BAT RESEARCH NEWS

VOLUME 51: NO. 1 **SPRING 2010**

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Front Cover

The photograph of *Desmodus rotundus*, the common vampire bat, was taken by Edvard Magalhães, a speleologist who worked in the field with Dr. Mariella Freitas. Many thanks to Mariella and especially to Edvard for sharing the photo with us.

BAT RESEARCH NEWS

Volume 51: Number 1 Spring 2010

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Institutional/Group subscriptions	US $50.00
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printed edition (U.S.A.)	US $25.00
printed edition (outside U.S.A)	US $35.00

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Bat Research News is ISSN # 0005-6227.
Bat Research News is printed and mailed at Lycoming College, Williamsport, Pennsylvania 17701 U.S.A.

This issue printed March 24, 2010.

Activity of P-enolpyruvate Carboxykinase and Levels of Plasma Insulin in Common Vampire Bats (*Desmodus rotundus*)

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Introduction

Unlike most mammals, the common vampire bat (*Desmodus rotundus*) shows a severe hypoglycemia following fasting (Freitas et al., 2003), culminating in death after only 48–72 h (Breidenstein, 1982; McNab, 1972). Vampire bats also have low reserves of liver glycogen and fat (Freitas et al., 2003), suggesting small contributions of both glycogenolysis and gluconeogenesis, which are metabolic pathways usually activated by other mammals to elevate circulating blood glucose when food is not available (Tirone and Brunicardi, 2001).

Phosphoenolpyruvate carboxykinase (PEPCK) plays an important role in control of gluconeogenesis (Barthel and Schmoll, 2003). PEPCK catalyzes one of the rate-limiting steps of gluconeogenesis, the conversion of oxaloacetate to phosphoenolpyruvate, which leads to the final step of gluconeogenesis, the production of free glucose (Barthel and Schmoll, 2003). Although this enzyme is found in the liver of many vertebrates, its intracellular distribution varies among species. In rodents, this enzyme is predominantly cytoplasmic (Hakimi et al., 2005), while in other vertebrates, including quails, rabbits, cats, humans, and frugivorous bats, it is also present in the mitochondria (Croniger et al., 2002; Hakimi et al., 2005; Pinheiro et al., 2006; Sartori et al., 2000). Activity of this enzyme is mediated by hormones, which influence transcription of the gene for PEPCK (Hagopian et al., 2003; Hanson and Reshef, 2003). The most important hormone that inhibits expression of this gene is insulin, whereas expression is induced by glucagon during fasting, by glucocorticoids during periods of stress, and by catecholamines during exercise (Barthel and Schmoll, 2003). Because insulin has a strong effect on activity of PEPCK and on body energy reserves, we determined cytosolic and mitochondrial activity of PEPCK in the liver of common vampire bats, as well as levels of insulin in the plasma, for both fed animals and those that were fasted for 24 h.

Materials and Methods

Adult male and non-pregnant female common vampire bats weighing 22–37 g, were captured from caves near Brasília, Brazil (15°30'S, 48°10'W). Prior to the experiments, bats were caged in pairs and maintained in the laboratory at room temperature. Bats were fed on defibrinated bovine blood for at least 4 nights; during each night, the bats were offered 40 ml of blood, which exceeded the average daily consumption (13.7 ml) of captive vampires in a previous study (Breidenstein, 1982). Petri dishes containing blood were offered at 2000 hours and removed at 0730 hours the next morning. Water was available ad lib. All measurements

of PEPCK and insulin were conducted between 0800 and 1000 hours.

To determine the effects of feeding on activity of PEPCK, bats were randomly sorted into two groups, a fed group and a group that was fasted for 24 h. Each group consisted of six males and six females. Bats in the fed group were killed by decapitation after the 4th night that blood was offered. The fasted group was fed for 4 nights but deprived of food on the 5th night, when only water was available; these bats were decapitated following the 5th night.

