relic structures into potential roosting habitat.

Current and Projected Risk of Land-use and -cover Change Near Indiana Bat (*Myotis sodalis*) Hibernacula

Michael G. Just and Matthew G. Hohmann; University of Illinois, Urbana, IL; U.S. Army ERDC-CERL, Champaign, IL

An estimated 95% of all federally endangered Indiana bats (*Myotis sodalis*) hibernate in 71 priority 1 (> 10,000 bats) and 2 (> 1,000 bats) hibernacula in ten states. Given the species' high site fidelity, seasonally heightened densities, and apparent limited availability of suitable sites, land-use and -cover change (LUCC) near hibernacula is expected to affect wintering populations. The landscapes surrounding hibernacula not only provide critical roosting and foraging habitat during fall swarming and spring staging, they also support the highly specific microclimates Indiana bats need for successful hibernation. Unfortunately, landscapes surrounding the majority of hibernacula are not afforded any land-use protections. Consequently, it is important that LUCC near hibernacula is evaluated to assess and prevent impacts to wintering populations. We characterized recent landscape composition and configuration using landscape pattern indices (LPI). We modeled potential future LUCC through 2016 using two empirically derived, stochastic projection models. Characterization and modeling were performed at two extents, chosen for their relevance to the species' biology. For the larger extent, we found that the percent of the landscape composed of forest changed from a range of 7.38–98.99% with a mean of 74.55% (± 4.94%; 95% CI) in 1992, to 4.91–95.14% with a mean of 65.72% (± 4.75%) in 2001, and a projected range of 3.33–78.09% with a mean of 49.67% (± 3.92%) in 2016. This represents a 24.88% decrease in the mean percent forest surrounding hibernacula over the 24-year projection. This rate of forest cover loss is likely to be unsustainable with regard to the species' biology. The mean percent of urban land observed in the 71 landscapes varied from 2.37% (± 1.07%; 95% CI) in 1992 to 7.45% (± 1.46%) in 2001, and was projected to increase to 17.00%

(± 1.85%) by 2016. We found a general decline in the perimeter-area fractal dimension LPI indicating a less complex landscape. Changes in the mean nearest neighbor suggest that forest patches have become generally more isolated and are projected to become increasingly isolated. This loss of edge habitat and patch connectivity has the potential to impact bat habitat use near hibernacula. Results of this study address several priority research needs identified in the USFWS Revised Indiana Bat Recovery Plan.

A Meta-analysis Examining Roost Fidelity with Roost Type in Microchiroptera

R. Julia Kilgour; University of Regina, Regina, SK

Roost fidelity in bats is well known from species around the globe but there is diversity in the degree of fidelity exhibited to different roost types. Lewis (1995) qualitatively assessed fidelity by bats and reported two general trends: an increase in fidelity associated with increased roost permanence, and a decrease in fidelity with increased roost abundance. Meta-analysis provides the opportunity to quantitatively compare the conclusions of many studies while controlling for differences in sample sizes. I quantitatively assessed roost fidelity for five different roost types: foliage, exfoliating bark, tree cavities, rock crevices, and buildings. I examined 38 studies that employed radiotelemetry to assess roost fidelity of reproductive females of 22 different species of Microchiroptera published since 1995. The degree of fidelity was categorized into low (less than 2 days per roost), medium (2 to 5 days per roost), and high (greater than 5 days per roost). I found no significant association between degree of fidelity and roost type. There was a slight trend for increased roost fidelity with increased roost permanence, as no bats found roosting in foliage and exfoliating bark exhibited high degrees of fidelity, while bats that roosted in buildings exhibited only high degrees of fidelity. There was no trend in fidelity with respect to roost abundance, although this was not consistently reported in all studies. My analysis demonstrates a clear need for increased research, especially experimental manipulations, to determine the underlying factors influencing roost fidelity in bats.

Behavior and Summer Roost Selection by Female Indiana Bats *Myotis sodalis* in New Jersey

Marilyn E. Kitchell and Lance S. Risley; USFWS Great Swamp National Wildlife Refuge, Basking Ridge, NJ; William Paterson University, Wayne, NJ

Much effort has been expended studying the roosting ecology of the federally endangered Indiana Bat *(Myotis sodalis)* during the maternity season; yet there is a paucity of studies on roosting behavior in the Northeast, where populations have increased significantly over the last 40 years. The primary goals of this study were 1) to identify and characterize roosts selected by reproductively active females in and around Great Swamp National Wildlife Refuge; 2) to observe behavior such as colony size, roost fidelity, home range size, and foraging activity; and 3) to compare results to studies conducted elsewhere in the species' range. Transmitters were placed on adult females, and bats were tracked daily to identify roosts and foraging areas. The characteristics of roost trees and their surrounding habitat (0.1 ha) were measured, and emergence counts were conducted during 2007 at all trees containing bats with transmitters. Using all known locations (capture site, roosts, and estimated foraging points), home range estimates were produced using minimum convex polygons (MCP) and fixed kernel density estimates (KDE). Twenty-four females were tracked to seventy-four roosts representing three colonies between 2006–2007; only two roosts were re-used by different bats during the course of the study. Peak emergence counts at 4 primary trees were 252, 164, 52, and 55 bats. Selected roosts were largely similar to those documented elsewhere; however, several variables differed significantly between years, including dbh, height, and canopy closure. Roost switching occurred on average once every 1.8 (± 0.27 se) days, and mean distance moved between consecutive roosts was 1,003.4 (± 299.98) m. Mean home range size was 236.6 (± 136.45) ha for MCP estimates and 325.0 (± 33.10) ha for 50% KDE estimates. The variation in roost characteristics observed between years emphasizes that Indiana bats may be flexible in their roost requirements even within a study site. Furthermore, the number of colonies found, the number of roosts identified, and the average distance moved between roosts suggest that Great Swamp NWR may represent ideal maternity habitat for Indiana bats. Lastly, the large home ranges identified suggest that bats may range widely across the habitats available to them, even if roosting and foraging habitat is not limiting.

The Risk of Rabies Transmission from Bat Carcasses to Mammalian Scavengers at Wind Energy Facilities in Alberta

Brandon J. Klug and R. M. R. Barclay; University of Calgary, Calgary, AB

Hundreds to thousands of migratory-bat fatalities have been reported at some wind energy facilities in North America. Research has focused primarily on the causes and patterns of fatalities. Our research investigates the impact of bat fatalities on the ecology of the surrounding mixed-use environment at a wind energy facility in southern Alberta. An influx of bat carcasses may be used as a source of food. To determine what species are scavenging carcasses and at what rate, we set bait stations at the base of the turbines, equipped with motion-sensitive cameras and baited with a hoary bat (*Lasiurus cinereus*) or silver-haired bat (*Lasionycteris noctivagans*) carcass. Bait stations were also placed in control fields containing no turbines. Carcasses were checked daily, and if present the condition, mass, and temperature were recorded, and the presence and quantity of any insect scavengers noted. Internal temperature was recorded hourly on an additional set of carcasses, one hoary bat and one silver-haired bat. Scavengers ingesting bat carcasses may be at risk of contracting rabies, as previous studies have shown the virus to be transferred by ingestion of infected tissue. The risk is dependent on the rate of scavenging and environmental variables such as temperature and exposure to direct sunlight, as rabies virus is rapidly denatured in heat, UV light, and with decomposition of the host. Given that the facility is located in a mixed agriculture and prairie environment, the risk may be extended to domestic animals, such as cats, dogs, and cows. We will present preliminary data from our research.

Arousal Patterns During Hibernation in Captive Little Brown Bats *Myotis lucifugus*

John B. Kobilis, Kaitlyn J. Piatt, and DeeAnn M. Reeder; Bucknell University, Lewisburg, PA

Along with many other small, temperate mammals, insectivorous bats undergo seasonal variations in their metabolic activity and ecological behavior. Little brown bats (*Myotis lucifugus*) found in the colder northern regions of the U.S. are limited to a relatively short feeding period lasting only a few summer months. One mechanism for dealing with this environmental constraint is hibernation, which consists of bouts of prolonged torpor interrupted by the occasional arousal to euthermic temperatures. These arousals seem paradoxical, as each arousal bout requires the utilization of stored fat, and high numbers of winter arousals may compromise overwinter survival. The aim of this study was to examine arousal patterns in little brown bats under tightly controlled captive conditions (an environmental chamber maintained at 4° C and 95% humidity). We were interested in numbers of arousals, time between arousal bouts, and in whether arousals were timed to correspond with dusk. Thirty female little brown bats were captured from two different caves, fitted with iBBat data-loggers set to record body temperature every 30 minutes, and monitored for a total of 39 days. We found that bats aroused at all times of day, with significantly more arousals between 1200 h and 1600 h and less than expected between 0400 h and 1200h. Additionally, bats aroused in clusters, suggesting strong social influences on arousal timing but only weak circadian influences. The average number of arousals was 4.5 times (~ every 11 days) during the 39-day test period; however. there was significant variation, with some bats arousing as many as nine times and some as little as once. Interestingly, the provenance of the bats significantly affected their arousal patterns. Half of the bats were captured a few weeks before the study began from a site that was typically relatively undisturbed. These bats were housed at 4° C prior to the beginning of the 39-day test period and they aroused less frequently (on average 3.7 times during the 39 days) than those captured just before the study from a site with disturbance on a regular basis (aroused on average 5.2 times during the 39 days). Whether this difference is tied to their variable times in captivity or to some site-specific characteristics warrants further exploration.

San Francisco's Other Dining Scene: Foraging Ecology of Urban Bats

Jennifer J. Krauel and Gretchen LeBuhn; San Francisco State University, San Francisco, CA

The response of different vertebrates to urbanization has been surprising. Changes in structure, water availability, predator and prey communities, and connectivity provide opportunities for some taxa while limiting the success of others. The few studies of urban bats indicate that diverse communities of bats persist in these modified environments; however, no comprehensive study of the bat fauna has been done for the city of San Francisco, California. I surveyed 19 natural areas in parks across the city using Pettersson D240X acoustic monitoring equipment to estimate species richness and relative foraging activity on a quarterly basis beginning in late Spring 2008. Preliminary results show at least three species are present, and there is a positive correlation between presence of lakes and perennial streams in parks and both species richness and relative foraging activity. *Tadarida brasiliensis* is widespread and abundant, and *Myotis yumanensis* and *Lasiurus blossevillii* are restricted to parks with lakes.

Bat Blitzes in the Southeastern United States: A Partnership Program of the Southeastern Bat Diversity Network

Dennis L. Krusac, Darren A. Miller, and Joy M. O'Keefe; USDA Forest Service, Atlanta, GA; Weyerhaeuser Company, Columbus, MS; Clemson University, Clemson, SC

The "Bat Blitz" program is the key partnership effort of the Southeastern Bat Diversity Network (SBDN; http://www.sbdn.org). A bat blitz is an intensive, short-duration survey of local bat communities using experienced volunteers. Blitzes are efficient, allowing collection of data in three nights that would usually require an entire season of surveys. At SBDN bat blitzes, our objectives are to 1) obtain baseline data on local bat populations especially in areas where information is lacking; 2) provide information to host agencies for incorporation into their planning and management activities; 3) provide educational opportunities for local communities;

4) provide experience for graduate students working on bats; 5) and facilitate positive media exposure for bat conservation. The first Bat Blitz was held in 2002 at Great Smoky Mountains National Park as part of the All Taxa Biodiversity Inventory organized by the Park. Since then, SBDN has sponsored six additional blitzes on national forests in six states (AL, AR, GA, NC, SC, and TN). The Forest Service Southern Region has been the primary host in the Bat Blitz program with more than 100 additional partners, including more than 30 colleges and universities. Participation has ranged from 26 volunteers in 2002 to 105 in 2007, with representatives from universities, agencies (local, state, and federal), private industry, zoos, museums, and grade schools. In seven years, these partners have donated more than $10,000 cash and over 13,000 hours of service with an estimated value over $315,000. These events have yielded valuable data on status and distribution of 14 bat species in the Southeast, including several new county of occurrence records. Over 1,900 bats have been captured, including 2 endangered species and 3 Forest Service sensitive species. The location of an Indiana bat maternity roost using radiotelemetry provided valuable information on maternity habitat for this endangered species. Blitzes have also enabled the collection of echolocation calls, specimens for museums, DNA, hair, feces, and ectoparasites. The information SBDN provides to the Forest Service from blitzes allows better planning and management for bat conservation on national forests. Check the SBDN webpage for more information on the upcoming SBDN Bat Blitz on the Mark Twain National Forest in southeastern Missouri.

Aeroecology: A New Frontier

Thomas H. Kunz and Nickolay I. Hristov; Boston University, Boston, MA; Brown University, Providence, RI

Every so often in the history of science and technology, empirical discoveries, theory, and technological developments converge, making it possible to recognize a new discipline. Past examples include astrobiology, biomechanics, sociobiology, and more recently, macroecology, bioinformatics, and nanotechnology—disciplines that are now well established in the lexicon of modern science and technology. "Aeroecology" is one such discipline that embraces and integrates the domains of atmospheric science, earth science, geography, ecology, computer science, computational biology, and engineering. The unifying concept that underlies this new discipline is its focus on the planetary boundary layer, or aerosphere, and the myriad of airborne organisms that, in large part, depend upon this environment for their existence. Bats, birds, and arthropods that use the aerosphere are influenced by an increasing number of anthropogenic conditions and structures such as lighted towns and cities, air pollution, skyscrapers, aircraft, radio and television towers, and more recently the proliferation of communication towers and wind turbines that dot the Earth's landscape. In addition, human-altered landscapes increasingly are characterized by the extent of deforestation, intensive agriculture, urbanization, and assorted industrial activities that are rapidly and irreversibly transforming the quantity and quality of available terrestrial and aquatic habitats that airborne organisms rely upon for navigational cues, sources of food, water, nesting and roosting habitats—factors that can in turn influence the structure and function of terrestrial and aquatic ecosystems and the assemblages of organisms therein. Climate change and its expected increase in global temperatures, altered circulation of air masses, and effects on local and regional weather patterns are expected to have profound impacts on the dispersal, foraging, and migratory behavior of arthropods, bats, and birds. Ecologists who study animals that use the aerosphere face three important challenges: 1) to discover best methods for detecting the presence, taxonomic identity, diversity, and activity of organisms that use this aerial environment; 2) to identify ways to integrate relevant environmental variables at different temporal and spatial scales; and 3) to determine how best to understand and interpret behavioral, ecological, and evolutionary responses of organisms in the context of complex meteorological conditions and patterns within both natural and anthropogenically-altered environments. Appropriate integration of diverse tools and concepts for probing into the lives of organisms aloft can help inform important ecological and evolutionary concepts and management decisions associated with the spread of invasive species, emergence of infectious diseases, altered biodiversity, and sustainability of terrestrial, aquatic, and aerospheric environments.

A Novel, Remote-controlled BatCam for Censusing Small Colonies of Active Bats
Thomas H. Kunz, Jimmy C. Chau, Zheng Wu, Lisa Hong, Jonathan D. Reichard, Margrit Betke, and Thomas D. C. Little; Boston University, Boston, MA

Assessing colony and population size and dynamics are among the most important challenges that face bat ecologists. We describe a remote-controlled, infrared BatCam capable of recording nightly emergence of bats and for transmitting digital data over the Internet to remote stations or to a local laptop computer. The BatCam consists of a small, weatherized Internet camera connected to a local video server and gateway for Internet access. The server enables video recording at predetermined intervals corresponding to expected nightly emergence. Internet connectivity allows sampling the real-time video from off-site. This is particularly important for maintaining confidence in the quality of the collected video when away from the site. Using the BatCam, we successfully recorded and analyzed video data from a small bat colony of little brown myotis (*Myotis lucifugus*) that emerged nightly from a man-made bat house located at Moore State Park, Paxton, Massachusetts, in June 2008. We applied automated computer vision algorithms to detect and track bats in the video. The bats in each video frame were first detected by an algorithm using background modeling, in which an observed image frame was compared with an estimate of the background images without bats. A second algorithm tracked each newly detected bat through the camera's field of view. An estimate of colony size was determined from the number of bats that were tracked throughout the video sequence recorded during emergence. This novel, remote-controlled BatCam and analytical approach promises to be a valuable addition to the tool kit needed for assessing seasonal and inter-year changes in colony size—and may be especially important for assessing changes in some maternity colonies of bat species affected by White Nose Syndrome.

Sex Ratios of Long-distance Migrants in the Lower Peninsula of Michigan
Allen Kurta; Eastern Michigan University, Ypsilanti, MI

In eastern North America, three species are considered long-distance migrants—the Hoary Bat (*Lasiurus cinereus*), Eastern Red Bat (*Lasiurus borealis*), and Silver-haired Bat (*Lasionycteris noctivagans*). Based on specimens in museums and information in the literature, various authors have made predictions concerning the sex ratio of these species in different parts of the continent, but these predictions have not been tested with actual field data. Using data that my students and I accumulated through mist netting on about 1,000 net-nights since 1978, I calculated adult sex ratios for each of these species in a distinct and natural geographic area—the

Lower Peninsula of Michigan. I tested the hypotheses that 1) hoary bats would have a female-biased sex ratio, although some males would be present (Cryan, 2003); 2) red bats have a male-female ratio of 0.69:1 (Ford et al., 2002); and 3) only female silver-haired bats migrate north of Indiana into Michigan in spring (Whitaker et al., 2007). I restricted the analysis to adult animals netted during the months of June and July to minimize inclusion of migrating individuals. Adult sex ratio was statistically equal (12:16) for hoary bats, whereas the populations of red (270:107) and silver-haired bats (35:3) were male biased. Hence, none of the published hypotheses was supported.

Response of Northern Bats, *Myotis septentrionalis*, to Prescribed Fires in Eastern Kentucky Forests

Michael J. Lacki, Daniel R. Cox, Luke E. Dodd, and Matthew B. Dickinson; University of Kentucky, Lexington, KY; Northern Research Station, USDA Forest Service, Delaware, OH

Prescribed fire is growing in use as a management tool for restoring historic ecological conditions to deciduous forests in eastern North America; however, implications of the use of prescribed fire for forest-dwelling bats remain unclear. Roost selection of a few species of bats has been observed in association with forest fires, but data on prey availability, foraging behavior, and habitat use of bats following fires are still needed. During 2006 and 2007, we monitored prey availability, foraging behavior, and roost selection of adult female northern bats (*Myotis septentrionalis*) before and after two prescribed fires on the Daniel Boone National Forest in eastern Kentucky. Size of home ranges ($p = 0.46$) or core areas ($p = 0.55$) did not vary between bats radio-tracked before and after fires. Bats foraged more often in the vicinity of pine stands ($p < 0.1$) than hardwood or mixed stands, and along ridges and mid-slopes ($p < 0.1$) than lower slopes, regardless of burn condition. Position of home ranges was closer to burned habitats following fires than to unburned habitats ($p < 0.1$). Abundance of coleopterans ($p < 0.0001$), dipterans ($p < 0.0007$), and total insects ($p < 0.04$) captured in black-light traps increased following prescribed fires, and fecal samples of radio-tagged bats demonstrated coleopterans [% volume = 35.5 ± 4.36 (se)] and dipterans (% volume = 7.8 ± 2.28) to be the second and third most important groups of insect prey of these bats. Northern bats chose roosts that were taller in height and in earlier stages of decay than random snags ($p < 0.05$), and after prescribed fires chose roosts in trees with a greater number of cavities ($p < 0.05$) and a higher percentage of bark coverage ($p < 0.01$). More roosts of northern bats were observed in burned habitats (74.3%; $n = 26$) after fires than in unburned habitats (25.7%; $n = 9$). These data indicate that northern bats appear to be fire-adapted and can respond to habitat alterations resulting from prescribed fires through shifts in the location of foraging areas by tracking changes in insect availability, and through shifts in the selection of roost trees by occupying trees and snags possessing more potential roosting sites.

Scaling of Body Size and the Abdominal Wall in Echolocating Bats

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

Body size is an important characteristic in animals. Several studies have established that bats as a group have a smaller range of body sizes than other orders of mammals. Furthermore, bats that use high-intensity echolocation calls are smaller on average than those that use low-intensity calls or those that do not use echolocation. Power for echolocation calls is produced by the muscles of the abdominal wall and we suggest that the effects of scaling of these muscles may act as a limitation on the size of bats that use intense biosonar calls. From measurements on 38 species (13 families) of alcohol-preserved bats from the collections of the Royal Ontario Museum and the American Museum of Natural History, we estimated body volumes, and the cranio-caudal length of the abdominal wall. Samples of the abdominal wall were collected to measure thickness and examine the structure of the muscle. Cross sectional area of abdominal wall muscles determines the power available to compress the thoracoabdominal cavity. The cross sectional area of the muscles of the abdominal walls of bats that use high intensity echolocation increase in relation to body volume at a higher rate ($y = 0.257x^{0.67}$, $r^2 = 0.64$) in comparison to bats that use low intensity echolocation or are non-echolocators ($y = 0.133x^{0.40}$, $r^2 = 0.37$). Scaling of the cross-sectional area of the abdominal wall in bats using high-intensity calls was significantly greater than isometry (paired two-sample t-test, $p = 0.016$). This suggests that the demands of high intensity pulse production requires a greater thickness of the abdominal wall than would be expected if scaling were isometric ($y = x^{0.667}$). Our data indicate that the cross sectional areas of the abdominal walls of bats that use low intensity echolocation increase with body volume at a rate that is significantly less than isometry. This could be an adaptation for weight reduction. We suggest that requirements for flexibility of the trunk for feeding and grooming limit the thickness of the abdominal wall muscles that would be required to produce the pressure necessary for high intensity biosonar calls and therefore act as a limit on the body size of these bats.

Landscape Genetics of Prairie Bats: The Role that Rivers Play in Shaping Population Structure

Cori L. Lausen, Isabelle Delisle, Robert M. R. Barclay, and Curtis Strobeck; University of Calgary, AB; Birchdale Ecological Ltd., Kaslo, BC; University of Alberta, Campus Saint-Jean, Edmonton, AB

Increasing human disturbance on the landscape makes understanding the forces shaping populations necessary to ensure some measure of influence over future biodiversity. Given their ability to fly, one might expect bats to be relatively uninfluenced by landscape structure, similar to non-sedentary birds. We investigated whether prairie landscape features shape bat movement, dispersal, and consequently genetic population structure. We tested the hypothesis that degree of mobility and habitat specificity affect bat genetic population structure by comparing three species of bats (big brown, *Eptesicus fuscus*; little brown, *Myotis lucifugus*; western small-footed, *M. ciliolabrum*) in southern Alberta and north-central Montana, where river valleys are the dominant landscape feature. Using both nuclear DNA microsatellites and mitochondrial DNA sequences, we found varying degrees of structure according to rivers and river systems, with *E. fuscus* displaying the least amount of genetic structure associated with rivers, *M. ciliolabrum* displaying the most structure, and *M. lucifugus* showing an intermediate degree of structuring by river topography. Additionally, we documented a genetic fracture within *M. ciliolabrum*, separating summer populations on the Missouri River from those on the Milk, South Saskatchewan, and Red Deer rivers. We concluded that greater flight ability corresponded to less genetic structure, and that specificity for rock-roosts in the prairies may cause greater dependency on rivers as movement corridors. We investigated relatedness and roosting behavior at a smaller landscape scale for both *E. fuscus* and *M. ciliolabrum*, revealing fine scale structure (hundreds of meters) in the latter. As riparian cottonwoods continue to disappear, and drought

puts additional pressure on governments to dam and divert rivers, the prairie landscape is almost certain to change in a way that will influence many species, including bats. Understanding the differential roles that rivers play in the ecology of species found in river valleys may influence these decision-making processes.