After death, the liver was rapidly removed and homogenized in 4 ml of ice-cold Krebs buffer containing sucrose (0.2 M), triethanolamina (20 mM), mercaptoethanol (5 mM), and ethylenediaminetetraacetic acid (1 mM) at a pH of 7.5. The homogenate was centrifuged for 10 min at 2,200 g, and the supernatant was decanted and recentrifuged at 10,000 g for 15 min. The sediment from this second centrifugation was resuspended to the original volume and centrifuged twice more for 15 min at 10,000 g to provide the mitochondrial fraction. The cytosolic fraction was obtained by centrifuging the supernatant from the second centrifugation at 40,000 g for 30 min. All steps were carried out at 4 ^{o}C. Mitochondrial and cytosolic fractions were further diluted to obtain concentrations within the linear part of the assay, which was based on the $NaH^{14}CO_3$-oxaloacetate exchange reaction (Ballard and Hanson, 1967). Reactions were stopped with 10% trichloroacetic acid, and the fractions were centrifuged. Activity was measured in a liquid scintillation spectrometer.

For determination of plasma insulin, the same experimental procedures were followed with a fed and a 24-h-fasted group. However, only 13 animals were used—seven males in the fed group and six males in the fasted group. Bats again were killed by decapitation, and blood, which was flowing from the trunk, was directly collected into a test tube. Plasma insulin of fed and fasted bats was measured by radioimmunoassay (Scott et al., 1981).

Data were presented as the mean ± SE. Statistical analyses were performed using repeated-measures one-way ANOVA. Alpha was set at 0.05.

Results

Sex did not influence any of the measured variables, so data from male and female bats were pooled. Activity of PEPCK was higher ($F_{1, 21}$ = 72.49; P = 0.001) in the cytosol of the liver of fed bats (47.31 ± 3.65 nmol•mg of protein^{-1}•min^{-1}) than in the mitochondria (12.87 ± 2.06 nmol•mg of protein^{-1}•min^{-1}). After fasting, activity of PEPCK in the cytosol increased sharply ($F_{1, 19}$ = 96.98; P = 0.001), attaining levels 400% higher (179.27 ± 13.44 nmol•mg of protein^{-1}•min^{-1}) than values for fed animals, whereas activity in the mitochondria were unaltered ($F_{1, 22}$ = 0.05; P = 0.83) after fasting (12.22 ± 2.09 nmol•mg of protein^{-1}•min^{-1}). Plasma insulin in fed vampire bats (0.81 ± 0.22 ng/ml) was significantly reduced ($F_{1, 11}$ = 1.08; P = 0.047) after 24 h of fasting (0.34 ± 0.11 ng/ml).

Discussion

The common vampire bat has a low resistance to fasting, probably due to the small amount of fat in the body and low reserves of glycogen in the liver and in breast and limb muscles (Freitas et al., 2003, 2005). Vampires develop a severe hypoglycemia after 12 h of fasting, which persists for the next 36–60 h of fasting (Freitas et al., 2003). This inability to maintain proper levels of blood glucose is unusual and suggests that known mechanisms of glucose homeostasis, such as glycogenolysis and gluconeogenesis, may not be operating in vampires.

Gluconeogenesis promotes homeostasis

during fasting by conversion of lipid and protein stores into glucose. This metabolic pathway has been repeatedly observed in other mammals, especially those fed high-protein diets (Exton, 1972; Kettelhut et al., 1980; Kraus-Friedmann, 1984). PEPCK is a key enzyme of gluconeogenesis, and its high activity usually indicates activation of that process (Barthel and Schmoll, 2003).