Eastern Red Bat Arousal Responses to Winter Fires

Jason T. Layne and Lynn W. Robbins; Missouri State University, Springfield, MO

Prescribed burning is an important management tool used to increase plant diversity and reduce competition for desired tree species. However, this process may have negative impacts on wildlife species that inhabit the area. Winter burns are believed to be a threat to populations of eastern red bats (*Lasiurus borealis*) that go into torpor and roost under leaf litter during cold temperatures (less than 0° C). Eastern red bats were captured during the 2006–2007 and 2007–2008 winters at Peck Ranch Conservation Area in Carter County Missouri and subjected to an experimental fire in the field. Latency to arouse and fly in response to fire was measured via video surveillance, while weather conditions were recorded by wind directional Kestrel units. Observations show that bats respond directly to the stimulus of smoke from fire. Mean time for bats (n = 10) to arouse from torpor and fly at temperatures less than 10° C was 46.7 minutes, while bats (n = 10) mean time to fly at temperatures greater than 10° C was 16 minutes. Using previous data on winter roosting behavior of eastern red bats, prescribed fires can be planned in order to reduce the risk of direct fatalities on this species.

Exploring the Dichotomy of Bat Echolocation Behavior: Low and High Duty-cycle Echolocation

Louis Lazure and M. Brock Fenton; University of Western Ontario, London, ON

Low duty-cycle (LDC) and high duty-cycle (HDC) echolocation are two distinct behaviors found in echolocating bats. I intend to explain this dichotomy in call behavior diversity. My hypothesis is bats that tolerate overlapping call and echo (actual HDC bats) will have better ability to detect prey as the duty-cycle increases. In other words, once the constraint of overlapping is overcome, it is advantageous to increase its duty-cycle and other associated variables, which increases the divergence between the two echolocation behaviors. I conducted fieldwork in five forested sites in Taiwan. LDC and HDC bats were present during experiments. I set up an artificial mechanic prey in known foraging sites. The prey variables were wingbeat rate, wing size, and movement (flying or still). Recording started at the bats' emergence and continued for a 3-h period. From the video recordings, I determined the number of approaches toward the prey, and from sound files I determined the number of passes and identified the species. I estimated the detection ability of each species by calculating the number of attacks on the number of passes. Using an ANCOVA, I looked for an effect of duty-cycle on attack rate, using prey variables as covariate. HDC bats have a higher attack rate than LDC bats. Detection of prey is not significantly different based on the prey size. LDC bats' detection is not affected by changes in the prey wingbeat frequency. On the contrary, the faster the wingbeat, the better is the HDC bats' detection ability. A 50% attack rate is attained from 31.1% duty-cycle with fast flying prey (80 kHz wingbeat rate) to 46.7% for slow flying prey (20 kHz). Other call variables that show positive correlation with attack rate are pulse duration, frequency with maximum energy, and presence of harmonics. Ongoing work involves further investigation using synthetic

echolocation calls. Numerous combinations of variables will be tested and the echoes will be analyzed to find more precise variation in detection ability of different call designs.

Things That Go Bump in the Night: Nocturnal Activity and Information Transfer of an Indiana Bat Colony

Wynnell Lebsack and Dale W. Sparks; Indiana State University, Terre Haute, IN

Previous researchers have reported that Indiana bats (*Myotis sodalis*) frequently make return trips to their day roosts during the night, and participate in a behavior known as rallying or checking at these roosts in early morning. Earlier studies purposed that rallying or checking may be advertising a roost or, simply, bats making multiple approaches to the roost due to difficulty in alighting on a chosen roost site. The purpose of this study was to document the rallying behavior and to establish location, frequency, and participating individuals. We broke rallying into two components: 1) touch and go; and 2) circling the roost without approaching. With the aid of a thermal imaging camera, night vision equipment, and radiotelemetry, we were able to observe behaviors of bats both en masse and individually. Our findings indicate rallying behavior occurred continuously throughout the night during July and early August occurring at both artificial and natural roosts. Touch and go behavior was continuous throughout the night; however, at dawn during return to the day roost, the maximum number of participating individuals was observed. Participating individuals appeared to be all individuals at the maternity colony, including both adult females and juveniles. Information transfer is suggested by this activity as bats would be seen approaching the tree, and if many individuals were circling and touching the tree, the approaching bats would join the activity. Participating bats almost exclusively were in groups of two to five individuals while single approaching bats were uncommon.

Using Amplified Fragment Length Polymorphism to Evaluate Patterns of Genetic Divergence among *Myotis californicus, M. ciliolabrum*, and *M. leibii

Dana N. Lee, Loren K. Ammerman, and Russell S. Pfau; Angelo State University, San Angelo, TX; Tarleton State University, Stephenville, TX

*** Dana Lee** received the **Karl F. Koopman Award**

The California Myotis (*Myotis californicus*) and the Western Small-footed Myotis (*Myotis ciliolabrum*) are largely sympatric in the western United States, and are so morphologically similar that subtle features of their skull must be used to distinguish between them. Previous analysis of mitochondrial DNA (mtDNA) sequence data demonstrated that these two species are paraphyletic. The objective of this study was to use a DNA fingerprinting technique, amplified fragment length polymorphism (AFLP), to resolve the conflicting morphological and mtDNA data sets. We analyzed 198 loci from 17 *M. californicus*, 16 *M. ciliolabrum*, and 10 *M. leibii* using principle coordinate (PCoA) and parsimony analysis. Eighteen specimens were common to both the mtDNA and the AFLP study. We recovered a well-supported separation of *M. ciliolabrum* and *M. californicus* based on nuclear markers and suggest that the failure of the cytochrome-*b* gene tree to recover monophyletic lineages is due to lack of lineage sorting or mitochondrial introgression between *M. ciliolabrum* and *M. californicus*. Unexpectedly, *M. leibii* individuals from the eastern United States and Canada did not form a separate lineage from *M. ciliolabrum*. In the PCoA, there is more separation between subspecies of *M. californicus* than between these two recognized species (*M. leibii* and *M. ciliolabrum*). A Mantel test including individuals of these two species from across the U.S. showed a significant correlation between genetic and geographic distances indicating recent gene flow. The AFLP data also revealed distinctly different genotypes shared by two *M. ciliolabrum* individuals from southern Arizona that warrants further study.

Origins and Biogeography of Bats in South America

Burton K. Lim; Royal Ontario Museum, Toronto, ON

In spite of the fact that South America was an insular continent for most of the Tertiary, it has the highest species diversity for many organismal groups, including bats. However, the colonization of South America by bats has been poorly studied, even though they are the second most speciose order of mammals. A review of taxonomy, systematics, distribution, and the fossil record suggests that there were several dispersals to South America within three superfamilies (Emballonuroidea, Noctilionoidea, and Vespertilionoidea). The reconstruction of ancestral areas based on bat phylogenies infers that Africa is the geographic area of origin for most basal nodes. This suggests that the diversification of Neotropical species in Noctilionoidea occurred after a single colonization of South America from Africa in the Eocene by the most recent common ancestor of the New World families Furipteridae, Mormoopidae, Noctilionidae, Phyllostomidae, and Thyropteridae. Within Emballonuroidea, a similar trans-Atlantic dispersal in the Oligocene gave rise to the New World tribe Diclidurini in the family Emballonuridae. The situation for Vespertilionoidea is more complex with multiple dispersals in three families (Molossidae, Natalidae, and Vespertilionidae). For Molossidae, there are hypothesized five dispersals to South America perhaps beginning as early as the Eocene but the timing and origin of these colonizations are unsettled because of the lack of comprehensive phylogenies for the family and an incomplete fossil record. Similarly for Vespertilionidae, the exact timing of events are uncertain but there were three independent dispersals from North America to South America within the subfamily Myotinae, and at least two dispersals from North America and one dispersal from Africa within tribes of the subfamily Vespertilioninae. In Natalidae, the family originated in North America and colonized the Caribbean with a subsequent dispersal probably during the Pliocene that gave rise to two species of *Natalus* in South America. After the establishment of the Panamanian land connection, there were several overland dispersals from North America to South America, but many species also expanded their distributional ranges in the opposite direction. Although general hypotheses of the origin of bats in South America can be inferred based on previous phylogenetic studies, as new paleontological data are discovered and comprehensive phylogenies based on morphological and molecular data are proposed for more groups, the details of historical biogeography, modes of speciation, and times of diversification will be better resolved and corroborated.

Genetic Structuring Among Hibernacula Populations of the Endangered Gray Bat (*Myotis grisescens*)

Denise L. Lindsay and Richard F. Lance; U.S. Army Engineer Research and Development Center, Vicksburg, MS

Past population declines in the federally listed gray bat (*Myotis grisescens*) have been attributed to the loss of suitable hibernacula. However, as hibernacula have been increasingly well protected, gray bat numbers seem to have increased, with some apparent shifts in the locations of wintering populations (large losses and gains in numbers of individuals at major hibernacula). We have collected a total of 330 guano and tissue samples from 10 major hibernacula populations across 5 states in order to assess population genetic structure in this species. These samples will also be used in an initial assessment of genotypic assignment-based mixed stock analysis for estimating linkages between hibernacula and summer roost populations. We also obtained DNA from 43 individual gray bats at a maternity colony on Fort Leonard Wood, MO, with the intent of assessing, broadly, the relative genetic affinity of this colony to the various sampled hibernacula. A total of six microsatellite loci, previously identified in *M. myotis*, were used to genotype our samples. Assignment-based assessments of population structure, which are conservative in the presence of null alleles, have identified different putative genetic clusters, some of which are composed of hibernacula that are relatively geographically distant (isolation-by-distance was not detected). These early results indicate that linkages between summer colonies and winter hibernacula, and, likewise historical gene flow patterns in gray bats, are not simply structured around geographic proximity.

Failure of an Acoustic Lure to Attract Rafinesque's Big-eared Bats *Corynorhinus rafinesquii*

Susan C. Loeb and Eric R. Britzke; USDA Forest Service, Clemson, SC; Britzke and Associates, Forrest City, AR

Bats often respond to the calls of conspecifics as well as to those of other species. For example, bats eavesdrop on the echolocation calls of other bats to gain information on the availability and location of resources or respond to social or distress calls. Bats may either be attracted or repelled by the calls of others. We tested the response of Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) to playback calls as a possible method to increase capture success. We recorded calls of Rafinesque's big-eared bat colonies at a tree roost site at the Savannah River Site (SRS) in the Upper Coastal Plain of South Carolina and in a mine in the Mountains. Calls were recorded while bats were in the roosts and as they exited, and playback sequences for each site were created by cutting and pasting individual pulses into a file. Two mist nets were placed near roost sites with the net with the playback equipment serving as the Experimental net and the one without the equipment as the Control. Playback was accomplished using two BAT AT100 transmitters facing in opposite directions. The playback equipment was placed at the Experimental net for 1 hour and then moved to the other net for 1 hour. The entire process was repeated during a 4-hour sampling period. At each Experimental net, calls were played for 5 minutes on and 5 minutes off throughout the hour. Call structures differed significantly between the Mountain and SRS populations with calls from the Mountains being higher in frequency. Bats were captured at all sites but 10 of 11 Rafinesque's big-eared bats were caught in the Control nets. In contrast, 13 of the 19 bats of other species were captured at Experimental nets. Overall bat activity (number of bat passes and number of pulses per pass) did not differ significantly between Control and Experimental nets. Our results suggest that foraging Rafinesque's big-eared bats may be repelled by their social calls although other species may be attracted. The response of bats to the echolocation and social calls of other bats and the use of acoustic lures in increasing capture rates need further study.

The Last of the Mohicans: Fruit-eating Bats as the Last Large-seed Dispersers in Defaunated Forest Fragments

Felipe Pimentel Lopes de Melo, Bernal Rodriguez-Herrera, Robin, L. Chazdon, Gerardo Ceballos, and Rodrigo A. Medellin; Universidad Nacional Autónoma de México, México DF, México; University of Connecticut, Storrs, CT

In Neotropical regions, fruit-eating bats of the family Phyllostomidae are among the most important components of the frugivorous fauna remaining in disturbed landscapes. Yet, the role of bats as seed dispersers of large-seeded plants is poorly documented. We investigated the seed shadows generated by small tent-roosting bats *Artibeus watsoni* in the Sarapiquí Basin, Costa Rica. We estimated the total number of seeds and seed species larger than 8 mm that bats disperse under their roost sites, compared the density and species composition of seeds dispersed by tent-roosting bats with seeds sampled away from the influence of tents, and compared bat-generated seed shadows in intact vs. fragmented forests. In all forests examined, tent-roosting bats increased both seed and species density below tents by up to 10 times with the levels in control quadrats. Mean seed density beneath tents was reduced in small forest fragments compared to large, intact forest reserves. We observed a total of 43 seed species > 8 mm but non-parametric estimators suggest up to 65 species may actually be present in the study areas. Our study demonstrates that the role of frugivorous phyllostomid bats on dispersal of large-seeded plants is far greater than previously understood. Assuming that bats may persist in relatively large numbers in human-disturbed landscapes, we expect that at least a small flux of large seeds will be maintained in the absence of the medium to large frugivores extirpated from forest fragments and over-hunted sites.

Sonar Calls and Geographic Location: Is There a Sonar Call Dialect and Do Bats Pay Attention to it?

Laura K. Lynn and Karry A. Kazial; SUNY Fredonia, NY

The purpose of this research was to examine whether the sonar calls of little brown bats (*Myotis lucifugus*) differ based on geographic location of summer roosting colonies. A database of previously recorded sonar calls was analyzed to look for evidence of dialect among little brown bat calls. All calls used in the analysis were recorded at the same location using the same equipment during the summers of 2003–2005. Sixteen adult little brown bats were also captured from several sites at two separate geographic locations (approx. 17.5 miles apart) within Chautauqua County, NY for use as subjects in playback experiments: Chautauqua Institution in Mayville, NY and SUNY Fredonia campus in Fredonia, NY. Calls from the database were used to create call sequences, each of which consisted of a 60-second repetition of ten calls. The call sequences were then matched by gender and paired so that each test subject was played one sequence from each location in random order. Paired trials were completed over a 3-day period, with the first trial occurring on day 1, followed by a day of rest, followed by the second trial on day 3. Each trial consisted of a pre-playback, playback, and post-playback segment. The pre- and post-playback segments were 60 seconds of zero-amplitude equipment noise and were used to establish a base-line call rate and to allow for delayed response following the play-out of a call sequence. The subjects' responses were recorded, including latency to first call as well as call rate, and will be used to determine if there is evidence of call recognition based on geographic location.

Vertical Flight Performance and Load Carrying in Lesser Dog-faced Fruit Bats *Cynopterus brachyotis*

Leigh C. MacAyeal, Daniel K. Riskin, and Sharon M. Swartz; Brown University, Providence, RI

Bats must maintain flight performance, even when they experience the changes in total body mass associated with feeding, pregnancy, and postnatal transport. This study examined the vertical flight performance and power production of *Cynopterus brachyotis*, lesser dog-faced fruit bats, with and without the effects of added loads. Five female *C. brachyotis* (mean body mass = 38 g) were trained to take off from the ground and accelerate vertically through a transparent flight column (0.6 m x 0.6 m x 0.86 m height). They were loaded with 0%, 7%, 14%, and 21% of their normal body weight via intra-peritoneal injections of physiological saline solution. Three representative flights at each experimental condition were recorded with three phase-locked high-speed cameras at 1000 Hz, and markers on the body and wing were digitized to reconstruct the three-dimensional trajectories of these flights. Analysis demonstrates marked changes in wing kinematics and power production with changing loads.

Floristic Evolution in the Neotropics and the Geographic Conquest of Nectarivory in Phyllostomid Bats: Implications of Convergent Histories

Hugo Mantilla-Meluk, Miguel Pinto, and Robert J. Baker; Texas Tech University, Lubbock, TX

Molecular clock estimates of geologic times of diversification, species distribution models, and geostatistical analyses were combined to reconstruct the potential geographic and ecological scenarios that contributed to the radiation of the three continental lineages of nectarivorous bats proposed by Baker et al. (2003)—the tribes Choeronycterini and Glossophagini in the subfamily Glossophaginae, as well as the subfamily Lonchophyllinae. Our analysis revealed a geographic and ecological partitioning among nectarivorous bats in the Neotropics in three geographic domains as follows: Choeronycterini—Andean domain, Glossophagini—Central American domain, and Lonchophyllinae—Chocoan domain providing geographic support to Baker's et al. (2003) phylogenetic hypothesis. Based upon the geographic partitioning observed in conjunction with species divergence times, we propose a floristic partitioning among continental phyllostomid nectarivorous bats that placed the origin of nectarivory in the middle of the Tertiary 23–17 mya when biogeographic and global climatic changes resulted in a floristic shift in the Neotropics that associates the emergence of nectarivory with the appearance of the C4 and CAM photosynthetic mechanisms in the Neotropical endemic families Cactaceae and Bromeliaceae and the adaptation of bats within the tribe Choeronycterini to the consumption of plants with a Holarctic origin adapted to life in the highlands of the Neotropics.

The Effects of Temperature and Meal Size on Short-term Torpor Use in Little Brown Bats *Myotis lucifugus*

Amanda L. Matheson, Craig K. R. Willis, and Kevin L. Campbell; University of Manitoba, Winnipeg, MB; University of Winnipeg, Winnipeg, MB

Torpor is an energy saving strategy where body temperature and metabolic rate are actively lowered. Although it is known that torpor is used when ambient temperature and/or food availability decrease, use of torpor varies from individual to individual, and surprisingly little is known of the proximate factors influencing torpor expression on a daily basis. In this study we

used open-flow respirometry to quantify torpor expression in little brown bats (*Myotis lucifugus*) while varying meal size prior to metabolic trials and ambient temperature during metabolic trials. Immediately before each trial, bats were given one of three high-protein feeding treatments ad lib (0, 50, or 100% of the meal mass required to reach satiation for each individual). Ambient temperature was controlled at either 7 or 17° C for the duration of each metabolic trial. Little brown bats relied heavily on torpor during all metabolic trials. The data collected from these trials will allow us to examine the effect of recent feeding on torpor expression and will help us understand the time scale of energy budgets.

Opportunistic Predation by Bats Tracks and Exploits Changes in Insect Pest Populations: Evidence from Quantitative (qPCR) Analysis of Fecal DNA

Gary F. McCracken, Veronica A. Brown, Melanie Eldridge, Paula Federico, and John K. Westbrook; University of Tennessee, Knoxville, TN; U.S. Department of Agriculture, College Station, TX

The role of bats in suppressing insect pest populations depends on the bats' ability to track and exploit pest populations in space and time. Because of the damage they cause to crops and the costs of controlling this damage, the spatial and temporal dynamics of populations of corn earworm moths (*Helicoverpa zea*; also, known as cotton bollworms) are well characterized. To investigate the ability of Brazilian free-tailed bats (*Tadarida brasiliensis*) to track and exploit populations of corn earworm moths in the Winter Garden Agricultural Region in Texas, we developed and employed an insect species-specific gene marker and use quantitative polymerase chain reaction (qPCR) analysis of bat fecal DNA. Moth consumption by the bats is documented in relation to independently obtained measures of moth abundances that were obtained at four farm sites within the foraging range of the bats. The corn earworm gene marker was amplified from the feces of 34.4% (or 129) of 375 bats sampled in the summer of 2006. Average gene copy numbers in qPCR-positive fecal samples ranged from a low of 10.6 to a high 7,607,284 gene copies / g feces. The seasonal patterns of moth abundance at three of the four sites where moths were captured show strong positive correlations with the numbers of bats that are positive for the corn earworm gene marker, and composite (spline) functions of moth abundances at all four sites significantly explain patterns of corn earworm consumption by bats. The best fit regression is obtained with a composite function based on the maximum numbers of moths at sites ($r^2 = 0.394$; $p < 0.001$), a result consistent with the hypothesis that bats go where insects are most abundant. Our results demonstrate that Brazilian free-tailed bats in Texas fulfill all requirements to function as effective agents for biological pest control in a contemporary industrial agricultural ecosystem.

Plasma Metabolite Analysis: A Method for Determining Individual Feeding Performance of Insectivorous Bats

Liam P. McGuire, M. Brock Fenton, Paul A. Faure, and Christopher G. Guglielmo; University of Western Ontario, London, ON; McMaster University, Hamilton, ON

Insectivorous bats regularly experience dramatic and sometimes rapid changes in nutrient stores; yet our ability to study these changes has been limited by available techniques. Traditional methods require either recaptures, which are rare, or rely on group averages, which sacrifice valuable information at the level of the individual. Plasma metabolite analysis provides an estimate of feeding performance for individuals captured once. Plasma metabolite analysis has proven effective for studying individual rates of mass change in birds but has not been validated for other taxa. We tested the effectiveness of plasma metabolite analysis by conducting a study with captive big brown bats (*Eptesicus fuscus*) and a field study with little brown bats (*Myotis lucifugus*). In the lab, we varied food availability to induce various rates of mass change. Individual rate of mass change was positively correlated with plasma triglyceride concentration, but unlike birds there was no relationship with plasma β-hydroxybutyrate concentration. In the field, we collected blood samples from post-lactating females as they emerged in the evening (fasted) and when they returned from feeding in the morning. Plasma triglyceride concentration was greater in fed bats than fasted bats and the increase was less when rain limited foraging. Contrary to predictions, β-hydroxybutyrate concentration was also greater in fed bats than fasted bats. Our results confirm that analysis of plasma triglyceride concentration provides a technique for assessing individual feeding state and rate of mass change of bats that will facilitate further study of bat nutritional ecology and energetics.

Results of a Workshop, "Conserving North American Bat Diversity"

Angela McIntire, Tim Snow, Rodrigo Medellin, Mary K. Clark, Pat Ormsbee, Jamie Stewart, and Michael Herder; Arizona Game and Fish Department; UNAM, México; Southeastern Bat Diversity Network, Raleigh, NC; USFS, Eugene, OR; OMNR, Canada; BLM, Ely, NV

Special interest groups representing birds, fishes, herpetofauna, and other taxa have organized nationally and internationally to achieve greater success through collaborative conservation efforts for their respective groups. The resulting partnership coalitions, such as Partners in Flight and the North American Fish Habitat Initiative, have successfully achieved implementation of large-scale or continent-wide conservation strategies to address landscape scale and cross-border challenges. A need for such a collaborative effort for bats has long been recognized. Bats as a group face a growing number of conservation pressures in North America. Of the 16 species shared by the three countries, at least a dozen cross Canadian, U.S., and Mexican borders. Progress at the national and international levels will require coordinated communication on bat conservation needs to key decision makers; in addition new funding initiatives such as State Wildlife Action Plan funds provide new opportunities for bats that can only be utilized through an organized and coordinated efforts. For the last four years, an initiative to promote bat conservation across North America has been presented to the Trilateral Committee for Wildlife and Ecosystem Conservation and Management, which facilitates cooperation and coordination among wildlife agencies of the three nations. The Trilateral Committee endorsed the initiative as a priority in 2007 and 2008. In addition, the Association of Fish and Wildlife Agencies, which represents North America's fish and wildlife agencies, also supported the need to organize a new bat conservation initiative. In 2008 funding was secured from state, federal, and non-governmental organizations to support a workshop to develop a continental conservation effort for bats. The workshop was held at the Arizona Sonora Desert Museum in August, and was attended by a diverse group of bat conservationists who drafted a mission statement, identified goals and objectives, and outlined an infrastructure that will allow planning input from a diverse group of interests. Participants included representatives from each of the three countries, state/provincial and federal agencies, industry, and private organizations. Follow-up action items include seeking more widespread input, collaboration, and endorsement for this initiative, as well as developing a strategic North American bat conservation plan.

The Physiological and Ecological Inequality of Bird and Bat Flight

Brian K. McNab; University of Florida, Gainesville, FL

The cost of powered flight is bats 20–25% less than in small birds. This difference reflects the intermediate to large pectoral muscle masses in birds and the smaller flight muscles of bats. Differences in the cost and morphology of bird and bat flight have consequences. One is that bird flight is local, long-distance, and pelagic, whereas bat flight usually is local and often modified to fly in cluttered environments. A second consequence is that temperate birds that feed on flying insects avoid winter's seasonally harsh conditions by migrating to subtropical and tropical environments, whereas most temperate bats with similar habits respond by hibernating in local caves. A few temperate tree bats migrate to a limited extent and these species tend to have aspects of their physiology and behavior modified compared to non-migratory species. Some tropical bats that marginally invade temperate environments have a wing morphology that facilitates fast, long-distance flight and permits a seasonal retreat to tropical environments. The general immobility of small mammals led many species to respond to conditions in temperate and arid environments with daily or seasonal torpor, responses rarely used by birds, except as associated with a small mass, both in temperate and tropical environments.

The Long and the Short of It: Phylogenetics of the Long-fingered Bats, Genus *Miniopterus*

Cassandra, M. Miller-Butterworth, Geeta Eick, David S. Jacobs, M. Corrie Schoeman, William J. Murphy, Stephen J. O'Brien, Mark S. Springer, Eric H. Harley, and Emma C. Teeling; Penn State Beaver, Monaca, PA; University of Oregon, Eugene, OR; University of Cape Town, South Africa; Texas A&M University, College Station, TX; National Cancer Institute, Frederick, MD; University of California, Riverside, CA; University College, Dublin, Ireland

Despite their very wide distribution, the taxonomy of the long-fingered bats, genus *Miniopterus* remains largely unresolved. For example, their traditional classification as members of the subfamily Miniopterinae, within Vespertilionidae remains controversial. To address this issue, we generated one of the largest chiropteran datasets to date, incorporating ~11 kb of sequence data from 16 nuclear genes, and included representatives of all bat families. Our data provide conclusive evidence for recognition of the family Miniopteridae, a sister taxon to Vespertilionidae. The miniopterids diverged from Vespertilionidae and other families 49–38 mya, around the time that all major extant bat families originated. This speciation event likely led to greater diversity among the miniopterids than has traditionally been recognized. To illustrate this, we generated a global *Miniopterus* phylogeny and confirmed the existence of two geographically isolated, monophyletic clades. Furthermore, *M. schreibersii,* which traditionally is considered to be a single species with a global distribution, instead forms a paraphyletic species complex. Even at the local geographic scale, both intra- and interspecific genetic differentiation is high. As a case in point, we examined ecological and molecular differences among South African colonies of *M. natalensis,* and between *M. natalensis* and *M. fraterculus*, which occur sympatrically and are morphologically almost indistinguishable. The *M. natalensis* population in South Africa consists of three genetically and morphologically distinct subpopulations, which correspond to ecological biomes. Despite their superficial similarities, *M. natalensis* and *M. fraterculus* echolocate at divergent peak frequencies, and molecular markers indicate that they diverged ~2 mya. Possible colonization strategies for southern African miniopterids will be discussed in light of these findings.

Rabies Exposure, Relative Immune Function, and Life-history Traits in the Big Brown Bat, *Eptesicus fuscus*

Marianne S. Moore, Felix R. Jackson, Amy S. Turmelle, Brian J. Panasuk, Mary T. Mendonça, Charles E. Rupprecht, Thomas H. Kunz, and Gary F. McCracken; Boston University, Boston, MA; Centers for Disease Control and Prevention, Atlanta, GA; Auburn University, Auburn, AL; University of Tennessee, Knoxville, TN

Innate and adaptive immune functions provide vertebrates with numerous mechanisms used in response to invading pathogens. The relative strength of these responses affects how animals respond physiologically to exposure and infection. This study aimed to characterize immune responses in the Big Brown Bat, *Eptesicus fuscus*, and how variation in immune function may relate to population differences, life-history traits, and pathogen exposure, specifically to rabies virus. Bats were captured from ten barns located in New Hampshire and Massachusetts in 2005, 2006, and 2007. To measure the innate immune response, whole blood was used in a bactericidal assay in which it was diluted, mixed, and incubated with a standard concentration of *Escherichia coli*. To assess the cell-mediated adaptive response, bats were injected subcutaneously with phytohemagglutinin (PHA), a known T-cell mitogen. Assessment of pathogen exposure was conducted using the rapid fluorescent focus inhibition test (RFFIT) to measure virus-neutralizing antibodies (VNA) to rabies virus in the blood plasma of individual bats. Infection status was estimated from oropharyngeal swabs by nested RT-PCR and sequencing. Significant differences were observed between presence of VNA, reproductive stage, and year. Specifically, pregnant and lactating females were more likely to exhibit VNA compared to post-lactating individuals. Among all bats sampled, the proportion exposed to rabies virus was 2% in 2005, 17% in 2006, and 6% in 2007. Rabies viral amplicons (derived from viral particles in the saliva) were generated from only 3 of 515 individual bats sampled during the three-year study. Bactericidal ability of bat blood was significantly related to colony-level effects and reproductive stage. Specifically, post-lactating bats showed greater bacterial killing compared to lactating bats. Additionally, females demonstrated a bactericidal ability that was ~13% greater compared to males. PHA index was significantly related to date and year. Results suggest that sex, reproductive status, colony site, and seasonal and annual variation may influence the ability of bats to respond immunologically. Moreover, our results suggest that pregnant and lactating females, which exhibit increased gregarious behavior compared to bats in other reproductive stages, have greater pathogen exposure.

Are Hibernating Bats Capable of Mounting an Effective Immune Response? Histological Evaluation of a Cellular Response to Phytohemagglutinin (PHA) Injections in the Little Brown Myotis, *Myotis lucifugus* and the Big Brown Bat, *Eptesicus fuscus*?

Marianne S. Moore, Elizabeth L. Buckles, and Thomas H. Kunz; Boston University, Boston, MA; Cornell University, Ithaca, NY

White Nose Syndrome (WNS) is a recently observed condition affecting bats in the northeastern United States that has caused up to 95% mortality in some hibernacula. First reported in the winter of 2006–2007, bats affected with WNS exhibit unusual behaviors, develop a fungal growth on their faces, ears, and wing membranes, are depleted of fat reserves, and exhibit extensive wing necrosis and scaring. It is not known whether the fungus, for which this syndrome is named, is the cause of death or an opportunistic condition of immuno-compromised

individuals. However, bats that have the visible fungal colonies on their noses and wings have fungal hyphae within the dermis and epidermis and are absent of local inflammation. To test the hypothesis that hibernating bats are unable to mount an effective inflammatory response to the fungus because of physiological constraints associated with deep torpor, we collected biopsies of swellings developed in response to the standard immune function challenge using subcutaneously injected phytohemagglutinin (PHA). PHA injection stimulates the recruitment of, first, inflammatory cells and, second, T lymphocytes. Given that inflammatory cells are usually associated with immune response against fungi, this test should provide valuable insight into potential causes and correlates of WNS. For the first phase of this study, we challenged pregnant *Myotis lucifugus* and *Eptesicus fuscus* and post-lactating *M. lucifugus*. Biopsies were collected at 6, 12, and 24 hours post-injection and analyzed histologically for variation in immune function cells responding to experimental and control injections. The data collected over the summer have established a baseline response to PHA. The response to injection is mild, but does vary depending on time post-injection. These results will be compared to results from hibernating bats sampled during the winter of 2008–2009, used to describe potential differences in inflammatory response between active and hibernating bats, investigate possible variables associated with WNS, and establish whether or not hibernating bats can respond to a potentially infectious fungal condition.

Activity of Bats in a Managed Pine Forest Landscape with an Emphasis on Edges
Adam Morris and Matina Kalcounis; University of North Carolina, Greensboro, NC; Weyerhaeuser Company, Columbus, MS

Forest edges represent the interface of two vegetation types and often have increased species richness and abundance (edge effect). Edges can affect spatial behaviors of species and dynamics of species interactions. Landscapes of intensively managed pine (*Pinus* spp.) stands are characterized by mosaic-patterning of forest patches and linear forest edges. Because managed pine forests are a major landscape feature of the southeastern U.S., and effects of intensive pine management on bat communities are poorly understood, we examined bat foraging behavior in four structurally distinct stand types (open-canopy pine, pre-thinned pine, thinned pine, and unmanaged forest) and along forest edges within a managed pine forest landscape in the coastal plain of North Carolina. During May–August 2006 and 2007, we recorded echolocation calls of bats using Pettersson D240X bat detectors with digital recorders at 156 sites. We also sampled nocturnal flying insects at each site using malaise insect traps. We used negative binomial count regression models to describe bat foraging behavior relative to stand types, forest edges, and prey availability. Although bat species showed affinities for certain stand types and prey items, bat activity was most strongly related to forest edges. Edges were used extensively by six aerial-hunting bat species, but avoided by *Myotis* species. Our results emphasize that forest edges are important landscape features for bats in forested landscapes.

Darwin's Coevolutionary Race in a Bat-Flower Mutualism
Nathan Muchhala; University of Toronto, Toronto, ON, Canada

Darwin hypothesized that extremely long flowers and the long mouthparts of the animals that pollinate them evolved together in a coevolutionary race. Although selective pressures for the animal side of such a race are relatively clear (longer tongues allow the animal to reach more nectar), the plant side remains controversial. What selective pressure might favor long corolla tubes? I examined this question for the highly specialized mutualism between the long-tubed flower *Centropogon nigricans* and the nectar bat *Anoura fistulata*, which possesses the longest tongue relative to body length of any mammal. I used flight cage experiments to examine the effects of artificially manipulated flower lengths on 1) bat behavior and on 2) pollen transfer. In the first experiment, increased length corresponded with increased visit duration, but did not affect the force bats applied during visits. In the second experiment, flower length increased both the male and female components of flower function; long male flowers delivered 123% more pollen grains, and long female flowers received 144% more pollen grains. However, pollen transfer was not correlated with visit duration, thus the mechanism behind differences in pollen transfer remains unclear. By demonstrating that bats select for increasing flower length, these results are consistent with the hypothesis that *Anoura fistulata* evolved its remarkable tongue through reciprocal evolution with long-tubed flowers, in a coevolutionary race similar to that envisioned by Darwin.

Bats and Wind Energy: One-year Review of the Pennsylvania Game Commission's Wind Energy Voluntary Cooperative Agreement

Tracey M. Librandi Mumma, Calvin M. Butchkoski, Douglas A. Gross, Gregory G. Turner, and William A. Capouillez; Pennsylvania Game Commission, Harrisburg, PA

The Pennsylvania Game Commission (PGC) Wind Energy Voluntary Cooperative Agreement was created in February 2007, and on 18 April 2007, 12 wind companies entered into the agreement. Currently, 20 wind companies have entered into the agreement representing approximately 68% of Pennsylvania's 75 wind sites (65 proposed and 10 active). The PGC and cooperators, in an effort to best avoid, minimize, and/or mitigate potential adverse impacts with specific intent to birds and mammals, have entered into the cooperative agreement in an effort to standardize wildlife monitoring protocols and wildlife impact review methods associated with wind energy development projects in a mutually beneficial and flexible manner and with high regard to both party's goals and objectives. The agreement outlines standardized surveys with level of effort determined by the potential risk level assigned to each wind site. The PGC determines potential bat risk by criteria outlined in the agreement; risk levels are subject to change given new information such as that obtained from pre-construction surveys. Fourteen wind sites have conducted pre-construction bat surveys since the agreement was implemented in 2007. Seven sites were investigated for bat hibernacula, thirteen acoustic surveys were completed or in progress, fourteen mist-net surveys were completed, and four telemetry surveys were completed. PGC biologists have investigated 144 mine features within 5 miles of project areas to determine if they were potential bat hibernacula; only 3 warranted further investigation. During 2007 one post-construction mortality survey was conducted and in 2008, four are being conducted. New bat findings include the discovery of the second largest Indiana bat (*Myotis sodalis*) maternity colony and the first record of a lactating female silver-haired bat (*Lasionycteris noctivagans*) in Pennsylvania; both were found during pre-construction surveys conducted by cooperators. The first year of the agreement has been a success in that some high bat risk areas have been avoided, cooperators are becoming pro-active in terms of getting PGC input early in the planning stages to determine where to best site wind facilities, and data collection is ongoing following standardized protocols. The biggest challenge remaining is that there are a few wind companies proposing wind facilities that are not yet signed into the agreement.

Diet of the Evening Bat, *Nycticeius humeralis*, on the Northern Edge of its Range

Olivia M. Munzer and Allen Kurta; SWCA Environmental Consulting, Austin, TX; Eastern Michigan University, Ypsilanti, MI

In general, migratory bats in temperate areas have a small window of time to molt, reproduce, and raise young, which are tasks that require high amounts of energy (food) consumption. During these times of high-energy expenditure, it would be expected that the diet of bats would vary. Research on the diet of evening bats (*Nycticeius humeralis*) is limited, particularly at the northern periphery of their range. We obtained fecal samples from under roost trees and from individual bats from May until September 2006–2007 at the northernmost colony of evening bats on the continent, in southern Michigan. The average percent volume and percent frequency occurrence for each order of insect was calculated and statistical comparisons were made between years and reproductive conditions. Dietary diversity index was calculated using the inverse of Simpson's diversity index. Diet of evening bats included 14 orders of insects and two orders of arachnids. Six orders (Coleoptera, Diptera, Hymenoptera, Hemiptera, Lepidoptera, and Trichoptera) comprised 94% of the diet. There was an overall significant difference between the diet of pregnant and post-lactating evening bats, and between lactating and post-lactating bats. There was a significant difference in the abundance of insect orders between 2006 and 2007, and for both years, the dietary diversity index was 4.34. Thirty-one families and three species were identified within the diet of evening bats in 2006–2007. The three species were spotted cucumber beetle (*Diabrotica undecimpunctata*), green stink bug (*Acrosternum hilare*), and emerald ash borer (*Agrilus planipennis*), and each is an economically important pest of crops or forests.

Species on the Edge: Molecular Differentiation in Three Lineages of Endemic West Indian Bats

Kevin L. Murray, Theodore H. Fleming, and Dean A. Williams; University of Miami, Coral Gables, FL; Texas Christian University, Fort Worth, TX

Species on islands live on the edge of potential dispersal barriers. These ocean barriers may limit gene flow among islands and facilitate genetic differentiation and speciation among island populations. We examined genetic differentiation within three genera of phyllostomid bats endemic to the islands of the West Indies, *Brachyphylla*, *Erophylla*, and *Phyllonycteris*. The current taxonomy of these bats is based on morphology, and there is strong potential for cryptic species within these genera due to the isolating effect of islands. We used mitochondrial genes (cytochrome-*b* and control region) to investigate genetic differentiation and phylogenetic relationships within each genus. In addition, we used nine microsatellite loci to examine more recent genetic divergence within *Erophylla*. Genetic distances and phylogenetic analyses (neighbor-joining, maximum parsimony, and Bayesian analysis) from mitochondrial data supported three species (one cryptic species) within *Brachyphylla* and three species (one cryptic species) within *Phyllonycteris*. Mitochondrial data were equivocal for *Erophylla*, but microsatellite data supported the existence of two species within the genus. Our data highlight the fact that populations of island bats may be important reservoirs of cryptic diversity and are attractive targets for taxonomic investigation. Our findings also indicate that there are several effective quantitative techniques for molecular species delimitation and that a combination of mitochondrial cytochrome-*b* data and microsatellite loci may be an effective means of differentiating among congeneric species.

***Does Wind Affect Genetic Structure and Gene Flow in Two Phyllostomid Bat Species in the Bahamas and Greater Antilles?**

Robert A. Muscarella, Kevin L. Murray, Derek Ortt, and Theodore H. Fleming; University of Miami, Coral Gables, FL

*** Robert Muscarella** received the **Luis F. Bacardi Bat Conservation Award**

Gene flow dictates a broad range of ecological and evolutionary processes. Understanding the factors mediating magnitude and direction of gene flow is crucial for interpreting patterns of genetic diversity and for answering many kinds of biological questions. Recent advances at the interface of population genetics and GIS technology have expanded our perspective of the geographic and physical features influencing gene flow and, in turn, shaping genetic structure of populations. I investigated the effect of surface-level trade winds on genetic structure and gene flow in two species of phyllostomid bats in the Bahamas and Greater Antilles: *Erophylla sezekorni* (the Buffy Flower Bat) and *Macrotus waterhousii* (Waterhouse's Leaf-nosed Bat). Bayesian Clustering Analysis revealed that all islands sampled represent independent genetic populations for *M. waterhousii* but not for *E. sezekorni*. Samples from 13 islands (spanning *E. sezekorni*'s range) clustered into five genetic populations and revealed the existence of two main clades (eastern: Hispaniola and Puerto Rico; western: Cuba, Jamaica, and Bahamas). To test the hypothesis that surface-level trade winds mediate gene flow in this system, I generated measures of effective distance between islands using anisotropic cost modeling based on wind data from the National Climactic Data Center. Both species exhibited significant isolation by distance with geographical distance and some of the measures of effective distance, but effective distance did not provide increased explanatory power in predicting distribution of genetic diversity. The IBDGEO slope was steeper for *E. sezekorni* than *M. waterhousii*, suggesting greater dispersal ability in the former species. According to Maximum Likelihood analysis, a majority (80%) of gene flow between genetic populations was asymmetric in both species. The degree of asymmetric gene flow between populations was not explained by the degree of asymmetry in effective distance or island area, indicating an unknown mechanism driving asymmetric gene flow. More information about the ecology of these taxa is required to understand the incidence of asymmetric gene flow in this system. The results of this study suggest that gene flow among islands is highly restricted for *M. waterhousii* and that this species deserves greater taxonomic attention and conservation concern.

Variations in Distress Calls of Belize Bats

Juliet J. Nagel; University of Western Ontario, London, ON

I recorded distress calls from ten species of bats from Belize and broadcast those distress calls at mist nets in Belize. Research was conducted at Lamanai Outpost Lodge in Belize, Central America, during May through July 2005. Calls were analyzed with BatSound Pro (Pettersson Elektronik AB) and MATLAB 7.1 (Mathworks, Inc.). I grouped calls into ten categories based on the call structure, and compared call use within and between the different species. The structure of distress calls varied extensively within individuals, within species, and among species. "Distress calls" are defined by the situation in which they were produced and have no specific structure. Any call can be a distress call if produced under conditions of physical duress. Bats often produced very complex distress calls, even switching which harmonic contains the most energy within a call. Playing distress calls seemed to attract other bats to the area, though mist-net captures were lowered. Distress calls were paired with struggling. The main function of distress calls of bats is to startle predators, and secondary functions include warning other bats of danger and possibly passing on information about the predator.

Bat Activity and Species Presence in Riparian Zones Pre- and Post-Timber Harvest
Joy M. O'Keefe, Susan C. Loeb, and J. Drew Lanham; Clemson University, Clemson, SC; USDA Forest Service, Clemson, SC

Although streams are thought to be important foraging habitat for bats, there are few data to support this hypothesis, and no data are available on the relationship between riparian buffer size and the foraging habits of bats. Our objective was to relate bat activity and species presence to riparian zone structure pre- and post-timber harvest. From May–July 2004–2007, we recorded bats in three treatment stands in which different riparian buffers (0 m, 9.1 m, and 30.5 m) were retained after a 2005–2006 harvest and one control stand (no harvest) in the Nantahala National Forest in western North Carolina. Anabat detectors were placed in three positions in each stand: stream (0 m), mid (22.9 m), and far (45.7 m) for ≥ 5 full nights each month. We used regression models to determine the effects of harvest, buffer size, and position on foraging activity (pulses/hour) and we constructed occupancy models for four phonic groups (*Myotis* spp., eastern red bats, eastern pipistrelles, and low frequency bats) using Program PRESENCE to determine how species presence varied with harvest, buffer size, and detector position. One year post-timber harvest, bat activity was 6.7–34.7 times higher than pre-harvest activity in the stream and mid positions in the 0 m and 9.1 m buffer stands. In contrast, post-harvest activity was not significantly different from pre-harvest activity in the 30.5 m buffer stand, suggesting that larger buffers may be better at maintaining riparian zone structure over the long term. Larger bats, especially red bats, responded positively to clutter reduction near streams post-harvest but the more clutter-adapted *Myotis* species were present in all treatments and positions pre- and post-harvest. It is likely that the increase in bat activity in the 0 m and 9.1 m stands was a short-term response to the reduction in clutter in these stands. The long-term effects of these treatments on bat activity and occupancy are unknown but it is important for researchers to follow responses over time as the impact of harvesting riparian buffers on bats may not be fully evident one to two years post-harvest.

Barcoding Bats: Molecular Phylogenetics of Hipposideridae and Rhinolophidae
Monik Oprea, Jeffrey Hunt, Kristofer M. Helgen, and Don E. Wilson; National Museum of Natural History, Smithsonian Institution, Washington, DC; Smithsonian Institution, Suitland, MD

Sequence diversity in the cytochrome *c* oxidase subunit 1 (CO 1) gene has been shown to be an effective tool for species identification in various groups of animals, but has not been extensively tested in bats or most mammals. We examined the performance of DNA barcodes in the discrimination of eight species of bats from Malaysia: six species of Hipposideridae and two

species of Rhinolophidae were examined by sequencing 658 bp of the CO 1 gene. Analyses of our test sample of Hipposideridae and Rhinolophidae suggest that each formed a monophyletic group. The phylogenetic analyses indicate that *Coelops* remains as a genus within Hipposideridae, with mean percentage sequence differences of 18.38%. Within *Hipposideros*, genetic distance values suggest that *H. cervinus* and *H. dyacorum* diverged from each other approximately 2.8 mya, and *H. galeritus* diverged from the *cervinus-dyacorum* clade approximately 2.4 mya. The genetic distance values also suggest that *H. bicolor* diverged from the *cervinus-dyacorum-galeritus* group approximately 2.3 mya, and *H. diadema* and *Coelops robinsoni* diverged from each other approximately 3.5 mya. Within *Rhinolophus*, *g*enetic distance values suggest that *R. borneensis* and *R. philippinensis* diverged from each other approximately 1.0 mya.

Obstacle Avoidance by Inebriated Fruit Bats, *Rousettus aegyptiacus*

Dara N. Orbach, M. Brock Fenton, and Carmi Korine; University of Western Ontario, London, ON; Ben-Gurion University of the Negev, Midreshet Ben-Gurion, Israel

The Egyptian Fruit Bat, *Rousettus aegyptiacus*, eats primarily fleshy fruits, which, as they ripen and sugars ferment, expose feeding bats to increasing concentrations of ethanol. Bats can become intoxicated from consuming these ripening fruits. To understand how increased ethanol concentrations in the diet of *Rousettus aegyptiacus* affect their motor function and orientation systems, we fed eight captive adult males 1% and 0% ethanol in fruit juice and measured their obstacle avoidance capabilities and echolocation clicks over 15 consecutive trials. We predicted that 1% ethanol-treated bats would have longer inter- and intra-click intervals and would collide more times into obstacles than 0% ethanol-treated bats, indicating compromised acoustic detection and maneuverability around the obstacles. Ingesting 1% ethanol significantly increased the number of bat collisions with obstacles. The large divergence in collision numbers between bats suggests that they have variable alcohol tolerances determined by factors besides their body mass. Trial number had no effect under 0% or 1% ethanol conditions, suggesting that time, habituation, and exhaustion did not impact obstacle avoidance. Because of their reduced maneuverability and orientation capabilities, inebriated *Rousettus aegyptiacus* potentially risk limited foraging success and reduced predator avoidance capabilities when ingesting overripe fruits under natural conditions.

Inter- and Intra-Specific Variation in the Distribution, and Roosting and Foraging Ecology of Bats on the Island of Newfoundland

Allysia Park and Hugh Broders; Saint Mary's University, Halifax, NS

Resource availability limits both the distribution of species and individual fitness. Therefore, characterizing resource requirements and availability at different spatial scales can provide great insight into the basic ecology of a population. With recent technological advances and greater knowledge regarding the threats facing bats, the study of bat ecology is becoming more common, thus increasing the potential to learn a great deal regarding the evolution and ecology of bat behaviors. However an understanding about the distribution, life history, and social structures of bats within the Province of Newfoundland and Labrador is limited. Four species have been recorded on the Province, but two (*Lasiurus borealis* and *Lasiurus cinereus*) are believed to be extra-limit records. Little brown bats (*Myotis lucifugus*) are known to range across the island of

Newfoundland, while the documented distribution of northern long-eared bats (*Myotis septentrionalis*) is restricted to the southwest portion; however, there are no documented instances of research performed outside of this area. The goal of the first year of this two-year project is to characterize the distribution of bats across Newfoundland by species and gender, and to quantitatively characterize this distribution using local and regional variables (stand and landscape attributes, climate, etc.). It is predicted that the biology of bats in this region may be different from those inhabiting other areas because of differences in environmental conditions at the eastern periphery of their range relative to other areas where the species have been previously studied. During the summer of 2008, systematic trapping surveys were conducted in 13 provincial or national parks across the island of Newfoundland. In the second year of the project we will be conducting more intensive studies on the roosting and foraging dynamics of the forest-restricted Northern Long-eared Bat, using radiotelemetry to characterize resource selection at a localized scale.

Evaluation of Ecuador-collected *Lonchophylla* using Karyological, Morphological, and Sequence Data

Julia A. Parlos, Vicki J. Swier, Hugo Mantilla-Meluk, and Robert J. Baker; Texas Tech University, Lubbock, TX

Nectar-feeding bats within the genus *Lonchophylla* represent one of the most diverse and geographically widespread genera of phyllostomid bats in the Neotropics. During the past five years, our knowledge of the diversity of *Lonchophylla* has increased with the descriptions of five new species, bringing the total to 13 species. In contrast, our knowledge of karyotypic information for *Lonchophylla* consist of a karyotype described for *L. robusta* (2N = 28, FN = 50) and four described karyotypes for *L. thomasi* (2N = 30, FN = 34; 2N = 32, FN = 38; 2N = 32, FN = 34; 2N = 32, FN = 40). During expeditions to Ecuador in 2001 and 2004, specimens of *Lonchophylla* were collected and individuals identified as different species karyotyped. To establish a relationship of karyotypic data to sequence and morphological data, sequence data for the first 400 base pairs of the *Cytochrome-b* (*Cyt-b*) gene were generated for all collected *Lonchophylla* specimens and morphological evaluations were conducted using published descriptions for specimens housed at the TTU museum. The karyotype found among the Ecuador-collected *L. robusta* was similar to that previously described by Baker (1973). This study presents the karyotype of *L. concava*, which has the same diploid FN number and karyotype like *L. robusta*. A unique karyotype for specimens of *L. thomasi* (2N = 36, FN = 50) from the western side of the Andes is described. Although similarities were found among the karyotypic data of *L. robusta* and *L. concava*, sequence and morphological data separate these two species. All specimens of *L. thomasi* with the unique karyotype (2N = 36, FN = 50) were similar when morphological and sequence data were compared. Data from karyotype, morphology, and *Cyt-b* sequences are evaluated to ascertain the data basis according to the species names available.

Temporal Changes in the Demography and Masses of Southeastern Myotis *Myotis austroriparius* in a Central Louisiana Summer Colony

Kyle J. Patton and Paul L. Leberg; University of Louisiana at Lafayette, Lafayette, LA

Little is known about the roosting ecology of the Southeastern Myotis, *Myotis austroriparius*, a colonial bat recently designated as a species of special concern in Louisiana. In Camp Claiborne, an abandoned World War II training facility near the LA town of Forest Hill, three water storage buildings house southeastern myotis during the summer months of each year. In 2008, we assessed sex ratios, age ratios, reproductive condition, and sex-specific variation in the masses of the bats from the months of March until July to understand how demography and body condition varies throughout reproduction and lactation. With an increase in females' weights in the beginning of April, and a dramatic drop in the first two weeks of May, we predict the gestation period to be about 40 days. Lactation occurred from May to early June, when the juveniles were weaned and able to fly on their own. With an average mass of 6.01 g (se = 0.02), no change in body condition was found among the adult males from the months of March until July. The masses of the females were found to fluctuate based upon month and season. Sex ratios found that more adult females were departing the buildings from the months of April until July than adult males.

Does the Little Brown Bat, *Myotis lucifugus*, Use Chemical Cues to Discriminate Between Individuals from Near and Far Roosting Sites?

Jessica L. Pawlowski, Erica M. Stephens, and Karry A. Kazial; State University of New York, Fredonia, NY

The purpose of this study was to determine whether little brown bats use chemical cues to discriminate between individuals from a roost site near to their own and a far roost site. A total of 18 bats were captured for use as test subjects (10 females, 8 males, 11 adults, 7 young of year) from the SUNY Fredonia campus and Chautauqua Institution and tested in a Plexiglas Y-maze (29 cm x 12 cm x 12 cm base, 34 cm x 12 cm x 12 cm arms). Scents were obtained on cotton swabs that were rubbed five times on the chin, cheek, and genital areas of the bats. The end of one arm of the Y-maze contained the scent of a bat from a near roost site and the other arm contained the scent of a bat from a far roost site. The researcher recording the response of the bat was unaware of which arm had which scent. Scents were gender-matched. The scent of a bat from a near roost site was placed in the right arm of the Y-maze for half of the trials. Each bat was placed into the base of the Y-maze initially for one minute in a covered gated area. The bat was then released by opening the gate allowing the bat to move through the Y-maze for three minutes. Ethyl alcohol and water were used to clean the Y-maze between trials. Results will include an examination of the number of times the bat entered each arm, the amount of time the bat spent in each arm, and additional behavioral observations. This examination will allow us to conclude whether little brown bats prefer to be near the scent of a bat from a roost site near to their own or a far roost site.

Additional Data on Bat Predation by Cats
Jansel Perez, Jean Manuel Sandoval, Mari Ana Montalban, and Armando Rodriguez-Duran; Universidad Interamericana, Bayamon, PR

Last year we provided data on bat predation by cats based primarily on wing remains obtained at the entrance to Culebrones Cave, Puerto Rico, West Indies. Culebrones Cave is a hot cave located in the karst region of northern Puerto Rico. The temperature gradient inside the cave sustains a multi-species assemblage of bats consisting of approximately 300,000 individuals of six species, namely: *Brachyphylla cavernarum, Erophylla bombifrons, Monophyllus redmani, Mormoops blainvillii, Pteronotus quadridens*, and *Pteronotus parnellii*. Here we report additional observations on the predation on bats by feral cats. We filmed the hunting strategy of cats and recorded the number of wings left as remains of these hunting bouts. We also examined cat scats found at the entrance to the cave. Wing and bone remains were identified to species. It appears as if bat captures are not a function of their potential prey abundance in the cave. Although *Mormoops blainvillii* (11 g) and *Pteronotus quadridens* (5 g) are more commonly captured with a harp trap placed at the entrance to the cave, wing remains from *Brachyphylla cavernarum* (50 g) and *Monophyllus redmani* (11 g) were more commonly found. Cat scats showed a preponderance of bones from *B. cavernarum* and *E. bombifrons.* Remains from cockroaches represented the most common item in scats. Feral and domestic cats are known to adversely impact native faunas in the areas where they have been introduced. This impact is even greater on islands. Although rats are often their primary prey, cats will use alternative prey, which enables them to maintain their abundance when one prey is not available. In Puerto Rico, it is known that cats prey on birds and reptiles. Although cats are commonly observed in or around bat caves in Puerto Rico, no systematic attempt had been previously made to evaluate their impact on bat populations.

Weekly Capture Rates of Bats from Summer Mist Netting in Forests Provide Clues to Sex-specific Temporal and Spatial Patterns of Abundance
Roger W. Perry; Forest Service, U.S. Department of Agriculture, Hot Springs, AR

I quantified weekly capture rates and sex ratios from May to September for eight bat species during eight years of mist netting in forests to provide insight on temporal patterns in relative abundance and sex ratios that have implications for seasonal distributions, migration, site fidelity, and demography. Eastern red bats (*Lasiurus borealis*) were the species most often captured (76% of total captures) and overall capture rate was up to 27 times greater in August and September than in spring or early summer. Capture rates of hoary bats (*L. cinereus*) demonstrated peaks in late spring and late summer, but captures of both sexes were relatively low in mid-summer. Captures of evening bats (*Nycticeius humeralis*) and northern long-eared bats (*Myotis septentrionalis*) peaked in early- to mid-August as well. Silver-haired bats (*Lasionycteris noctivagans*) were abundant in late spring and late summer but were absent during mid-summer. Sex ratios of red bats were predominately male in late spring and late summer but were dominated by females in mid-summer, possibly because of increased activity by lactating females during mid-summer. Sex ratios of red bats, eastern pipistrelles (*Perimyotis subflavus*), and hoary bats were approximately 70% male, and sex ratios of evening bats, Seminole bats (*L. seminolus*), and big brown bats were almost exclusively male. I recaptured individual red bats, Seminole bats, pipistrelles, northern long-eared bats, and evening bats in multiple years, suggesting they are either year-round residents or returned to the same areas each summer. My results demonstrate that both capture rates and sex ratios of forest bats determined via mist netting are contingent on the period in which summer surveys are conducted.

Forest Bat Activity along Traditional and Sky-canopy Edges
Thomas W. Pettit and Kenneth T. Wilkins; Baylor University, Waco, TX

Forest edges support high levels of animal activity, particularly for forest bats. Most study of bat activity in forest edges has been in traditional vertical edge, and few studies have examined bat activity levels at sky-canopy edges. We expected both forest edge types (traditional, forest-meadow interfaces or horizontal, sky-canopy interfaces) to exhibit similar levels of activity and use. We investigated edges in mixed aspen (*Populus tremuloides*) and Douglas fir (*Pseudotsuga menziesii*) forest near Heber Valley, Utah, during the summer of 2008. Anabat II SD1 bat detectors were placed in both edge types, with 12 total sites (6 for each edge type). At each site, detectors ran from 20:00 to 06:30 each of 15 nights during July and August. Results revealed an average of 40.6 bat calls per night for traditional edges, significantly greater than the 5.1 calls per night for sky-canopy edges. Traditional edge activity levels tested as similar across most sites, and sky-canopy activity levels tested as similar across most sites. Levels of bat activity in neutral, “open” areas were similar to traditional edge data. Results suggest a distinction between bat activities in traditional and sky-canopy edges, perhaps indicating that bats use traditional edges for foraging and sky-canopy edges mainly as a means of commuting between other habitat types.

Is the Andes Mountain Range a Strong Geographic Barrier for Common Vampire Bats?
C. Miguel Pinto, Hugo Mantilla-Meluk, Steven R. Hoofer, and Robert J. Baker; Texas Tech University, Lubbock, TX; University of Kansas, Lawrence, KS

Common vampire bats (*Desmodus rotundus*) have economic and public health importance, for factors including losses caused to cattle ranching and transmission of zoonotic agents. Common vampire bats are widely distributed in the Neotropics, and historically all the populations have been considered as a single operational taxonomic unit; however, this traditional classification has been recently challenged by the use of molecular markers revealing high genetic diverge among populations. Herein we test the hypothesis of the Andes mountain range as an effective biogeographic barrier preventing gene flow between populations from both the eastern and the western versants of the system. In order to test our hypothesis we explore the genetic constitution of Ecuadorian populations of vampire bats, including samples collected in a trans-Andean transect in southern Ecuador, ranging from 251 m on the western side up to an elevation to 2,142 m in its maximum level, and descending to 875 m on the eastern side. For up to 138 individuals, the entire mitochondrial Cytochrome-*b* gene, and fragments of the nuclear Beta-fibrinogen and von Willebrand Factor genes were sequenced. Phylogenetic and computational geographic analyses were performed. For the mitochondrial gene, two highly divergent phylogroups were recovered, belonging each to either side of the Andes showing no signals of maternal trans-Andean gene flow and dispersal. However, the nuclear markers suggest paternal-based dispersal and gene flow events. The high human disturbance in the Andean region allowing the potential overlap in the current distribution of populations from each side of the Andes seems to be the major force influencing the mixing of these very divergent populations.

These results reinforce the need for examining at least two genetic transmission pathways (i.e., maternally and biparentally inherited) to solve biogeographic questions.

Roosting Ecology of *Perimyotis subflavus* in Southwest Nova Scotia

Joseph A. Poissant, Howard M. Huynh, and Hugh G. Broders; Saint Mary's University, Halifax, NS; Acadia University, Wolfville, NS

The population of eastern pipistrelles in Nova Scotia appears to be small and possibly disjunct. Further, research suggests they may be behaviorally (novel roosting sites in trees, predominately within clumps of bony beard lichen—*Usnea trichodea*) and morphologically (larger size) distinct from other eastern pipistrelle populations. Such distinct and peripheral populations are valuable as reservoirs of genetic diversity as they are less prone to extinction and have a higher probability of experiencing speciation due to genetic variation. Knowledge of the roosting behavior of this species is important for conservation because changes to roosting territory may have serious repercussions to a colony. The objectives of this research were to determine the local distribution of the population and characterize roost sites at the tree and stand level. From June–August 2007 and 2008, we captured eastern pipistrelles at a river foraging site within Kejimkujik National Park, attached radio transmitters, and tracked them to roost trees. Five distinct colonies were identified within 6.5 km of the capture site and individuals appeared to have an affinity to a single roosting area. Roost trees were dominantly coniferous with greater than 25% *Usnea trichodea* lichen coverage. It appears that *Usnea trichodea* is a limiting resource for this population, impacting their roosting ecology, and therefore, an understanding of the relationship between the biology of *Usnea trichodea* and its use as a roosting medium is important for making sound management recommendations for eastern pipistrelles in Nova Scotia.

Evening Emergence Behavior and Seasonal Dynamics in Large Colonies of Brazilian Free-tailed Bats

Jonathan D. Reichard, Lauren E. Gonzalez, Caitlin M. Casey, Louise C. Allen, Nickolay I. Hristov, and Thomas H. Kunz; Boston University, Boston, MA

Animals that form large aggregations benefit from employing flexible behaviors in response to endogenous and exogenous factors such as prey availability, reproductive status, social dynamics, and climatic conditions. Evening emergence behavior of Brazilian free-tailed bats (*Tadarida brasiliensis*) representing different reproductive cohorts was recorded to test hypotheses that this behavior is associated with predator avoidance and seasonal energy demands. In 2007, gestation lasted approximately 80 days in south-central Texas and median parturition occurred on 18 June. Median lactation period was about 54 days with juveniles commencing flight at about 40 days of age. On average, bats began evening emergences 11.8 (95% CI 7.1, 16.6) min after sunset. That colonies as a whole, and females in particular, tended to emerge after sunset is consistent with a predator avoidance hypothesis. Lactating females emerged earlier than other bats, consistent with the hypothesis that this is a period of high energy demand. Juvenile bats emerged later than adult females during their earliest flights, but emerged earlier as they matured, suggesting a trade-off between predator avoidance and energetic demands. The plastic behavior of Brazilian free-tailed bats during nightly emergences supports the hypothesis that responses to environmental cues are moderated by nutritional demands associated with reproduction.

Mayday Mayday Mayday! Effects of White Nose Syndrome on the Little Brown Myotis *Myotis lucifugus* at Maternity Roosts

Jonathan D. Reichard, Catherine C. Kang, Laura L. Vankhanh, and Thomas H. Kunz; Boston University, Boston, MA

The potential catastrophic impact of White Nose Syndrome (WNS) on bats in the northeastern U.S. became most apparent during the winter of 2007–2008. WNS has been judged responsible for major die-offs of hibernating bats; however, its effects on survival and reproductive success during the active season are not yet known. We monitored two maternity colonies of little brown myotis (*Myotis lucifugus*) in Massachusetts and New Hampshire at biweekly intervals from mid-May through mid-August to assess overall body condition of bats within the putative geographic range affected by WNS. Scarring was observed on the flight membranes of many bats, a condition hypothesized to be associated with WNS. We developed a wing damage index (WDI) to score flight membranes based on the relative prevalence and severity of depigmented and necrotic tissue. The WDI scores bats from 0 (no damage) to 3 (severe damage) and is proposed as a standard for monitoring wing conditions of bats. Up to 61% of bats in the two colonies studied exhibited scarring or damage to their flight membranes on a given sample night. Bats with damaged wings may experience reduced agility and foraging success. This hypothesis is consistent with significantly lower body mass for bats with WDI = 3 compared to those with WDI = 0 between 14 May and 4 June (6.9 g and 7.8 g, respectively, ∀=0.05). We expected that bats with severe wing damage early in spring did not survive later into the maternity period. WDI = 3 was recorded in early spring, but not after 6 June. WDI = 2 was not recorded after 9 July. Bats with WDI $\leq$ 2 may have healed, as supported by minor improvements observed in wing condition among several recaptured bats. Juveniles had very low prevalence of WDI $\geq$ 1 and observed scars were often associated with high ectoparasite presence. It is likely that exposure to WNS during hibernation may have adverse affects on survival and reproduction during the subsequent active season. Monitoring wing damage at maternity roosts provides essential information for assessing the full impact of WNS on affected bats and for determining and predicting the possible spread of this syndrome.

Feeding by Migrating Hoary *Lasiurus cinereus* and Silver-haired Bats *Lasionycteris noctivagans*: Are They Attracted to Insects at Wind Turbines?

Jesika Reimer, Erin F. Baerwald, and Robert M. R. Barclay; University of Calgary, Calgary, AB

As wind energy production grows, so do concerns about fatalities of migrating bats at wind turbines. One hypothesis to explain bat fatalities is that migrating bats are attracted to insects congregating near turbines, but little is known about the feeding habits of migrating bats. To test the insect-attraction hypothesis and examine the feeding behavior of migrating bats, we studied hoary bats *Lasiurus cinereus* and silver-haired bats *Lasionycteris noctivagans* at a wind energy facility in southwestern Alberta. We analyzed stomach contents from turbine-killed bats and echolocation recordings from wind turbine locations, to address three questions: 1) Do migrating hoary bats and silver-haired bats feed while en route? 2) What do migrating bats eat? 3) Do migrating bats feed at wind turbines? We found that both species feed while migrating and that their diets are similar to those found in their summer and winter grounds, with the exception that migrating bats consumed a considerable number of water boatmen (Order: Hemiptera, Family: Corixidae). Based on the echolocation recordings, there was little feeding activity around the turbines at rotor height. This suggests that bats are not attracted to insects around wind turbines.

Glucocorticoid Hormone Responses to Harp Trap and Mist Net Capture in Lactating, Post-Lactating, and Pre-Migratory *Myotis lucifugus*

Angela G. Remeika, Megan E. Vodzak, Scott M. Wasilko, and DeeAnn M. Reeder; Bucknell University, Lewisburg, PA

Bats are routinely captured in both mist nets and harp traps for a variety of reasons. The precise physiological effects of capture are not well understood, but capture and handling are known to elicit elevations in the stress-responsive glucocorticoid (GC) hormones, cortisol and corticosterone. In order to determine the time course of the stress response to capture in either harp traps or mist nets, little brown bats (*Myotis lucifugus*) were trapped and a blood sample was either immediately collected (time 0) or collected after the bat remained in the trap for 1, 2, 3, 4, 5, 10, or 15 minutes. Samples were collected during late pregnancy, lactation, post-lactation (harp trap only), and pre-migration (both harp trap and mist net) to assess whether the response to capture and handling differed across reproductive conditions. We hypothesized that capture would result in significant elevations in GC levels that would correlate with time spent in the trap, and that capture in a mist net would elicit a greater GC response than capture in a harp trap. In lactating, post-lactating, and pre-migratory conditions, the GC response to capture was significantly correlated with time in the trap. Contrary to our initial hypothesis, capture in mist nests was not more stressful than capture in harp traps.

The Value of Long-term Mark-Recapture Data for Identifying Life History Variation in the Little Brown Bat *Myotis lucifugus*

D. Scott Reynolds; St. Paul's School, Concord, NH

I have been conducting a mark-recapture project on a maternity colony of little brown myotis (*Myotis lucifugus*) in Peterborough, New Hampshire since 1993. Over the past 16 years, I have captured over 7,500 bats and banded 4,630 individuals. The majority of these bats (n = 1,713) were first banded as reproductive adult females. The average time to recapture was 1.8 years (range 0–9 years), suggesting that long-term studies are necessary for accurate survivorship estimates. A total of 857 mother-pup pairs were captured throughout the study in order to assess the influence of maternal age and size on reproductive timing and juvenile sex ratio. These data suggest primiparous females give birth significantly later (7–10 days) than experienced females and have a male-biased sex ratio (0.59). Data collected at this site also suggest that few females reproduce in their first year after birth, and that cohort-specific reproductive rates become age-independent after three years. Although the original focus of this study continues to be the development of an accurate life history model of this species, many ancillary projects have recently emerged as a result of these pre-existing data. These projects suggest that similar studies would be valuable for dealing with current and future issues with regards to bats.

Ambient Temperature as a Possible Effect on Roost Site Selection by *Corynorhinus rafinesquii* (Rafinesque's Big-eared Bat) in a Bottomland Hardwood Forest Streambed

Chris L. Rice and Kim M. Tolson; University of Louisiana at Monroe, Monroe, LA

Corynorhinus rafinesquii (Rafinesque's Big-eared Bat) is found in scattered localities throughout the southeastern United States and is listed federally as a "species of concern." Research efforts were initiated in an attempt to determine roost site preference during periods of fluctuating ambient temperatures. Twelve individuals were outfitted with 0.42 g radio transmitters attached to the interscapular region with surgical cement. Telemetry was conducted over the course of 52 days from 15 September to 26 December 2007 on the Upper Ouachita National Wildlife Refuge in northeastern Louisiana. Tree cavities of 59 potential roost sites (water tupelo, *Nyssa aquatica*; bald cypress, *Taxodium distichum*; willow oak, *Quercus phellos*; persimmon, *Diospyros virginiana*; and water oak, *Quercus nigra*) were also searched for 22 days during the last quarter of 2007. All trees were classified according to the location of tree cavity openings: Type 1 (basal opening only); Type 2 (basal opening and chimney opening); and Type 3 (chimney opening only). When ambient temperature fell below 8° C, 20 of 24 (83%) transmitter "fixes" were located in Type 3 trees, while the other four "fixes" were in Type 1 trees. Cavity searches of all 59 trees revealed *C. rafinesquii* were found in only water tupelo and bald cypress trees (Types 1 and 2), and that presence of these bats increased as ambient temperature increased ($r^2 = 0.7014$). Data will be analyzed on distance of movements, frequency of tree use, and site characteristics for all trees.

Allometry of Inertial Power during Flight in Pteropodid Bats

Daniel K. Riskin, Jose Iriarte-Diaz, Kevin M. Middleton, Kenneth S. Breuer, and Sharon M. Swartz; Brown University, Providence, RI; California State University- San Bernardino, CA

Because of their large range of body sizes, coupled with overall similarity in body and wing form, pteropodid bats comprise an ideal case study in the scaling of locomotor mechanics and performance. Like a machine, a bat uses energy to fly, and the total energy of flight can be partitioned into 1) basal metabolism (metabolic power), 2) pushing air around (aerodynamic power), and 3) the acceleration and deceleration of the mass of the wings (inertial power). In this study we sought to understand how the inertial power requirements of flight change for bats of different body sizes. We measured the wing kinematics of 28 bats drawn from 6 pteropodid species, spanning a 45-fold range of body masses. The smallest species in our study had an average mass of 27 g (*Cynopterus brachyotis*), and the largest, 1,270 g (*Pteropus vampyrus*). For each bat, we recorded five separate wingbeat cycles with 1000 fps high-speed cameras, and tracked the three-dimensional motions of 17 markers placed across the body and one wing. Based on more than half of the recorded trials, our data demonstrate that wing motions are strikingly similar across species and show the predicted pattern, decreasing wingbeat frequency with increasing body size. Based on a model that accounts for the complex spatial distribution of wing mass, we estimate that the cost of swinging the wing, in watts or joules/second, is larger for larger bat species. When the energetic cost of wing motions is normalized to body mass (watts per kilogram), the inertial cost of flight is similar for all species. We hypothesize decreasing wingbeat frequency with increased body mass serves to limit this energetic cost in larger animals.

Multimodal Target Facilitates Odor Discrimination Training in Lesser Dog-faced Fruit Bats

Alexander C. Robb, Sarah A. Stamper, and Sharon M. Swartz; Brown University, Providence, RI

Cynopterus brachyotis forage for fruit in dense tropical forests that present a diversity of sensory cues. It is believed that their foraging behavior is primarily guided by visual and olfactory information; however, no laboratory experiments have made use of this multimodal foraging behavior in a training paradigm. The aim of the study was to train *C. brachyotis* to associate a nectar reward with a multimodal (visual and olfactory) target to facilitate steady flight performance in a wind tunnel. Our preliminary training indicates that these bats can learn an association with a multimodal stimulus and exhibit targeting behavior. Two bats were pre-trained to associate a tone a with a nectar reward. This tone was used as a bridge in subsequent training. They were then trained to target a vertical rod placed approximately 3 cm in front of the bat. Targeting behavior consisted of a nose press to the rod within 5 seconds of stimulus presentation. At this distance, the rod served as a visual stimulus, and the tip was coated in peach extract to provide an olfactory cue, giving the bats a multimodal target. The bats rapidly learned the targeting behavior and reliability performed within five training sessions. To control for a position bias, the target was systematically moved relative to the bat in the horizontal plane during training. We noticed that when the target was moved in this way, bats physically tracked the target by moving their heads. The association that the bats had formed between the target and nectar reward was tested using a two-alternative forced choice discrimination. An apparatus was constructed to hold two vertical rods equidistant to the bat at 45° to either side. The positive stimulus (S+) was the rod used in training coated in peach extract, and the negative stimulus (S-) was coated in orange extract. The left-right presentation of the S+ was pseudorandom across blocks. The bats correctly targeted the S+ in 75% of the trials and made an incorrect choice in 5%. In the remaining trials bats did not respond to either stimulus within the 5-sec choice criterion. These results indicate the bats can exhibit targeting behavior using a multimodal stimulus in an odor discrimination paradigm.

Indiana Bats and Pre-construction Surveys: Methods and Goals

Lynn W. Robbins, Josh R. Flinn, Jason T. Layne, Shelly N. Dey, and C. Ryan Allen; Missouri State University, Springfield, MO; University of Missouri, Kansas City, MO

Pre-construction surveys are and have been designed to determine total bat activity and /or species or species group activity at presumed turbine sites and at different altitudes. The goal is to predict post-construction mortality using these data. To date, no published studies have found endangered bats, specifically the Indiana bat, to be present at the site prior to construction or as post-construction casualties. Presence/absence surveys in northern Missouri indicate the presence of Indiana bats including primary maternity roosts in and adjacent to proposed wind farms. In addition to captures and telemetry, we are using ground based Anabat II detectors to determine areas and timing of activity of each species, using habitat, season, and weather as variables. Although captures occurred in most areas with suitable habitat, detector-recorded activity levels relative to the other species were common only in specific habitats, namely within forested areas. Activity in more open habitat occurred more often during the presumed migration period, but was uncommon relative to other species. GIS-generated areas of predicted activity are being used in deliberations with wind energy companies to determine placement of turbines.

Results of a Five-year Bat Study at Fort Bragg and Camp Mackall, North Carolina with Emphasis on Day Roosts of *Myotis austroriparius* and *Corynorhinus rafinesquii*

Piper Roby and Mark Gumbert; Copperhead Environmental Consulting, Inc., Paint Lick, KY

A seven-year inventory and monitoring of bat species at Fort Bragg and Camp Mackall is in its fifth year. A total of 625 bats of ten species have been documented with the most commonly caught species being *Nycticeius humeralis* (40%). We examined the roost sites of 13 *Corynorhinus rafinesquii* (CORA) and 7 *Myotis austroriparius* (MYAU) with the use of radiotelemetry. Although the CORA that were documented included reproductive females and males, we were only able to locate roosts for male MYAU. We found a total of 17 roosts used by both species. Three roosts were on private property (two structures and one tree) while the remaining four structures and ten trees were within the Camp Mackall boundary. Both species used *Nyssa* spp. trees with hollow cavities, but CORA also used manmade structures (five abandoned buildings and one cistern). All tree roosts were within the floodplain of Drowning Creek (< 140 m away) whereas all manmade structures were away from the creek (> 1,000 m). CORA used larger trees than MYAU with respect to diameter at breast height (dbh) and tree height. Trees used by CORA averaged 73.3 cm dbh and were 22.7 m high while MYAU averaged 64.7 cm dbh and 18.7 m high. MYAU roost trees were closer to the capture site (mean = 592 m) than trees used by CORA (mean = 1,016 m). Manmade structures used as roosts were farther from the capture site (mean = 2,156 m) than trees used by either species. The cistern used in 2007 was periodically checked throughout the winter by Ft. Bragg Endangered Species Branch staff and contained bats, including CORA, on several occasions. It is believed that the colony size of CORA bats on Camp Mackall is relatively small, given the high number of recaptures of banded bats and the number observed in various roosts. To date we have been unsuccessful at locating a maternity roost for MYAU on or near Camp Mackall. However, continued data collection on both species will provide a better picture of the rare bat community on this military base.

Dynamics of Gene Flow and Extinction in Island Metapopulations under Climate Change: Model Discrimination through Population Genetic Simulations

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

Gene flow between metapopulations in habitats of differing quality and size allows species to persist in fragmented ecosystems. The combined effects of anthropogenic fragmentation and climate change are expected to further degrade and reduce natural habitats and lead to declining population sizes, as well as increased isolation between patches limiting gene flow. In many cases these trends will lead to local extirpation, and in the absence of habitat of adequate quality and size, to extinction. The pace of climate change expected over the next century is unprecedented, but its scale is not. During the last deglaciation the West Indies experienced a wave of extinction linked to the transition from xeric to mesic habitats and the decrease in connectivity resulting from higher sea levels. Environmental niche modeling has provided a methodology for using current patterns of ecological niche characteristics both to project past distributions under ancient climates and to forecast changes in distribution under future climate change models. Current practices in environmental niche modeling involve constructing inferred distributions by averaging over multiple equally-supported climate models, an approach that introduces considerable error into the procedure. We propose to utilize population genetic simulations as a method of rejecting reconstructed distribution models. We are modeling the dynamics of gene flow between islands for three Caribbean endemic lineages that underwent multiple local extinctions since the Last Glacial Maximum—*Tadarida brasiliensis*, *Mormoops blainvillei*, and *Artibeus jamaicensis*. By combining these results with niche-based models of habitat suitability for past and present climate conditions, we will elucidate the circumstances that led to local extinction on some islands but not others. The links modelled between extirpation and climate change will be projected to future climate conditions to identify populations at risk.

Density Response to Habitat at Different Scales: A Case Study in the Tent-roosting Bat *Uroderma bilobatum*

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

Species are more abundant in some habitats than others; however, most explanatory theories that are proposed to explain this generate ambiguous results. This ambiguity could be due to unaccounted variation in scale of habitat use. Two possible scales at which animals may perceive their environment are fine-grained, based on characteristics of the microhabitat surrounding the roost, and coarse-grained, by which some macrohabitats such as forest and open areas are selected preferentially over others. Heterogeneous landscapes are usually divided into patches; some are suitable and contain food and roost resources for individuals, and some are not. In a cost-free environment in which animals specialize on high-quality patches, individuals can select habitats containing advantageous resources such as food and roosts. At a coarse-grained scale, individuals may be selecting habitats with characteristics that maximize their reproductive fitness, such as particular vegetation or proximity to water. That is why we should examine different scales to find patterns in habitat selection. To determine the scaling of habitat use and density response by *Uroderma bilobatum,* we estimated microhabitat variation within small plots nested within different macrohabitats. The selected macrohabitats were based on land use—forest and urban areas. The microhabitat variables that we measured were vegetation below 2 m, number of bushes, number of trees, tree diameter, light penetration, plant and tent height, and distance to the forest. We measured microhabitat variables for all plants with tents and then randomly selected the same number of plants without tents to take the same measurements. The density of bats was calculated as the number of bats per m^2. Data were analyzed using a variation partitioning analysis to disentangle the variance explained by microhabitat (as a whole, as well as every individual variable) and macrohabitat. The macrohabitats (forest and open areas) were converted to dummy variables before performing the analysis. Disentangling density responses to different habitat characteristics at different scales will improve understanding of spatial and temporal dynamics of populations as well as habitat effects on group cohesion. The study of habitat selection also provides insights into the potential effects of alteration of habitats related to climate change on the distribution of organisms.

Evolution of Roost Making in Bats: Adaptations for Excavating Active Termite Nests in *Lophostoma* (Phyllostomidae: Phyllostominae)

Sharlene E. Santana, Dina K. N. Dechmann, and Elizabeth R. Dumont; University of Massachusetts, Amherst, MA; Leibniz-Institute for Zoo and Wildlife Research, Berlin, Germany

Male polygynous bats often attract females by defending key resources such as roosts. In one genus of New World leaf-nosed bats (Phyllostomidae, *Lophostoma*), males make roosts by excavating a chamber inside active termite nests. The material of these nests is much harder than the insects *Lophostoma* consumes, thus males spend considerable time and probably energy in roost construction and maintenance. We tested the hypothesis that roost making in *Lophostoma* is associated with either sexual dimorphism or unique performance attributes when compared to its non roost-making relatives. We documented roost-making behavior in *Lophostoma* and measured bite force, tooth wear, and basic morphometric variables in *Lophostoma* and four closely related phyllostomids. We found no evidence of sexual dimorphism in bite force, tooth wear, or cranial morphology, and no evidence that *Lophostoma* has unusually higher maximum bite force than other phyllostomids. However, we did find that *Lophostoma* uses its canine and incisor teeth to excavate termite nests and that its canine bite force is relatively higher than in close relatives with similar diets. The capacity of *Lophostoma* to generate relatively high bite forces with their canine teeth could represent an adaptation for excavating roosts in live termite nests. Whether high canine bite forces are traceable to specializations in muscular or bony morphology remains to be determined. In either case, there does appear to be a link between a social behavior, roost construction, and biting performance.

Invertebrate Assemblages in Guano Produced by Piscivorous Bats and Insectivorous Birds from Puerto Rico

Brian Schaetz, Allen Kurta, and Olivia Munzer; Eastern Michigan University, Ypsilanti, MI; SWCA Environmental Consultants, Austin, TX

Ventana Cave on the island of Puerto Rico, the easternmost island in the Greater Antilles, is home to greater fish-eating bats (*Noctilio leporinus*) and cave swallows (*Hirundo rustica*). Bat guano is the trophic basis for many communities of cave invertebrates. These caves are important for ecological studies because of their physically condensed and contained structures, which allow for close examination of defined interactions. No published studies compare the invertebrate community in guano of fish-eating bats to that of an insectivorous bird species roosting only a few meters from this species of bat. Two 16-ounce samples were obtained from each of four piles of bat and bird guano, using a bulb planter. Samples were dried in a Berlese funnel, and stored in 70% ethanol until the invertebrates could be identified under a dissecting microscope. We predicted that there will be differences in the invertebrate communities, and these differences should reflect the variation in diet between cave swallows and fish-eating bats. Coleoptera, Diptera, and Collembola were some of the orders of invertebrates identified in preliminary analyses of guano samples.

Dark Banquet: The Curious Lives of Blood-feeding Creatures
Bill Schutt; C. W. Post College of Long Island University, Brookville, NY

For centuries, vampires have inhabited our nightmares and horror stories, and until recently, the most shadowy realm of our scientific knowledge. Currently though, scientists have come to see blood-feeding creatures not as monsters, but as highly evolved specialists, exploiting a worldwide resource: blood. In mapping out the world of blood-feeding creatures, I focused on their natural history and behavior—especially their unique feeding habits. Among the sanguivores I studied were vampire bats (wildly misunderstood until relatively recently and feared for the transmission of rabies, their populations have exploded in some locales because of humans and their livestock); leeches (ancient invertebrates now helping surgeons save newly transplanted limbs); bed bugs (entomologists and pest control experts believe that *Cimex lectularius* will be the number one household pest within three years); mites (the tiny bee parasite *Varroa destructor* has been implicated as a factor in Colony Collapse Disorder—currently devastating bee populations across the world); and the candiru (a slender siluriform catfish with a nasty habit of swimming up the human urethra). What emerged from my studies was an understanding that feeding on blood is a difficult (but obviously not impossible) way to make a living, with the success and survival of the blood feeder dependant on overcoming a number of significant obstacles (e.g., thick skin, blood clotting mechanisms, and a tendency to get swatted by the prey/host if you're discovered). In that regard, blood-feeding creatures exhibit many examples of convergence, including small size, stealth, painless bites, and an array of salivary anticoagulants.

Costs and Benefits of Automated Call Detection
Mark D. Skowronski and M. Brock Fenton; University of Western Ontario, London, ON

Long-term acoustic surveys are emerging as the tool of choice for environmental assessments of bat activity and diversity. Acoustic methods offer six important advantages of operation: 1) ease of deployment; 2) coverage of a reasonable volume of airspace; 3) provide data on bat species, density, and activity times; 4) are non-invasive; 5) are capable of continuous unattended operation for months at a time; and 6) are inexpensive compared to radar systems. Triggered recording extends memory storage space and battery life, reduces transmission bandwidth when storing remotely, and reduces analysis time. Commercial recording systems offer several methods for triggering, but a systematic investigation of the costs and benefits of different automated call detection methods has not been undertaken. Analysis of the volumes of data represented by recordings is an important challenge to those using acoustic systems, including measuring activity (detecting calls) and identifying the species of bats that produced them. We tested the underlying detection algorithms against manual detection to quantify accuracy and speed of analysis. Human experts were the most accurate, increasing effective detection range by 25% compared to a model-based detector, the most accurate automated method. However, humans were 10 times slower than the model-based detector and 110 times slower than a broadband energy or zero-crossing detector, the fastest automated methods. The results allow researchers to better plan long-term acoustic surveys.

A Survey of Bats, Caves and Cave Resource Use on Bohol Island, Philippines

Jodi L. Sedlock, Reizl Jose, Jessica Vogt, Lisa Pungantulan, and Apolinario Carino; Lawrence University, Appleton, WI; Central Visayas State College of Agriculture, Forestry, and Technology, Roxas, Bilar, Bohol, Philippines; Cebu Biodiversity Conservation Foundation, Cebu City, Philippines; Bat Count Philippines, Magatas, Sibulan, Philippines

Prior cave fauna inventories within the Rajah Sikatuna Protected Landscape (RSPL) on Bohol Island resulted in the documentation of bat species absent or rare in other, more thoroughly studied regions of the Philippines. The absence of these species on other islands may reflect many species' requirement for large caves and lowland forest, resources present on Bohol Island and rare in other surveyed areas. In order to determine the conservation status of these cave-dwelling bats, we surveyed bats and documented the disturbance of 14 caves within the RSPL, and 11 caves outside RSPL that were either developed or earmarked for ecotourism development. We assessed bat diversity through a combination of harp trap sampling in forests near caves, visual assessments of cave populations, and acoustic monitoring. Cave disturbance was assessed by recording physical signs (e.g., digging, fishing nets, graffiti, etc.) within each cave, and also through standardized community cave use surveys. We documented 30 bat species, including 6 species not previously recorded on the island. Small-scale guano collection for use in local rice fields was common within RSPL; however, swiftlet nest collecting and treasure hunting activities appear to pose a greater threat to cave bat populations.

***Landscape Level Variability of Malaysian Insectivorous Bats**

Juliana Senawi, Norhayati Ahmad, Zubaid Akbar Mukhtar Ahmad, Thomas H. Kunz, Sucharita Gopal, and Tigga Kingston; Universiti Kebangsaan Malaysia, Selangor, Malaysia; Boston University, Boston, MA; Texas Tech University, Lubbock, TX

*** Juliana Senawi** received the **Speleobooks Award**

This study was conducted at Krau Wildlife Reserve, Pahang, Malaysia to understand the structure of insectivorous bat assemblages in an undisturbed rainforest. The study was targeted at the local and landscape levels. Five study sites were selected within the Reserve: Kuala Lompat (KL), Lubuk Baung (LB), Kuala Sungai Serloh (KS), Kuala Gandah (KG), and Jenderak Selatan (JS). At each site a 1 x 1 km grid comprising a system of 22 km of trails was established. Bats were captured using 10 four-bank harp traps, positioned approximately 50 m apart, across the trails. The harp traps were moved to new positions each day until the entire trail system had been trapped. A total 1,998 harp-trap nights generated a cumulative species list of 36 species. The highest number of species richness was at KS (31 species), followed by KL and LB (28 species each), JS (27 species), and KG (26 species). Species diversity at KL, LB, and KS was dominated by *Kerivoula pellucida*, *Rhinolophus lepidus*, and *K. intermedia*, respectively, whereas both KG and JS were dominated by *Hipposideros cervinus*. *Kerivoula intermedia* and *R. stheno* represent the most abundant species at all five study sites. Jaccard's Similarity Index suggested that the bat assemblages at JS and KS were similar with a value of 87%. The bat assemblages in the other sites were a subset of these two assemblages, beginning with KG (84%), LB (77%), and KL (69%). The rank order of the mean of Simpson's Index of Diversity was highest at KL (0.91), followed by KS (0.89), KG (0.88), LB (0.87), and JS (0.80). This ranking was consistent with those of species richness and dominance index. Pair-wise comparison of species richness indicated that KS was significantly more diverse than others. The bat assemblage at JS showed a

significantly high dominance index, compared to other sites. Combining the data from this study with those of a previous one, shows that Krau Wildlife Reserve supports the highest species richness recorded from a single locality in the Paleotropics. The data will be useful to predict relative vulnerability of bats species, and to provide strategies to relevant authorities on the management and conservation of bats.

Fourteen Years of Bat Hibernaculum Monitoring in Wisconsin with Non-Standard Bat Gate Designs

Joseph A. Senulis; Wisconsin Department of Natural Resources, Madison, WI

The Atkinson Mine bat hibernaculum was gated by caving groups in 1993 to keep out partiers and to protect the bats. This bat hibernaculum has been known for decades, but it was not until 1990 that the first census was made. Hibernators are primarily little browns (*Myotis lucifugus*), a number of eastern pipistrelles (*Perimyotis subflavus*), and some northern long-ear bats (*M. septentrionalis*) and big browns (*Eptesicus fuscus*). When the gate was constructed, the recommended design consisted of angle-iron bars with a 15.2 cm (6 in) vertical and at least 61 cm (2 ft) horizontal spacing, based on southern sites. However, no justification was available at the time for why that was the best design for a Wisconsin hibernaculum. Using available materials and to prevent youths from entering, the gate was constructed using 10 cm (4 in) I-beams and 12 cm (5 in) vertical spacing, with the lower quarter being a flat plate. The gate was placed about 4 m (12 ft) from the portal to take advantage of a natural crack and a larger passage to compensate for the airflow obstruction caused by the gate. Since gating, the bat population has slowly increased compared to a control site about 150 m (500 ft) away and two other hibernacula in the region, including a tunnel that is closed with a solid door for the winter yet harbors hundreds of hibernating bats. In particular, the census of *P. subflavus* at Atkinson, which is generally ten times larger than at the other sites, doubled from 129 in 1994 to 264 in 2007. The other sites stayed constant or had an increased *P. subflavus* census during the period. There are several factors that probably contribute to the success of the gate. The cooler climate of Wisconsin makes cool air ingress less important than in the south, the plate on the gate forces bats to fly above terrestrial predators, and the setback into the adit allows bats to fly faster through the portal before slowing down to negotiate the gate, reducing the risk of avian predation.

Flight Ontogeny in Two Species of Fruit Bats *Artibeus jamaicensis* and *Carollia perspicillata*

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

Much of the knowledge gained on flight ontogeny has concentrated on insectivorous species, especially *Myotis lucifugus.* We are currently testing flight ontogeny in a captive breeding colony of two species of New World fruit bats, the Jamaican Fruit Bat (*Artibeus jamaicensis*) and the Short-tailed Fruit Bat (*Carollia perspicillata*). This comparative investigation allows us not only to compare growth and development of flight between two species that are significantly different in body size (with implications for the evolution of body size in bats), but also differ in terms of altricial versus precocial natural history traits. We are providing data on growth and development of the wings from day 1 of parturition through adulthood for the two species. We are also quantifying functional flight development using drop evoked flight tests as well as quantifying maneuverability through a flight maze. Preliminary data show a significant difference ($p = 0.01$)

in timing of the flapping stage (horizontal movement prior to first flight) between the two species with *A. jamaicensis* at 18 days and *C. perspicillata* at 15 days with horizontal distance increasing daily until first flight is achieved. Day of first flight has a significant difference ($p = 0.01$) with a mean of 32 days for first flight for *A. jamaicensis* (relatively altricial), whereas this mark was attained for *C. perspicillata* (relatively precocial) on average of 26 days. Comparing these data with data on wing loading (wing area divided into mass) shows that *A. jamaicensis* is significantly higher than *C. perspicillata* ($p < 0.0001$), corresponding to the differences in overall body size. This follows the evolutionary trajectory that these two species have followed, with *C. perspicillata* being a hovering bat and overall more maneuverable than *A. jamaicensis*. Preliminary results indicate that *A. jamaicensis* shows more rapid growth in areas such as the forearm, wing surface area, and weight. This corresponds to the altricial versus precocial natural history traits. Overall, *A. jamaicensis* and *C. perspicillata* demonstrate differences in growth rate and timing of first flight development.

Response of Eastern *Myotis* Species to Human Presence while Day-roosting

Timothy J. Sichmeller, Timothy C. Carter, and Matthew G. Hohmann; Ball State University, Muncie, IN; U.S. Army ERDC-CERL, Champaign, IL

Advances in technology have allowed bat researchers to learn more about summer roosting than was previously available. It is now possible with telemetry for a researcher to find numerous roosting bats or colonies in a given day. Although the advantages of these advances in radiotelemetry have led to a plethora of new found information, the possible negative impact of disturbance to these roosting bats by the very researchers themselves has not been examined. Often when tracking bats, audible sounds from the roost are used to help locate the specific roost tree. It is not known if these animals are vocalizing as a result of the disturbance from the researcher, or if it is a common behavior exhibited throughout the day. Over the course of two maternity seasons, we have used temperature-sensitive transmitters combined with continuously recording receiving equipment to collect data on the daily activity patterns and body temperature of roosting bats. Using changes in body temperature and activity, we are able to assess possible disturbance events when researchers approach and work around roost trees. The timing of arrival and type of activity around roost trees are discussed and appropriate implications are presented.

Perception of Target Shape and Rejection of Clutter: Two Sides of the Same Coin

James A. Simmons, Mary E. Bates, and Sarah A. Stamper; Brown University, Providence, RI

Echolocating big brown bats (*Eptesicus fuscus*) emit very wideband sonar sounds at frequencies of ~20–100 kHz containing multiple frequency-modulated (FM) harmonics (e.g., FM1, FM2). They determine target range from echo delays and target shape from echo spectra. The shape of a target consists of the locations of a small number of component reflecting parts, called “glints” (e.g., head, wings, abdomen), separated by small distances that reflect replicas of the incident sound at slightly different delays. Echoes have approximately flat spectra except for interference notches, caused by overlapping glint reflections, at frequency and spacing governed by the time separation in each pair of reflections (e.g., 33-kHz intervals for 30 μs or 5 mm). Bats convert the frequencies of notches into estimates of delay separation that are perceived as differences in target range within the target—i.e., as shape itself. The range and shape systems constitute two separate neuronal displays that converge information about both types of delays onto auditory cortical neurons whose responses support a common perceptual scale of distance. Other spectral effects in echoes are lowpass in nature, caused by atmospheric absorption at long ranges or off-axis location of the target in the broadcast beam, both of which attenuate FM2 more than FM1. If the target is nearer than 2–3 m and kept within the beam by the bat's head aim, overall lowpass attenuation of FM2 is no more than a few decibels. In contrast, off-axis or far-away clutter, such as vegetation, yields echoes containing primarily FM1, as though there were many interference notches distributed across all frequencies in FM2. The presence of many potential notches triggers conversion of these notches into numerous estimates of spurious glint delays spread uniformly from 0 to 300–500 μs, which gives each element of the clutter a smeared image of shape. Onset of this smearing is too abrupt to be anything other than deliberate: Electronic separation and delay offset of FM2 from FM1 by only 1–2 μs causes the same smearing as offset by 300 μs. In effect, *Eptesicus* exploits greater attenuation of FM2 in clutter echoes to "turn off" the clutter on the shape display while keeping it on the range display. This explains why bats that fly in clutter typically use multiple harmonics.

Investigating Spatio-temporal Variation of Bat Activity at Desert Springs: Implications for Future Research

Samuel L. Skalak, John T. Agee, R. Mark Brigham, and Rick E. Sherwin; Christopher Newport University, Newport News, VA; University of Regina, Regina, SK

The purpose of this research is to investigate potential differential use of available habitats by bats at Ash Meadows National Wildlife Refuge, Nevada. Ultimately our findings will serve as baseline data for a large-scale restoration project being conducted at the site. Our results will come from a combination of data gathering techniques, including acoustic monitoring, mist netting, radiotelemetry, thermal imaging, night vision video, and radar. Ultimately we will develop models of habitat associations that will facilitate data-driven restoration efforts. As part of the process of developing models of habitat associations, we must first understand inherent variation in patterns of activity through space and time. For this talk, we assess acoustic data collected during the summer of 2008 by seven Anabat II bat detectors distributed throughout the refuge. These data represent 322 detector-nights between June and August 2008. Call files were analyzed to the specific level wherever possible and simply to "unknown bats" when acoustic structure supported this diagnosis. We accounted for the subjective nature of call identification by sending a random sample of (unlabeled) identified files to other researchers and compared their diagnoses with ours. This allowed us to develop estimates for the accuracy of our identifications and identify specific call types or species that might be problematic. Once call identifications were vetted (and corrected as necessary) we investigated variation of specific and generic activities within and among sample sites throughout the refuge. We will discuss the implications of spatio-temporal variation in bat activity and our approaches to resolving this issue for future research at the site.

Determining the Effectiveness of Acoustic Sampling Comparing Different Deployment Types

Brooke A. Slack and Eric R. Britzke; Kentucky Department of Fish and Wildlife, Frankfort, KY; Forrest City, AR

Surveys conducted for the federally endangered Indiana bat (*Myotis sodalis*) consist of mist netting and, in Kentucky, acoustic sampling. The objective of this research was to compare the angles of deployment (0°, 45°, and 90° angles) and two types of weatherproofing (waterproof container with PVC pipe and Bathat) used with Anabat II systems to determine which means of deployment yielded the highest bat call detection rate and quality. The deployment types consisted of the five Anabat II systems simultaneously placed on tripods randomly assigned to one of five deployment combinations: three systems with no weatherproofing each placed at 0°, 45°, and 90° angles; one system with PVC weatherproofing; and one system with Bathat weatherproofing. Each site represented a linear or open habitat type sampled for one night. Linear habitats sampled were streams, field edges, and fencerows; open habitats sampled were ponds, fields, wooded openings, and a large stream. A total of 14 sites were sampled from June to July 2008. Files recorded were processed in Analook using multiple filters. Remaining calls were identified through statistical comparison to a known call library. Approximately 4,823 bat call files were recorded at all five deployment types. Call files recorded at linear habitat sites totaled 4,360. Of those, 2,738 were identified as bat calls using filters. The PVC weatherproofing deployment detected the highest number of total identifiable bat calls at 750. On average, the 45° angle deployment and PVC weatherproofing deployment recorded identifiable bat calls over 56% and 53% of the time, respectively, at all habitat types. The Bathat recorded the lowest number of identifiable calls at 224 with only an average of 14% identifiable to species. The 45° angle detected bat calls similar in structure to Indiana bat calls at two different sites, while all other deployment types detected Indiana bat calls at only one site each. Overall, the 45° angle and PVC weatherproofing yielded the best results with regard to bat call detection rate and quality.

Neutrophil/Lymphocyte Ratio in Three Species of *Myotis*: Effects of Sex, Reproductive Stage, and Site

L. Ches Smith, Mary T. Mendonça, and Matthew G. Hohmann; Auburn University, Auburn, AL; U.S. Army ERDC-CERL, Champaign, IL

Little is known about the immune system of bats, despite their potential as a reservoir for emerging diseases, and their ecological and economic importance. One of the main reasons for this knowledge gap is the difficulty in capturing and holding bats in a way that minimizes acute stress, which is known to alter immune function. One immune measurement that can be taken quickly and easily in the field is the neutrophil/lymphocyte (N/L) ratio, which requires only a small drop of blood. Although it is inadvisable to use only one measurement to characterize an animal’s immune system, recent research suggests that elevated N/L ratios may, in fact, accurately assess exposure to chronic stress, which can adversely affect immune response. We examined variation in N/L ratio in three different species of bats from the eastern U.S.—*Myotis septentrionalis*, *M. lucifugus*, and *M. sodalis*—in order to assess whether anthropogenic disturbance (i.e., urbanization, military activity) may constitute a chronic stressor and potentially affect the exposed animals’ immunocompetence. Bats were captured by mist net at impacted and non-impacted sites in Indiana and Kentucky from May to August 2007. Blood samples were taken from a uropatagial vein within three minutes of capture, and blood smears were fixed, stained, and a standard white blood cell count was performed to determine N/L ratio. We compared N/L ratio among species, sexes, sample months for males, reproductive status for females, and sites. N/L ratios of male bats of all three species did not differ significantly by species, sample months, or site. However, *M. septentrionalis* females showed variation in N/L ratio by reproductive stage ($p = 0.004$): ratios for pregnant and lactating females were

significantly higher than in those that were post-lactating. A similar trend was present in *M. lucifugus* and *M. sodalis* females; however, it was not significant, perhaps because of small sample sizes. Also, *M. sodalis* females' N/L ratios were significantly higher than those of *M. lucifugus* and *M. septentrionalis* (p = 0.004). Additionally, N/L ratios of *M. septentrionalis* females from impacted areas were significantly higher than those from unimpacted sites (p = 0.02), suggesting that these bats may have been under chronic stress, which might have an effect on their immune response.

Preliminary Research on Two Species of Epauletted Fruit Bats in Kruger National Park, South Africa and their Effects on Sycamore Fig Seed Germination

Emily R. Snode and Rick A. Adams; University of Northern Colorado, Greeley, CO

In recent years, there has been a noticeable decline of sycamore fig tree (*Ficus sycomorus*) populations in Kruger National Park (KNP), South Africa. KNP is inhabited by two species of epauletted fruit bats, *Epomophorus wahlbergi* and *E. crypturus*, both of which eat figs from sycamore trees. In this study I quantified the direct effects of fig seed manipulations by fruit bats on germination percentage and rate outcomes. I hypothesized that foraging by epauletted fruit bats does have an effect on fig seed germination success. I predicted that both oral processing and seeds passing through the digestive tract of these fruit bats is enough to increase seed germination rate and percentage. Fecal and spat samples were collected from feeding roosts in Shingwedzi KNP, South Africa in June 2008. Control samples consisted of seeds taken directly from fruit and cleaned, as well as a separate control of seeds taken from the fruit with the pulp still attached. All seeds were germinated under the same ambient conditions for a maximum of 11 days in fecal, 18 days in spat, and 15 days in control samples. Preliminary results show that 96.8% of seeds that passed through the digestive tract of *E. crypturus* germinated within an average of seven days. Cleaned seeds in the control sample had a germination percentage of 26% within ten days, whereas 12% of pulp control seeds germinated over the same time period. None of the seeds from the spat samples germinated. Germination of all samples was done between pieces of filter paper in Petri dishes. Preliminary results of scanning electron microscopy imaging of the two experimental and control groups show fig seed surface differences. These results may indicate that epauletted fruit bats scarify the seed coat of sycamore fig seeds when digested, in a way that improves and expedites seed germination. Future avenues of research are to replicate this study in 2009. I am also feeding captive *Artibeus jamaicensis* at the University of Northern Colorado species of fig fruit with which they have not coevolved, in order to observe whether or not similar germination effects occur under these conditions.

Spatial Separation between Target and Clutter Enhances Detection Performance by Echolocating Bats

Sarah A. Stamper, Caroline M. DeLong, and James A. Simmons; Brown University, Providence, RI

Big brown bats (*Eptesicus fuscus*) emit frequency-modulated (FM) echolocation sounds containing two principal down-sweeping harmonics (FM_1 ~55–25 kHz, FM_2 ~105–50 kHz). FM bats in the genus *Myotis* (family Vespertilionidae) that can glean insects from substrates use more harmonics than aerial-feeding species. The large number of harmonics emitted by *Eptesicus fuscus* suggests that they may spend more time flying in vegetation than is appreciated.

Thermal video recordings show that these bats capture insects in open air and also from vegetation, which acts as clutter. Echoes from clutter can interfere with perception of targets depending on their strength and density. In the first experiment big brown bats were trained in a two-alternative forced choice task to locate a target, varying in height that was embedded partway in holes (clutter) cut in a foam surface. The holes were co-localized with the possible positions of the target at distances ranging from 25 to 35 cm. For successful perception of the target, the bat had to detect the echoes contributed by the target in the same time window that contained echoes from the clutter. The bats detected the target whenever target strength was greater than 1–2 dB above the clutter, showing that detection of insect-sized targets in the same locations as clutter depends on the increment in reflected sound pressure contributed by the targets relative to the clutter. In a second experiment, we tested the effects of clutter located not in the same position as the targets but distributed around the targets. Performance was best for target heights different from clutter height—whether taller or shorter. For the shortest targets, acoustic reflectivity was smaller than for the beads even though the bats' performance was higher. Spatial separation of targets from clutter may have allowed the bats to perceive the targets as separate objects in the area surrounded by clutter instead of relying only on sound pressure increments.

Bat Conservation and Management in Pennsylvania State Forests

Aura L. Stauffer; Pennsylvania Department of Conservation and Natural Resources, Harrisburg, PA

The Pennsylvania Department of Conservation and Natural Resources (DCNR), Bureau of Forestry manages over 2 million acres of land on 20 state forests. These state forest lands are managed for multiple resources including recreation, timber, and conservation of both non-game and game species. Bats are recognized as an important part of the state forest system requiring special management under the DCNR State Forest Resource Management Plan. Management for bat species includes: 1) protection of hibernacula; 2) bat inventory of hibernacula and state forests; 3) development of best management practices for timber operations; 4) conducting habitat enhancement projects; 5) assisting state biologist with telemetry studies; 6) monitoring for white nose syndrome; 7) providing funding for bat research on state forest lands; and 8) providing education about bats for DCNR staff.

Prolonged Solicitation Periods May Drive Ontogeny of Behavior in Bat Pups

Mia Strauss and Mirjam Knörnschild; Prescott College, Prescott AZ; Institute for Biology, Erlangen, Germany

In many mammalian species, adult behavior patterns develop throughout ontogeny. In bats, much of this development occurs before the pup is weaned. Prior to weaning, mother-pup interactions are the primary social influence on the behavioral ontogeny of pups, with the pups' solicitation for maternal care being the most conspicuous aspect of these interactions. In *Saccopteryx bilineata*, solicitation periods are prolonged and can last up to 30 minutes. They can be initiated by either the mother or her pup and cause both animals to move restlessly throughout the day roost, a behavior that is energetically demanding and conspicuous to predators. One reason for why this costly behavior might have developed could be the pups' need to practice adult behavior patterns that are important aspects of their later social life (e.g., hover displays during courtship). The behavioral development of pups was investigated using focal-animal sampling methods in the day roost throughout ontogeny. Behaviors were recorded as either temporal states or instantaneous events. Eighteen free-ranging pups from four different social groups were observed for a total of 74 hours of observation. We started behavioral observations when the pups were barely volant and ceased when the pups were weaned eight weeks later. We found solicitation periods to be the second most prevalent behavioral state after grooming. Successful solicitations that resulted in nursing were twice as long as unsuccessful solicitations. In addition, all behavioral events that involved movement (e.g., hover displays) were significantly more frequent within solicitation periods than during all other behavioral states, supporting our hypothesis that solicitations are important for practicing adult behavior patterns. Male and female pups did not differ significantly in length, frequency, or composition of solicitation periods or in their activity outside of solicitations, even though the behavioral patterns of adult bats differ remarkably. Female pups might exhibit similar behavioral patterns as male pups in order to estimate energetic costs of male courtship. The functional significance of a prolonged solicitation period may be comparable to mammalian play, because both activities can be viewed as preparation for adulthood in gaining kinesthetic skill and general fitness.

Species and Genetic Diversity of Insectivorous Bats in a Paleotropical Fragmented Forest Landscape

Matthew J. Struebig, Tigga Kingston, Akbar Zubaid, Adura Mohd-Adnan, and Stephen J. Rossiter; Queen Mary University of London, UK; Texas Tech University, TX; Universiti Kebangsaan Malaysia

Species diversity within assemblages and genetic diversity within species are two fundamental levels of biodiversity, and the processes that influence them may act in parallel: the so called species-genetic diversity correlation. Here, we examine whether this pattern occurs in a disturbed landscape in Peninsular Malaysia using insectivorous bat assemblages captured in forest fragments. Paleotropical insectivorous bats may serve as an ideal model in this respect: they are diverse, perform ecosystem services, and a dependence on forest by many species leaves them sensitive to disturbance events. Bats were captured in Krau, central Pahang, and the influence of fragment area and isolation on assemblage structure was tested. Genetic diversity was then quantified in fragment populations of five bat species with different dispersal capabilities. We ask whether bat assemblages are doubly affected by fragmentation, with reductions of species diversity in fragments associated with reductions of genetic diversity. Alternatively, if we save a fragment from conversion to agriculture do we 'buy-one-get-one-free' in terms of biodiversity conservation?

Diet of *Myotis* spp. in Southeast Michigan: A Community Perspective

Joshua Stumpf and Allen Kurta; Eastern Michigan University, Ypsilanti, MI

Indiana bats (*Myotis sodalis*), little brown bats (*M. lucifugus*), and northern long-eared bats (*M. septentrionalis*) are uncommon, yet morphologically similar species that coexist in few locations within the Great Lakes region. One of these locations is a small geographic area near the town of Palmyra, Michigan. We collected fecal samples during summer 2006–2007 and analyzed dietary composition of the three species. We then used a food-niche overlap analysis within the context of a principal components analysis to assess temporal patterns in overlap among the dietary optima of the three species. Although all three diets contained Diptera, Coleoptera, Hymenoptera, and Lepidoptera, northern long-eared bats consistently exhibited a larger dietary niche breadth than either Indiana bats or little brown bats. Little brown bats and Indiana bats exhibited significant amounts of overlap with one another during most months of the study.

Influence of Upstream Vortex Structures on Flight Behavior in *Cynopterus brachyotis*

Allyce Sullivan, Daniel K. Riskin, and Sharon M. Swartz; Brown University, Providence, RI

Flocking and schooling behaviors have been observed in animals such as geese and fish. These group locomotor behaviors are known to confer energetic benefits on the organisms participating, allowing them to take advantage of energy-rich flows produced by their surrounding conspecifics. Bats often fly in group formations, and are also known to have an array of sensory structure spanning their wings that are thought to play a role during flight. In this study, we investigated the ability of *Cynopterus brachyotis* to identify upstream vorticity created by a controlled source of vorticity: a stationary delta wing shedding vortices similar to those that might be shed from a bat flying upstream. We assessed the tendency of *C. brachyotis* to orient themselves downstream from the delta wing in a wind tunnel in a non-arbitrary fashion. The distance of the bat from the plane trailing the delta wing during each trial was determined. Although there is a trend toward preferential selection of structured flow, this experiment showed no significant difference between the flight location of the bats when the delta wing was present versus absent.

The Potential for Acoustic Broadcasts to Deter Bats from Approaching Wind Turbines

Joseph M. Szewczak and Edward B. Arnett; Humboldt State University, Arcata, CA; Bat Conservation International, Austin, TX

Bat mortality at wind energy facilities has become an established threat to bat populations and a complicating factor in carbon-neutral wind power development. We previously demonstrated that selected regimes of broadcasted ultrasound could deter bats from occupying such a treated airspace. To investigate whether bats could habituate to this acoustic treatment, we monitored foraging activity at six different pond sites for at least two nights to establish baseline activity levels, and then for five to seven days during continuous ultrasound treatment. We measured activity in the same way each night by counting visual passes of bats entering and leaving the recorded view from a Sony DCR-TRV520 Nightshot video camera equipped with high intensity infrared lamps. For the same one-hour period each night, the mean activity as a percentage of pretreatment activity was 9.8 (± 2.3), 6.2 (± 1.3), 6.3 (± 1.1), 5.2 (± 1.5), 6.7 (± 1.0), and 3.3 (± 0.0) for days 1, 3, 4, 5, 6, and 7 of treatment, respectively, within the effective range of the broadcast (< 15 m). These data suggest that bats do not habituate or accommodate to continued broadcast of deterring ultrasound. Despite this result, the limited range of ultrasound broadcast from a wind turbine tower or nacelle may provide only a moderate contribution toward reducing impacts of bats randomly flying through the rotor-swept area. However, for bats that may be drawn to and approach turbine towers as potential roosts or gathering sites, a learned avoidance response to ultrasound broadcast may have longer term indirect effects in reducing bat mortality at wind turbines. Bats that have previously experienced the disorienting effect of ultrasound broadcast may avoid approaching other treated towers, which they could detect as treated from beyond the physiologically affected airspace. In this way, ultrasound broadcast may effectively serve as acoustic beacons to direct bats away from wind turbines. During the 2008 field season, we have begun testing biological sounds that may deter bats by a behavioral response rather than a physiological response and have greater effective range. Ultimately, a combined broadcast of sounds eliciting both behavioral and physiological responses may render the most effective approach to acoustically deterring bats from approaching wind turbines.

Response to Vaccination with a Commercial Inactivated Rabies Vaccine in a Captive Colony of Brazilian Free-tailed Bats *Tadarida brasiliensis*

Amy S. Turmelle, Louise C. Allen, Barbara A. Schmidt-French, Felix R. Jackson, Thomas H. Kunz, Gary F. McCracken, and Charles E. Rupprecht; University of Tennessee, Knoxville, TN; Boston University, Boston, MA; Bat Conservation International, Austin, TX; Centers for Disease Control and Prevention, Atlanta, GA

A captive colony of Brazilian free-tailed bats (*Tadarida brasiliensis*) under rehabilitative care was vaccinated with a commercial monovalent inactivated rabies virus (RABV) vaccine. We measured baseline rabies viral neutralizing antibodies (VNA) and the response to vaccination in 50 adult bats. Rabies VNA were detected in the plasma of 64% (27 of 42) of bats that had been vaccinated one year prior. Females had higher mean residual rabies VNA titers from prior vaccination compared to males, and the response to booster vaccination was greater in females compared to males, in the 42 previously vaccinated bats. Rabies VNA were detected in the plasma of 63% (5 of 8) of bats with no record of previous vaccination, suggesting natural RABV exposure prior to captive care. All bats demonstrated a VNA response by 10 days post-vaccination, and baseline titer was a highly significant predictor of response to vaccination. No adverse reactions to vaccination or clinical signs of RABV infection were observed in the bats during a six-month post-vaccination observation period. Parenteral vaccination of insectivorous bats with a commercial monovalent inactivated RABV vaccine was safe, and effective in eliciting a VNA response. Although VNA titers were detected one year post-vaccination in the majority of bats, only 19% (8 of 42) had levels considered adequate. Our results suggest that yearly vaccine boosters may be necessary to maintain immunity against RABV infection in captive colonies of insectivorous bats.

Pennsylvania Hibernacula Management and Monitoring

Gregory G. Turner and Calvin M. Butchkoski; Pennsylvania Game Commission, Harrisburg, PA

The management and monitoring of hibernacula by the Pennsylvania Game Commission began in 1985 with the survey of 29 sites. Surveys have been conducted every year since 1985 and the database now contains 880 records consisting of 467 different sites surveyed. An overview of the database reveals 17 Indiana bat hibernacula in 10 counties, and 10 sites that have been surveyed a minimum of 10 times over a 20-year span. Seven of these sites have been gated for at least ten years and demonstrated substantial growth, while one gated commercial and three sites without gates that experienced internal disturbance during the hibernation period have shown little growth. Experimental manipulation of one entrance to restrict human entry and trap cold air occurred in 2005 at the Casparis mine. Surveyed five times over a 20-year period and for three consecutive years following, the total number of *Myotis* bats averaged 9.4 before and 120 for the 3 years immediately following.

Fifteen Years of Bat Conservation and Management Training Workshops in Central Pennsylvania and their Impacts on Bat Research and Monitoring in North America

Janet Tyburec, David Young, and Cal Butchkoski; Bat Conservation International, Inc., Tucson, AZ; Pennsylvania Department of Conservation and Natural Resources, Schellsburg, PA; Pennsylvania Game Commission, Petersburg, PA

In 1994 Bat Conservation International (BCI) partnered with the Pennsylvania Game Commission (PGC) and the Pennsylvania Department of Conservation and Natural Resources, Bureau of State Parks (DCNR) to host training workshops for professionals interested in formal instruction with techniques to design research, conservation, and education projects benefiting bat conservation. These workshops have been offered annually each August in central Pennsylvania. We have trained 503 participants including 91 employees from the PGC and DCNR, representing approximately 5% of the staff from each agency. The core workshop format combines daytime lectures and discussions with fieldwork and guided netting, trapping, and bat identification sessions. In 1995, we developed a focused, two-day event to target federal and state agency leadership staff in order to promote top-down policies for bat conservation and research on the ground region-wide. Next, special one-day educator workshops were added to highlight how bat conservation and research about bats can be used to generate public-level support of conservation and management initiatives, addressing a bottom-up effort to encourage conservation. Beginning in 2008, special focus, 3-day workshops were started to address regional needs for Indiana bat (*Myotis sodalis*) identification, study, and management. This directed dynamic training and intensive effort has created more interest and support for bat conservation at every level in the region. Numerous past participants have gone on to direct large-scale research and inventory projects, design first-of-their-kind survey and monitoring protocols, and pioneer innovations for bat capture and study techniques. Another important outcome of these workshops has been a comprehensive database of annual bat captures from prominent sites in the area, including state and regional parks, state managed game lands, and other natural areas. Information on species composition, sex ratios, reproductive conditions, age classes, and body mass have been religiously recorded, providing an important glimpse into the late-summer/early-fall population dynamics of the bats encountered. This 15-year data set, representing 10,080 captures, may be one of the most comprehensive resources of its kind in the region and an asset to future long-term monitoring and conservation initiatives for northeastern bat species.

Using Adaptive Management Scenarios to Address Impacts to Bats at Proposed Wind Farms

Karen Tyrell; BHE Environmental, Inc., Cincinnati, OH

Instances of bat mortality at wind farms have led to concern about the effect of wind turbine operation on bat population viability. As more wind farms are built, impacts on bats may be of increasing significance. At the same time, impacts of human energy demands are leading to establishment of environmental stewardship goals and legal requirements that increasingly compel us to develop sources of clean, sustainable energy. Wind energy allows power production that is widely compatible with these goals. There is, therefore, an inherent conflict between the need to conserve sensitive species of bats and the need to rapidly develop renewable energy, including wind power. Adaptive management offers a solution to this conflict. It provides an alternative to improving our understanding of bat impacts through the scientific method, which with its basis in testing and evaluating alternative hypotheses may provide information about the reasons bats are killed at wind farms (and measures to reduce or eliminate mortality) too slowly to meet current demands for developing clean energy. The adaptive management paradigm was developed to proceed with actions in the face of inherent conflicts and uncertainty as to how the elements of that action are influenced. In response to this opportunity, we developed a model to analyze effects on bats from wind farms, and guide measures to minimize impacts when they cannot be avoided. Adaptive Management Scenarios (AMSs) can be incorporated in wind project design to quantitatively evaluate the effect of mitigation under various operational conditions. Developers can use AMSs to evaluate financial impacts of mitigation, and to determine if a project can proceed and be compatible with bat conservation needs. Incorporating feedback from adaptive management scenarios (e.g., curtailment) to influence subsequent mitigation decisions at wind projects currently provides the best opportunity for limiting effects on bats at operational wind farms. AMSs must be tailored to site-specific conditions, and include monitoring and post-operational adaptation to align biological goals and cost-effective management. AMSs can be designed during pre-construction planning to resolve conflicts between project financial goals and potential impacts on bats, and to develop a successful conservation approach with agencies, ultimately allowing the development process to proceed. In this presentation we will describe how AMSs are constructed to resolve conflicts between bat conservation and wind energy projects.

***The Ear Bones of Bats: Variation in Manubrium Mallei Associated with Echolocating and Non-echolocating Bats**

Nina Veselka; University of Western Ontario, London, ON

*** Nina Veselka** received the ***Bat Research News*** **Award**

The diversity of bats is reflected in their echolocation behavior. Calls emitted can be of high intensity or low intensity. Most species separate pulse and echo in time (low duty cycle), whereas others separate pulse and echo in frequency (high duty cycle). I examined the manubrium of the malleus, which is located in the middle ear, to determine if any features were associated with differences in echolocation behavior. I photographed 58 skull specimens representing 49 species from 13 families in two orientations. I analyzed the digital images in Northern Eclipse Programme (Epix Imaging), and made several measurements of the manubrium: 1) orientation to a standardized reference line; 2) length; 3) width of the widest section at manubrium tip; and 4) width of the narrowest section at manubrium tip. In addition to using conventional digital photographs, several chiropteran species were also scanned to produce micro-CT images. The scanners used provided a nominal 20 µm isotropic spatial resolution over a 4.5-cm field of view. Fluid-filled specimens were scanned for about 180 minutes and scan data were reconstructed with a modified Feldkemp conebean CT reconstruction algorithm. There was a significant difference in manubrium morphology between each of the families examined. However, the result of a discriminant functional analysis revealed a low level of classification. Manubrium morphology also varied significantly with the type of echolocation call produced and the intensity at which the call was emitted. As with family variance, discriminant functional analysis revealed a low level of classification (52.3% for echolocation type and 63.6% for call intensity). Although there was a large amount of variation in manubrium mallei morphology of bats, there is not a clear relationship between manubrium shape and echolocation behavior.

Preliminary Survey of the Bats of Eastern Equatoria, Southern Sudan
Megan E. Vodzak and DeeAnn M. Reeder; Bucknell University, Lewisburg, PA

Kajo Keji District, located in equatorial southern Sudan, is characterized primarily by moist savanna and montane forests, and is historically known to house a wide variety of vertebrate species. However, this region has been largely closed to scientific exploration since the 1950s because of nearly constant conflict. Although extensive research is needed to fully understand how the region as a whole has been affected by the war and the subsequent repatriation of war refugees within the past two years, our small, local study of Kajo Keji illustrates the value of such research. While in Kajo Keji, we worked closely with Sudanese wildlife officers. Discussions with the officers and other locals gave us insight into the attitudes of the people and knowledge base of mammals in the region. For example, using a picture book of potential mammalian species of the area, the wildlife officers and others were able to identify species they have seen in the area and provide common names in the local languages (primarily Bari and Juba Arabic). We estimate that up to 85 different species of bats may inhabit the area, representing 9 families. In our limited sampling of 5 different sites, we identified at least 11 different species from 6 families: Pteropodidae (2 species), Emballonuridae (1–2 species), Hipposideridae (2 species), Rhinolophidae (1 species), Nycteridae (1 species), and Vespertilionidae (4 species). Although this study was done on a very local scale, it demonstrates that there is much to be gained from combining scientific surveys, local knowledge bases, education, and conservation efforts. Future plans include returning to the area for a more extensive survey of the bat population and a survey of local attitudes towards wildlife.

Phylogeography and Population Genetics of Spix's Disk-winged Bats in Central America: High Levels of Genetic Isolation Revealed by Nuclear and Mitochondrial Markers
Maarten J. Vonhof; Western Michigan University, Kalamazoo, MI

The distribution of genetic variation within species represents the combined influences of historical events and current factors such as gene flow, selection, mutation, and drift. Historical factors are generally expected to be more influential in sedentary species with comparatively low vagility, and barriers to dispersal are thought to have been a major driver of diversification in the tropics where such species are common. Previous analyses of the phylogeography of Neotropical bats have focused on large, generalist frugivores with high dispersal capabilities, and have reported little phylogeographic structure. Here I report on the phylogeography and population genetic structure of a habitat specialist bat species with limited dispersal capability, Spix's disk-winged bat *Thyroptera tricolor*. Previous work has demonstrated that populations of *T. tricolor* are segregated into discrete, cohesive social groups characterized by philopatry of both sexes and high within-group relatedness. I predicted that these fine-scale patterns of kinship and limited dispersal would lead to low current and historical levels of genetic exchange among populations, and a large phylogeographic break across the continental divide between the Atlantic and Pacific lowlands. In support of these predictions, levels of genetic differentiation were extremely high (microsatellites: $F_{ST} > 0.4$; mitochondrial control region: $\Phi_{ST} > 0.6$), indicating low levels of gene flow among populations separated by as little as 2 km. I observed low haplotype diversity within populations (1–4 haplotypes per population), and no haplotypes were found in more than one population. Phylogenetic analyses revealed significant phylogeographic structure, with well-supported clades defining virtually all sampled populations. Populations in Costa Rica were highly divergent from those in central Panama and Ecuador, and these clades likely represent separate species.

Providing Scope: Genetic Approaches to Understanding the Implications of Bat-Wind Power Interactions

Maarten J. Vonhof and Amy L. Russell; Western Michigan University, Kalamazoo, MI; Grand Valley State University, Grand Rapids, MI

Documented fatalities of bats at wind turbines have raised serious concerns about the future impacts of increased wind power development on populations of migratory bat species. Much of the research on bat-wind power interactions has focused on examining patterns and predictors of mortality at wind farms, operational mitigation, and possible deterrents, and provides valuable information to prevent or mitigate bat mortalities on a local scale. However, to understand whether mortalities at wind power developments pose a serious risk to bat populations we need to have a greater understanding of current population size and trends of affected species, whether populations of these species are differentiated geographically, and the migratory pathways used by different populations and/or species. I will discuss how each of these information gaps can be addressed using genetic markers, focusing on North American migratory bat species. I will present data on genetic population structure and the phylogeography of eastern red bats (*Lasiurus borealis*), and discuss some of the challenges with respect to defining populations and migratory pathways using molecular markers. In addition, I will discuss the concept of effective population size and how it may be used to detect future population trends. I will argue that population genetic studies are necessary and complementary to existing research on bat-wind power interactions, and will allow us to place local-scale mortalities at wind power developments into a broader context.

Somatosensory Hair Distribution across Wing Membranes of Various Bat Species

Melissa D. Walker, Daniel K. Riskin, Katie McComas, and Sharon M. Swartz; Brown University, Providence, RI

Sensory structures involved in proprioception are a crucial but poorly understood aspect of bat flight mechanics and maneuverability. To date, little has been learned about the mechanisms bats employ to perceive and respond to airflow during lift generation. It has been postulated that microscopic hairs (100–700 µm) found across the wing membrane, which are associated with Merkel cells, may be involved in such perception. By quantitatively describing the distribution, angle, length, shape, and density of these hairs across a variety of bat species with diverse flight behavior, we hope to provide insight into their mechanism. Maps of hair location and characteristics were generated from digital microscopy (3.15x magnification) at 36 locations along the digits, membrane, and prominent structures for both dorsal and ventral aspects of the wing of alcohol-preserved specimens of five bat species: *Eonycteris spelaea, Eidolon helvum, Pteronotus parnellii, Tadarida brasiliensis, and Myotis lucifugus*. Control comparisons were made to frozen specimens to confirm that the hairs were not affected by the preservation process. Hair distribution patterns are roughly similar across species, with relatively high density along blood vessels, bones, plagiopatagiales muscles, leading edges, and trailing edges. We hypothesize that the location and size of these structures allows them to detect aerodynamic conditions in the boundary layer during flight, particularly transition to turbulence. Species differ markedly in hair length, hair angle, and hair distribution across the membranes' collagen-elastin networks. These patterns may correlate to the unique requirements for different species flight styles and maneuverability.

Assessment of Wound Healing Rates in Free-ranging Little Brown Bats *Myotis lucifugus*
Kimberly N. Weaver, Sara E. Alfano, Amanda R. Kronquist, and DeeAnn M. Reeder; Bucknell University, Lewisburg, PA

Large numbers of little brown bats (*Myotis lucifugus*) in the northeastern U.S. are dying from the recently described White Nose Syndrome. Unfortunately, very little is known about the immune function in bats. The aim of this study was to add to the limited data on bat immunocompetence by assessing wound healing rates in free-ranging little brown bats. Female little brown bats were banded at a single site, and a 3.0-mm hole was created in each wing using a sterile biopsy punch. Subjects were recaptured for the following three weeks, and closure of the wound was assessed using both calipers and digital photography. We hypothesized that all wounds would heal within two weeks, and that digital photographs would give a more reliable measurement than calipers. Results showed that, although little healing occurred within the first week, all wounds healed within 16 days. The initial delay in wound closure followed by rapid healing most likely reflects the nature of the integrated immune response to wounds, which includes an initial inflammatory response, followed by a proliferative phase, and finally a protracted remodeling stage. Although the two methods of measurement were strongly correlated—suggesting either may be used—we felt that quantification of the surface area and healing margin of the wound using the image processing and analysis software ImageJ more accurately described the healing process than did measurement of the diameter of the wound with calipers. This study will provide baseline data on one aspect of immune function for comparison with bats affected by White Nose Syndrome, which will allow us to better understand the problem.

Isotopic Fractionation between Diet and Tissue in *Carollia perspicillata* (Phyllostomidae)
Janelle M. Weber and Heather A. York; Doane College, Crete, NE

Stable-isotope analysis is a useful tool for investigating various aspects of animal ecology, including feeding behavior and habitat utilization. A recent carbon and nitrogen stable-isotope analysis of diet in the short-tailed fruit bats (genus *Carollia*) indicates that these animals occupy a higher trophic level than would most exclusively frugivorous species, with insects likely comprising a significant portion of the diet, as well as agreeing with earlier studies that highlight differences in foraging habitat and food plants among co-occurring species. Nonetheless, results of isotope analyses in wild bats are not directly comparable across space and time because of spatial and temporal differences in environmental isotopic composition. The current study seeks to determine the degree of isotopic fractionation between diet and bat tissues and the timing of the isotopic response of tissues to changes in diet. These values are useful for inferring dietary isotope values from those in the tissues, allowing for standardization that will permit broader ecological analyses. Captive *C. perspicillata* were fed a series of homogenous diets, and blood was sampled regularly for isotope analysis. The degree and timing of carbon and nitrogen isotopic fractionation between diet and tissues in this controlled situation are discussed.

Mapping Habitat Associations and Activity of Bat Species Assemblages: A Monterey County, California Case Study

Susan K. Whitford and Dave S. Johnston; San Jose State University, San Jose, CA

Bats were surveyed using passive acoustic monitoring during the summer months of 2007 to examine how landscape characteristics and configuration affect species assemblages in the agricultural and urban landscapes of Monterey County, California. This work presents a relative index of presence and activity levels of detected species at 26 sites. Six species—*Corynorhinus townsendii, Eumops perotis, Lasiurus blossevillii, Myotis evotis, M. thysanodes,* and *Parastrellus hesperus*—were identified by call sequences alone. Other species were grouped by their minimum frequencies of 50 kHz (*M. californicus* and *M. yumanensis*), 40 kHz (*M. ciliolabrum, M. lucifugus,* and *M. volans*), 30 kHz (*Antrozous pallidus, Eptesicus fuscus,* and *Lasionycteris noctivagans*), and 20 kHz (*L. cinereus* and *Tadarida brasiliensis*). The extent of the analysis is a 1-km circular buffer of individual survey sites. Geospatial analyses were used to derive independent variables in the form of continuous metrics such as the distance to the nearest road and categorical metrics such as vegetation community structure. Categorical metrics were derived with object-based segmentation of high-resolution aerial photographs. Regression analyses suggest that increasing fragmentation of native habitat and high road densities surrounding surveyed locations negatively affect bat community diversity (Spearman's $r = -0.546$, $df = 24$, $r^2 = 0.298$, $p = 0.004$). At sites where the urban forest is a part of the landscape, increasing proximity from one patch to the next and a lack of connectivity between patches is associated with fewer species detections and lower activity levels. Bat activity varies dissimilarly with land use and habitat fragmentation, as the presence of large freshwater bodies in the urban landscape had a disproportionate number of recordings during the survey period (Mann-Whitney U-test = 10.678, $df = 1$, $p = 0.001$). Results stress the importance of incorporating context of the surrounding environment when analyzing species-habitat relationships.

Non-phyllostomid Bats across a Gradient of Agricultural Intensification in Coffee Agroecosystems of Chiapas, Mexico

Kimberly Williams-Guillén, Ivette Perfecto, and John Vandermeer; University of Michigan, Ann Arbor, MI

Although many studies in the Neotropics have described the effects of habitat change on phyllostomid bats, our understanding of responses of other bat families to habitat loss and degradation have rarely been documented. This situation results from the fact that most bat surveys in the Neotropics rely on ground-level mist netting for data collection, a method biased towards capture of phyllostomid bats. As part of a survey of the impacts of agricultural intensification on bat communities, between May and August 2008, we used ground-level and subcanopy mist nets and harp traps to capture bats at various sites in the Sierra Madre mountains of southwestern Chiapas, Mexico; this landscape is dominated by coffee agroforestry. To augment capture methods, we used acoustic monitoring to help characterize the non-phyllostomid bat community. We used both passive monitoring with an Anabat II recording to a ZCAIM and active monitoring with a Petterson 240x recording to a digital recorder to monitor bats in four habitat types ordered along a gradient of management intensity: forest fragments; and traditional polyculture (high shade), commercial polyculture (medium shade), and commercial monoculture (low shade) coffee. Passive recording at capture sites with the Anabat revealed differences between habitat types in activity levels: average passes per 10 minutes were similar in forest [3.8 ± 1.8 (sd)], high shade (3.3 ± 2.7), and moderate shade (3.2 ± 1.1) plantations, but declined sharply in intensively-cultivated low shade (1.4 ± 1.0) plantations. A similar pattern was observed using active monitoring with a Pettersson, with passes recorded per ten minutes with each system showing a significant correlation ($r^2 = 0.424$, $p = 0.039$). Although we did not observe significant differences between habitats in passes recorded per 10 minutes, the patterns conform with those observed from capture data, and suggest that non-phyllostomid bat activity declines with increasing agricultural intensification in coffee plantations. Species identification of calls is ongoing, although preliminary analyses suggest that species richness also declined with increasing habitat modification.

Warming Up from Torpor in Bats

Craig K. R. Willis; University of Winnipeg, Winnipeg, MB, Canada

Warming up from torpor is energetically costly and many torpor-using mammals rely on passive warming to reduce energy expenditure during the warming phase. However, animals that live in stable microenvironments likely have little opportunity to exploit passive warming. These species may benefit from high warming rates because, when other factors are held equal, short-duration warming bouts cost less energy than long ones. Similarly, species that do not exploit social thermoregulation might face stronger selection pressure for rapid warming rates than social species, if individuals of social species can share arousal costs with other group members. I analyzed published and new data for 35 species of bats to test the hypothesis that species that roost in stable microenvironments and small colonies are characterized by faster warming rates than those living in variable microclimates and large colonies. After controlling for body mass and phylogeny, I found no influence of roost temperature stability or coloniality on arousal rates across all species or for 17 vespertilionids. However, when I analyzed data for nine species from a mostly tropical/subtropical clade, I found a strong influence of both roost temperature stability and colony size on warming rates. Species from this group, which roost in stable microenvironments and in small colonies, had significantly higher warming rates than other species. These findings complement recent work that highlights the influence of torpor arousal, and its energetic costs, on the lives of heterothermic endotherms like bats.

Migratory Patterns and Behavior of the Eastern Red Bat *Lasiurus borealis* along the Allegheny Mountains of Southwestern Pennsylvania

Julie Z. Winner, Jeffery L. Larkin, Calvin M. Butchkoski, and Steve J. Pernick; Indiana University of Pennsylvania, Indiana, PA; Pennsylvania Game Commission, Harrisburg, PA; L. Robert Kimball and Associates, Ebensburg, PA

In the fall of 2007, Mountain Watershed Association supported a project to assess migratory patterns and behavior of the Eastern Red Bat to assist with filling data gaps on migratory tree bat species. The objectives of the 2007 project was to initiate the first step towards developing a protocol for capturing, radio-tagging, and tracking migratory eastern red bats and to assess the viability of using an airplane and ground crew to radio-track long distance bat migration. Ultimately, we can determine the influence that weather conditions may have on migration and also determine how migrating bats utilize mountain ridges and other landscape features. Over a proposed three-year study period, sufficient data can be collected and a landscape level analysis

conducted using analytical software to determine land use types and topographic features that may be influencing bat migration. This will be useful in generating basic but missing natural history information for *Lasiurus* spp. that can be applied to other regions of Pennsylvania and the Mid-Atlantic. As a result of the 2007 project, we were able to preliminarily correlate weather patterns to high bat activity and migratory behavior and begin to assess the use of landscape features during migration. Preliminary results from 2007 show that decreasing temperatures and decreasing pressure may influence bat migration. We also observed that eastern red bats used a variety of human-altered and natural landscape features including utility right-of-ways and river corridors during foraging and migrating. Additional migratory data will be collected in September 2008 to better elucidate those factors that influence *Lasiurus* spp. migratory patterns in southwestern Pennsylvania.

Social Influences on Foraging in Jamaican Fruit Bats *Artibeus jamaicensis*

Genevieve Spanjer Wright, 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 information through interactions with conspecifics, but competition for resources or unreliable information from conspecifics may negatively impact a group-living individual. 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. Jamaican fruit bats (*Artibeus jamaicensis*) roost in harems and can be found foraging in large numbers at fruiting fig trees, but there is mixed evidence regarding whether this species forages in cohesive groups or exchanges information about food. I captured 31 *Artibeus jamaicensis* on Barro Colorado Island, Panama, and presented them with three food-finding tasks of increasing complexity in groups of four or five bats (n = 19) or individually (n = 12), and assessed the time taken for each bat to feed, time spent at the food source, failed feeding attempts, and other behaviors. In the most complex task, bats tested alone accessed the food significantly faster (mean = 66 minutes; sd = 86) than bats tested in groups (mean = 150 minutes; sd = 96). In all three tasks, the trend was towards lone bats accessing the food more quickly than those flying with conspecifics. I discuss several alternative explanations that could account for this result.

List of Participants
38th Annual North American Symposium on Bat Research

(S) = student

Amanda Adams (S)	aadams26@uwo.ca
Danielle Adams (S)	dma2133@columbia.edu
Rick Adams	rick.adams@unco.edu
John Agee (S)	john.agee.05@cnu.edu
Abdulaziz Alagaili	aziz99@gmail.com
Sara Alfano (S)	sea015@bucknell.edu
Louise Allen (S)	allenlou@bu.edu
Loren Ammerman	loren.ammerman@angelo.edu
Fred Anderka	fred@holohil.com
Wesley Anderson (S)	weanderson@davidson.edu
Reese Arh (S)	reese.arh@utoronto.ca
Maria Armour (S)	m.t.armour@gmail.com
Mike Armstrong	mike_armstrong@fws.gov
Ed Arnett	earnett@batcon.org
Erin Baerwald (S)	girlborealis@gmail.com
Joseph Bahlman (S)	joseph_bahlman@brown.edu
Michael Baker	mbaker@batcon.org
Robert Baker	rjbaker@ttu.edu
Janna Barcelo (S)	jbarcelo@psyc.umd.edu
Robert Barclay	barclay@ucalgary.ca
Karla Barquero Villalobos	kbarquero@tirimbina.org
Isabelle-Anne Bisson	ibisson@princeton.edu
David Blehert	dblehert@usgs.gov
Frank Bonaccorso	fbonaccorso@usgs.gov
Kristin Bondo (S)	kbondo@yahoo.com
Neil Bossart	nbossart@cecinc.com
Brittany Bovard	bnb124@psu.edu
Barbara Bowman	ken@batcow.org
Ken O. Bowman	ken@batcow.org
Justin Boyles (S)	jboyles3@indstate.edu
Elizabeth Braun de Torrez (S)	ecbraun@bu.edu
Mark Brigham	mark.brigham@uregina.ca
Eric Britzke	ebritzke@sbcglobal.net
Hugh Broders	hugh.broders@smu.ca
Patricia Brown	patbobbat@aol.com
Veronica Brown (S)	vabrown@utk.edu
Michael Buchalski (S)	michael.buchalski@wmich.edu
Elizabeth Buckles	elb36@cornell.edu
Calvin Butchkoski	cbutchkosk@state.pa.us
Cassandra Butterworth	cmm48@psu.edu
Allen Calvert	acalvert@lc.usbr.gov
Karen Campbell	kcampbell@alb.edu
Gerald Carter (S)	batbum@gmail.com
Tim Carter	tccarter@bsu.edu
John Chenger	jchenger@batmanagement.com
Beth Clare (S)	eclare@uoguelph.ca
Matthew Clement (S)	clementm@warnell.uga.edu
Jeremy Coleman	jeremy_coleman@fws.gov
Joanna Coleman (S)	jcoleman@ucalgary.ca
Daniel Cox	cougar_9_@hotmail.com
Paul Cryan	cryanp@usgs.gov
Robert Currie	laura_rogers@fws.gov
Liliana Davalos	mdavalos@gmail.com
Noa Davidai (S)	(not available)
Emily Davis	mike@speleobooks.co
Katie Day	kmd1930@gmail.com
Luke Dodd (S)	luke.dodd@uky.edu
Richard Dolman (S)	suparichy22@gmail.com
Barbara Douglas	barbara_douglas@fws.gov
Elizabeth Dumont	bdumont@bio.umass.edu
Miranda Dunbar (S)	milam20m@uregina.ca
Barry Duncan,	formations@earthlink.net
Yvonne Dzal (S)	yvonne.dzal@gmail.com
D.J. Eichenberger (S)	djeichenberger@gmail.com
Thomas Eiting (S)	tpeiting@bio.umass.edu
Nural Ain Elias (S)	ain.elias@ttu.edu
Anthony Elliott	tony.elliott@mdc.mo.gov
Laura Ellison	ellisonl@usgs.gov
Greg Falxa	gregf@efn.org
Brock Fenton	bfenton@uwo.ca
Kathryn Fidiam	casaiud@susqu.edu
Theodore Fleming	ted@sonaura.net
Erin Fraser (S)	efrase4@uwo.ca
Mike Frayer	michael.frayer@milwcnty.com
Mary Frazer	mefrazer@ncdot.gov
Winifred Frick	wfrick@batresearch.org
James Fullard	james.fullard@utoronto.ca
Michael Gannon	mrg5@psu.edu
Thomas Garin	tgarin@atstrack.com
Colin Garroway (S)	colin.garroway@gmail.com
Lisa Gatens	lisa.gatens@ncmail.net
Emma Gamez	biolemma@gmail.com
Erin Gillam	gillam2e@uregina.ca
Kristen Goland	kristengoland@iberdrolausa.com
Margaret Griffiths	griffm@lycoming.edu
Thomas Griffiths	grifft@lycoming.edu
Blayne Gunderman	bgunderman@acciona-na.com
Thomas Hallam	thallam@utk.edu
James Hart	jahart@pa.net
Aimee Haskew (S)	ahaskew@al.umces.edu
Sara Hayden (S)	sara.hayden@ucd.ie
Mark Hayes (S)	haye4932@bears.unco.edu
Cris Hein	chein@abrinc.com
John Hermanson	jwh6@cornell.edu
Carl Herzog	cjherzog@gw.dec.state.ny.us
Alan Hicks	achicks@gw.dec.state.ny.us
Bronwyn Hogan	bhogan@dfg.ca.gov
Laura Hohman (S)	lhohman@indstate.edu
Paul Homnick,	homnickp2@scranton.edu
Lauren Hooton (S)	lhooton@uwo.ca
Audrey Hopkins	audrey.hopkins@biomark.com

G. Roy Horst rhorst@twcny.rr.com
Reginald Hoyt reg.hoyt@forestpartnersinternational.org
Nickolay Hristov nickolay.hristov@brown.edu
Tatjana Hubel tatjana_hubel@brown.edu
Howard Huynh (S) huynh.hm@rogers.com
Martin Ince sebastian.irazuzta@mkince.ca
Carlos Iudica casaiud@susqu.edu
Roymon Jacob (S) r.jacob@bucknell.edu
Joel Jameson (S) ra-jamesonj@uwinnipeg.ca
Amanda Janicki (S) janicki13@missouristate.edu
Mark Jensen mrj@binaryacoustictech.com
Joseph Johnson josephsjohnson@hotmail.com
Dave Johnston djohnston@harveyecology.com
Kristin Jonasson kristin.jonasson@gmail.com
Daniel Judy djudy@cecinc.com
Karry Kazial karry.kazial@fredonia.edu
Jim Kennedy jkennedy@batcon.org
Julia Kilgour (S) kilgourr@uregina.ca
Tigga Kingston tigga.kingston@ttu.edu
Al Kisner alkisnerforthewild@earthlink.net
Marilyn Kitchell (S) marilyn_kitchell@fws.gov
Brandon Klug (S) bjklug@gmail.com
John Kobilis (S) jbk015@bucknell.edu
Jennifer Krauel (S) jennifer@krauel.com
Amanda Kronquist (S) ark010@bucknell.edu
Dennis Krusac dkrusac@fs.fed.us
Lesley Kunikis (S) lesleykunikis@gmail.com
Thomas Kunz kunz@bu.edu
Allen Kurta akurta@emich.edu
Gary Kwiecinski ggk301@scranton.edu
Michael Lacki mlacki@uky.edu
Winston Lancaster wlancaster@csus.edu
Richard Lance richard.f.lance@usace.army.mil
Cori Lausen corilausen@netidea.com
Louis Lazure (S) llazure@uwo.ca
Wynnell Lebsack (S) wynnellann@gmail.com
Dana Lee (S) dlee9@angelo.edu
Tracey Librandi Mumma tlibrandi@state.pa.us
Burton Lim burtonl@rom.on.ca
Kim Livengood kiml@titley.com.au
Susan Loeb sloeb@fs.fed.us
Jonathan Lucas varanus7@charter.net
Laura Lynn (S) laura.lynn@fredonia.edu
Leigh MacAyeal Leigh_Macayeal@brown.edu
Hugo Mantilla-Meluk (S) hugo.mantilla@ttu.edu
Beatrice Mao (S) bmao1@umd.edu
Amanda Matheson (S) ummath23@cc.umanitoba.ca
Melanie McCahey (S) mlmccahey@bsu.edu
Gary McCracken gmccrack@utk.edu
Liam McGuire (S) lmcguir5@uwo.ca
Angela McIntire, amcintire@azgfd.gov
Bree McMurray bree.mcmurray@modot.mo.gov
Brian McNab bkm@zoo.ufl.edu
Cara Meinke, cmeinke@stantec.com
Jean Mengelkoch jmengel@inhs.uiuc.edu
Darren Miller darren.miller@weyerhaeuser.com
Jennifer Miller (S) jennifer.miller@ttu.edu
Shahroukh Mistry mistrys@westminster.edu
Bryan Moore bryan_moore@nps.gov
Marianne Moore (S) mmoore@bu.edu
Derek Morningstar dmorningstar@golder.com
Nathan Muchhala n_muchhala@yahoo.com
Mariana Munoz-Romo mariana1@bu.edu
Olivia Munzer omunzer@swca.com
Kevin Murray lager33@gmail.com
Robert Muscarella (S) bob.muscarella@gmail.com
Juliet Nagel julietjoy1@yahoo.com
Jessica Newbern hwhidden@po-box.esu.edu
Joy O'Keefe (S) joyokeefe@gmail.com
Barbara Ogaard batlady4bats@comcast.net
Kevin Olival kjo2002@columbia.edu
Cory Olson (S) colson@ualberta.net
Theresa Olson tolson@lc.usbr.gov
Monik Oprea monik.bats@gmail.com
Dara Orbach (S) dorbach@uwo.ca
Allysia Park (S) allysia.park@smu.ca
Tracie Parkinson (S) tparkins@iam.uwinnipeg.ca
Julie Parlos (S) julie.parlos@ttu.edu
Janice Patten janice.patten@us.army.mil
Kyle Patton (S) kjp3879@louisiana.edu
Jessica Pawlowski (S) pawl5059@fredonia.edu
Scott Pedersen scott.pedersen@sdstate.edu
Jansel Perez Martinez che.32@hotmail.com
Roger Perry rperry03@fs.fed.us
Heidi Peters heidi2007peters@yahoo.com
Sandra Peters (S) speter33@uwo.ca
Thomas Pettit (S) tommy_pettit@baylor.edu
Kaitlyn Piatt kjp010@bucknell.edu
Miguel Pinto (S) miguel.pinto@ttu.edu
Joseph Poissant (S) joseph.poissant@smu.ca
DeeAnn Reeder dreeder@bucknell.edu
Jonathan Reichard (S) reichard@bu.edu
Jesika Reimer (S) jesika.reimer@gmail.com
Angela Remeika agr005@bucknell.edu
D. Scott Reynolds sreynolds@sps.edu
Marco Riccucci, m.riccucci@tin.it
Christopher Rice (S) chrisrice44@yahoo.com
Alexander Robb (S) alexander.c.robb@gmail.com
Lynn Robbins LynnRobbins@missouristate.edu
Piper Roby plroby@copperheadconsulting.com
Craig Rockey (S) crockey@emich.edu
Bernal Rodriaguez Herrera (S) bernalr@racsa.co.cr
Jane Rodrigue jrodrigue@fs.fed.us
Armando Rodriguez-Duran arodriguez@bc.inter.edu
Vanessa Rojas (S) vrojas@umflint.edu
Ashley Rolfe (S) arolfe1@emich.edu
Matina Rueppell mckalcou@uncg.edu
Amy Russell russelam@gvsu.edu
Maria Sagot (S) msagot1@lsu.edu
Jean Manuel Sandoval (S) lunatic_boy10@hotmail.com

Sharlene Santana (S) ssantana@bio.umass.edu
Jennifer Saville (S) ahaskew@al.umces.edu
Michael Scafini hwhidden@po-box.esu.edu
Brian Schaetz brianschaetz@hotmail.com
Michael Schirmacher mschirmacher@batcon.org
Dierdre Schultz didj@scc.net
William Schutt draculae@hotmail.com
Jodi Sedlock sedlockj@lawrence.edu
Juliana Senawi (S) juliana.senawi@ttu.edu
Joseph Senulis Joseph.Senulis@wisconsin.gov
Jim Serach jserach@lawrenceville.org
Alisha Shah alishanatural@gmail.com
Jason Shaw (S) shaw9972@bears.unco.edu
Timothy Sichmeller (S) tjsichmeller@bsu.edu
James Simmons james_simmons@brown.edu
Nancy Simmons simmons@amnh.org
Angela Sjollema (S) scutter@al.umces.edu
Samuel Skalak (S) Sskalak1@gmail.com
Mark Skowronski mskowro2@uwo.ca
Brooke Slack brooke.slack@ky.gov
Brenna Smith (S) bsmith97@emich.edu
Ches Smith (S) SMITHL9@auburn.edu
Emily Snode (S) emandmmuskie@yahoo.com
Tim Snow tsnow@azgfd.gov
Donald Solick dsolick@west-inc.com
Sarah Stamper sarah_stamper@brown.edu
Aura Stauffer astauffer@state.pa.us
Erica Stephens (S) step8009@fredonia.edu
Jamie Stewart jamie.stewart@ontario.ca
Mia Strauss (S) miastrauss@gmail.com
Timothy Strickler stricklt@gvsu.edu
Joshua Stumpf (S) jstumpf@emich.edu
Allyce Sullivan allyce_sullivan@brown.edu
Sharon Swartz sharon_swartz@brown.edu
Joseph Szewczak joe@humboldt.edu
Daniel Taylor dtayloraz@sbcglobal.net
Howard Thomas hthomas@fsc.edu
Douglas Timm dwtimm389@Jacks.sdstate.edu
Tom Tomasi tomtomasi@missouristate.edu
Amy Turmelle (S) turmelle@utk.edu
Gregory Turner grturner@state.pa.us
Merlin Tuttle mtuttle@batcon.org
Janet Tyburec jtyburec@mac.com
Karen Tyrell ktyrell@bheenvironmental.com
Mike van den Tillaart mtillaart@lotek.com
Jacques Veilleux veilleuxj@franklinpierce.edu
Nina Veselka (S) nina.veselka@gmail.com
Megan Vodzak mev002@bucknell.edu
Susanna von Oettingen susi_vonoettingen@fws.gov
Maarten Vonhof maarten.vonhof@wmich.edu
Maryalice Walker maryalice.walker@gmail.com
Melissa Walker (S) melissa_walker@brown.edu
Allyson Walsh awalsh@lubee.org
Elizabeth Warburton elizabeth.m.warburton@wmich.edu
Kristen Watrous kristen.watrous@stantec.com
Kimberly Weaver (S) knw002@bucknell.edu
Janelle Weber (S) janelle.weber@doane.edu
Christa Weise cweise@batcon.org
Debbie H. Welch (S) d-welch@cecer.army.mil
Howard (Sandy) Whidden hwhidden@po-box.esu.edu
Susan Whitford (S) whitford@rohan.sdsu.edu
Ken Wilkins ken_wilkins@baylor.edu
Shannon Williams hwhidden@po-box.esu.edu
Kimberly Williams-Guillen kimwilliamsg@gmail.com
Craig Willis c.willis@uwinnipeg.ca
Don Wilson wilsond@si.edu
John Winkelmann jwinkelm@gettysburg.edu
Julie Winner jzwinner@comcast.net
Patricia Wynne wynneart@aol.com
David Yates dave.yates@briloon.org
Heather York heather.a.york@gmail.com
Andrew Zellner hwhidden@po-box.esu.edu
Jan Zinck zinckj@pdx.edu

The following biography of Lazzaro Spallanzani was presented by Marco Riccucci during the awards banquet at the 38th Annual NASBR in Scranton, Pennsylvania, October 25, 2008. Thank you, Marco, for sharing this with us.

Lazzaro Spallanzani

Marco Riccucci
via Maccatella 26/B, 56124 Pisa, Italy
E-mail: m.riccucci@tin.it, marco.riccucci@alice.it

"If I set out to prove something, I am no real scientist — I have to learn to follow where the facts lead me — I have to learn to whip my prejudices"

Lazzaro Spallanzani was born in Scandiano (Italy), a small town northeast of the Apennines, on 10 January 1729, and died in Pavia (Italy) on 12 February 1799. "*Natus Scandiani, clarus ubique*" (born in Scandiano, renowned everywhere) is the epigraph in the native house where the scientist was born. He was a distinguished eighteen-century naturalist, a biologist and physiologist, and one of the founders of modern experimental biology. Louis Pasteur wrote: "Spallanzani is, in my opinion, one of the greatest experimental researchers appeared on the face of the earth."

His father was a lawyer. Spallanzani received his early education at the Jesuit College of Reggio and started to study law at the University of Bologna, but he switched to science under the influence of his cousin Laura Maria Caterina Bassi Veratti (1711–1778), who was the first woman to earn a professorship in physics at any university in Europe. Spallanzani received the doctor of philosophy in 1753, and in 1757 he was ordained a priest; after that he was commonly designated "Abate Spallanzani."

At only twenty-five he became professor of logic, metaphysics and Greek at the University of Reggio. He taught Greek at a seminary, and physics and mathematics at the University of Reggio, and he taught philosophy at the University of Modena (1763). He was offered chairs at many Italian and foreign universities but he preferred Modena. Later (1768), at the personal solicitation of Empress Maria Theresa, he accepted the chair of natural history at the University of Pavia and also became director of the museum, which was greatly enriched by collections he obtained during his journeys along the Mediterranean.

Spallanzani made many expeditions throughout Europe, the Mediterranean and Turkey. He reached Constantinople (now Istanbul), and then, having dispatched the valuable museum collections by ship, he set out on the very difficult return overland. He reached Bucharest, crossing the Transylvanian Alps (but he did not meet any vampire!) to Budapest, Vienna, and Pavia.

He also had close relationships with famed contemporary scientists and philosophers such as Lavoisier, Buffon, and Voltaire. His research was so much appreciated that he was made a member of academies and learned societies of London (the Royal Society), Madrid, Stockholm, Uppsala, Gottingen, Holland, Lyons, Bologna, Milan, Siena, Turin, Padua, Mantua, Geneva, and Berlin.

Attacking the then prevalent notion of spontaneous generation, he placed some chicken broth in a flask, sealed the flask, drew off the air to create a partial vacuum, then boiled the broth: no microorganisms grew.

The theory of spontaneous generation was finally disproved in 1859 by Louis Pasteur.

Spallanzani was also a pioneer in animal insemination, and in 1784 performed the first successful experiment in a dog, which whelped three pups 62 days later. He did an important series of experiments on digestion, in which he obtained evidence that digestive juice contains special chemicals that are suited to particular foods. In his investigations he used gastric juice from many different animals and often experimented upon himself.

His studies in regeneration are still classic. He showed experimentally that many animals, such as lizards and snails, regenerate important parts of their bodies if accidentally injured. The land snail even regenerates its head. He also successfully grafted the head of one snail onto the body of another.

Spallanzani first postulated the idea of echolocation in 1793. By observing a captive owl (*Otus scops*, *chiù* in Italian) he noticed its disorientation and collisions against the walls when the candle was extinguished in the room. He began experimenting with bats (*Rhinolophus ferrumequinum, Rhinolophus hipposideros, Pipistrellus pipistrellus, Nyctalus noctula, Myotis myotis*) and found that the flying bats did not hit the walls or obstacles in complete darkness.

In his notes on bats (mostly unpublished till recently) we can find many interesting contributions on behavior, feeding habits, seasonal migrations, torpor and hibernation, along with detailed information about daily temperatures in connection with arousal and flight.

Most bats are nocturnal and can fly through dark forests or caves where their eyes must be useless for lack of light. Spallanzani blinded bats and found that they could fly as perfectly as before. Spallanzani used different methods to blind his bats: burning of the cornea or pulling out or cutting off the eyeball. He caught several wild bats in the Fortress of his town (Scandiano), blinded, marked and released them, and then recaptured them a few days later. By examining the stomach contents of the bats, he discovered that the blind bats had been just as successful at catching insects as the other bats. Thus he discovered that bats are not dependent on eyesight, and their ears are what guide bats throughout the night. He used to work on the rooftop of his house in Scandiano—by day and by night.

Spallanzani wrote many letters to his colleagues about his discovery of bats being independent of eyesight. This caught the attention of Swiss naturalist Charles Jurine. He reported in 1794 that bats use hearing in orientation, as they collided with wires when their ear canals were closed with wax. In the spring of 1794, Spallanzani meticulously repeated and confirmed Jurine's experiments. His final view before his death was that " …the ears of the bat serve more efficiently for seeing, or at least for measuring distances, than do its eyes … The experiments of M. Professor Jurine, confirming by many examples those which I have done, and varied in many ways, establish without doubt the influence of the ear in the flight of blinded bats. Can it then be said that… the ears rather than their eyes serve to direct them in flight? … I say only that deaf bats fly badly and hurtle against obstacles in the dark and in the light, that blinded bats avoid obstacles in either light or dark … ."

George Cuvier (1769–1832), a French naturalist, criticized Spallanzani's and Jurine's experiments in his papers published in 1795, 1800, and 1829. According to Cuvier the sense of touch in the body surface or wing membrane would explain the bat's ability to avoid obstacles. At that time, this seemed to be a more plausible explanation and was accepted by zoologists for over a century.

We know from a 1795 letter by Spallanzani that he was writing a general work on bat flight and hibernation. This "Trattato dé Pipistrelli" (Treatise on Bats) had been addressed to the Berlin Academy of Science, but for unknown reasons, Spallanzani never finished this project.

Before understanding the real physiological process of bat flight (the so called "Spallanzani's bat problem," solved by Pierce, Griffin, Galambos, and Dijkgraaf), his experiments had different developments. Both Galambos and Dijkraaf studied and translated into English sections of Spallanzani's original reports.

An Italian researcher, Paolo Mazzarello, claims Lazzaro Spallanzani was the model used by Ernst Hoffmann in his 1815 story Der Sandmann, about a scientist who builds a beautiful female robot that drives a young man insane. Der Sandmann inspired the Offenbach opera, "The Tales of Hoffman," in which the scientist is renamed Hoffman, but in the original story the scientist is called Spalanzani, differing from the real-life Spallanzani by just one letter.

The real Spallanzani reported that he had obtained "resurrection after death" by adding water to tiny dehydrated animals (*animalcula*, as he called Rotifera and Tardigrada). Spallanzani (who was a priest and a scientist as well) was disturbed by the metaphysical implications of what he had done and wrote to Voltaire, asking what he thought happened to the animals' souls while they were dead. "When a man like you announces that he has brought the dead back to life we have to believe him," Voltaire wrote back. "If there is someone, sir, that has the right to explain this mystery, this person is you."

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More information about Lazzaro Spallanzani may be found at the Spallanzani Studies Center Web site: http://www.spallanzani.it/INGLESE/Base_Inglese.htm

For a list of the complete works of Lazzaro Spallanzani (in Italian), please contact Marco Riccucci.

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BOOK REVIEW

Neotropical Tent-roosting Bats—*Murciélagos Tropicales que Acampan en Hojas*. 1st Edition. B. Rodríguez-Herrera, R. A. Medellín, and R. M. Timm. Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica. 184 pp., 2007.

Worldwide, 22 species of bat are known to fashion leaves into tents for roosting, and 17 of these species occur in the Neotropics. It is these 17 species of bats and the plants that they use for roosting that are the focus of *Neotropical Tent-roosting Bats*. The purpose of this book is to provide a compendium of previous research, as well as an update on this fascinating roosting habit. This field guide provides invaluable information on the diversity of plants used by tent-roosting bats and the diverse architectural styles created by them. With this book, Rodríguez-Herrera and collaborators set a new standard for field guides. Its straightforward organization, quality, and relevance to the conservation of tropical bats will definitely attract amateurs and professionals alike.

This field guide begins with a concise background section on roosting preferences of bats and then focuses on tent-roosting species and the plants used for tent-making. The natural history information presented is basic; nevertheless, it provides a good review and a starting point for those new to the field. The authors also present up-to-date information on eight architectural types of tents constructed by bats in the Neotropics. High-quality photographs of each architectural type help the reader appreciate these bats' ingenuity. The introduction concludes with a short section on conservation that highlights the ephemerality of tents, compared with more permanent roosts, such as caves, and the threats affecting tent-roosting bats. Although this section makes important points, I was slightly disappointed at its brevity, especially considering the grave consequences of deforestation on tent-roosting bats.

The second part of the book concentrates on what the authors term "species descriptions." Readers might initially be surprised by the style used by the authors, which emphasizes the various plants used by each bat species, contrary to the standard information in a typical species account. However, when current deforestation rates are extraordinarily high, the plant emphasis could have strong conservation implications. Therefore, I feel this approach is refreshing and appropriate. Of the 17 species descriptions that comprise this section, three are quite extensive—*Artibeus watsoni*, *Ectophylla alba*, and *Uroderma bilobatum*. In these three descriptions the authors include a wealth of information, which attests to their years of experience with these bats and their tent-roosting behaviors. The remaining 14 species were treated in much less detail, primarily because little information is available. Thus, these species descriptions are practically an invitation to an army of graduate students to tackle projects that investigate the roosting requirements and ecology of these rather unexplored species. This section is also packed with spectacular profile and roosting photographs of each species of bat (except *Rhinophylla pumilio*). Of these, the roosting photographs of *Artibeus watsoni* are particularly attractive and complement the vast amount of information on this species.

The final sections of the book offer distribution maps for each species of bat, a key for identification of different types of tents, and a list of plant species known to be used for tent-making that indicates the species of bat and type of architecture associated with each plant. Of these, the key for identification of tent architecture, with its ten exceptional line drawings, stands out as a magnificent piece of work that is easy to use and visually appealing. Furthermore, the authors have gone beyond the traditional field guide by developing this as a bilingual (English/Spanish) book. This, and its low price of $15.00 US (available online through Instituto Nacional de Biodiversidad), make this book readily accessible for scientists in the developing world, where this kind of work is most significant and applicable. As a first edition, *Neotropical Tent-roosting Bats* already exceeds the expectations for a field guide, and it is bound to be a must-have for amateur and professional naturalists interested in the roosting habits and ecology of Neotropical tent-roosting bats.

J. Angel Soto-Centeno, Florida Museum of Natural History and Department of Zoology, University of Florida, Gainesville, FL 32611; E-mail: sotocenteno@ufl.edu

NEWS

Congratulations to Elodie Maitre (Dr. Bernard Sigé's lab), who received her doctorate from the University Claude Bernard Lyon 1, France, in April 2008. The title of her doctoral thesis (French) is: "Les Chiroptères paléokarstiques d'Europe occidentale, de l'Eocène moyen à l'Oligocène inférieur, d'après les nouveaux matériaux du Quercy (SW France): systématique, phylogénie, paléobiologie." Elodie is now at the Ecole Normale Supérieure of Lyon. If you are interested in receiving a copy of her thesis (or would like to congratulate her personally), please contact her at elodie.maitre@ens-lyon.fr .

Tom Kunz and his lab continue their pioneering, cross-disciplinary work in the areas of aeroecology and agroecology. They are currently using information technology and advanced imaging to show the economic, agricultural, and ecological importance of bats—in particular, the Brazilian Free-tailed Bat, *Tadarida brasiliensis*—in controlling agricultural pests. Tom's cross-disciplinary team includes bat biologists, mathematicians, meteorologists, climatologists, economists, and entomologists. You can find out more about some of their most recent cross-disciplinary work at: http://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=112602

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

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*.

2009 Renewal Notices — *Bat Research News*

It is once again time for subscription renewals! You should be receiving a renewal notice for the 2009 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 2009. All of us at *Bat Research News* wish you a happy, safe, and productive 2009!

FUTURE MEETINGS and EVENTS

16–18 January 2009

The 1st International Symposium on Bat Migration will be held at the Federal Institute for Risk Assessment in Berlin, Germany. Contributions from the fields of behavior, ecology, physiology, and genetics concerning migratory bats are welcome; the conference language will be English. For more information, please contact the organizers, Christian Voigt and Ana Popa-Lisseanu, at batmigration09@izw-berlin.de or check the web page at http://www.izw-berlin.de and click on "Events."

12–13 February 2009

The 14th Annual Meeting of the Southeastern Bat Diversity Network and the 19th Colloquium on Conservation of Mammals in the Southeastern United States will be held in Jonesboro, Arkansas. Information can be found at: http://www.sbdn.org

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.

August 2011

XIIth European Bat Research Symposium will be held in Lithuania.

BAT RESEARCH NEWS

VOLUME 49: NUMBER 4 **WINTER 2008**

Table of Contents

Front Cover

The cover illustration of the big brown bat, *Eptesicus fuscus*, was drawn by Kara Lynn Pivarski. Kara is a biologist and artist who currently resides in New Hampshire. Thank you, Kara, for sharing your artwork with us.