In other vertebrates fed a high-protein diet, cytosolic PEPCK is remarkably adaptable, increasing two- to threefold in activity after 24 h of fasting. The mitochondrial form of the enzyme, in contrast, seems more related to rapid and constant processes of glucose production in the liver, such as the Cori cycle, and remains relatively unaltered by fasting or hormonal manipulation (Hanson and Garber, 1972; Hanson and Patel, 1996). In general, rats and mice have a predominantly cytosolic activity of this enzyme (Croniger et al., 2002), like the vampire, whereas other mammals have a more equal distribution (Hanson and Patel, 1996). Cytosolic activity of PEPCK in vampires is higher than observed in vertebrates with high-carbohydrate diets (Eisenstein and Strack, 1971; Pinheiro et al., 2006) but comparable to other vertebrates on high-protein diets (Eisenstein and Strack, 1971; Sartori et al., 2000).

Cytoplasmic activity of PEPCK in vampires is 400% higher in fasted than in fed bats. This marked increase in cytosolic PEPCK suggests activation of gluconeogenesis. Nevertheless, Freitas et al. (2003) show that blood glucose in vampires decreases markedly after 24 h of fasting, reaching levels near 1.6 mmol/l (ca. 30 mg/dl) after continued fasting (48–72 h); those observations indicate that the high enzymatic activity observed in the present study may result from either altered hormonal control or involvement of PEPCK with processes other than gluconeogenesis. In other words, how could gluconeogenesis be activated during fasting in vampires if their blood glucose is extremely low and remains low during subsequent nights without food, ultimately leading to death?

To answer this question, we decided to investigate other factors, such as hormones, which could affect the activity of PEPCK. Because insulin plays an important role in regulating levels of this enzyme and inhibiting its activity (Barthel and Schmoll, 2003), as well as influencing the accumulation of energy reserves in the body, we determined the concentration of insulin in the blood of fed and fasted vampire bats. Levels of plasma insulin in fed vampire bats (0.81 ± 0.22 ng/ml) are at least 50% lower compared to other fed mammals, such as rats (about 1.6–2.3 ng/ml—Lephart et al., 2004). Insulin normally suppresses expression of the gene for PEPCK, and the elevation in activity of PEPCK in vampires may simply be due to the low concentration of circulating insulin.

Recent studies have shown that PEPCK is also present in tissues that do not synthesize glucose to any appreciable extent, including white and brown adipose tissue, mammary gland, small intestine, brain, lung, and muscle (Hakimi et al., 2005). Furthermore, cytosolic PEPCK can be associated with various metabolic processes other than gluconeogenesis, such as glyceroneogenesis (Botion et al., 1995; Hanson and Reshef, 2003; Towle, 2005) and cataplerosis (Hakimi et al., 2005). These latter processes are critical for recycling of free fatty acids back to triglyceride in the liver and to the dynamics of the citric acid cycle, respectively, and high levels of PEPCK in vampires may reflect its involvement in these other processes. Nevertheless, vampire bats are characterized by low levels of circulating insulin, low energy reserves in the body, and an inability to withstand even short fasts (Freitas et al., 2003, 2005, this paper), and these peculiar

characteristics may have played a role in the evolution of behavioral adaptations in vampire bats, such as reciprocal food sharing through blood regurgitation (Wilkinson, 1990).

Acknowledgments

This work was supported by the National Council of Scientific and Technological Development of Brazil (grant number 140328/02-5). We thank N. Resano, as well as staff members of São Paulo University and the State University of Campinas for technical assistance. We are also grateful to E. Magalhães and C. Freitas, for field assistance, and B. Menezes, for revising the English version. Captures were approved by the Brazilian Institute of Environment and Natural Resources, and experimental protocols were approved by the Animal Care and Use Committee from the Institute of Biology at the University of Brasilia.

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Abstracts of Papers Presented at the XIth European Bat Research Symposium

Cluj-Napoca, Romania 18–22 August 2008

The following abstracts are from papers presented at the XIth European Bat Research Symposium. They were compiled and submitted by Abigel Szodoray-Paradi, and edited for publication by Margaret Griffiths. Any omissions or errors are inadvertent. Abstracts are listed alphabetically by first author. Contact information for authors who attended the Symposium follows the abstracts.

Bat Migration in the Western Baltic Sea Region and Effects of Offshore Wind Farms

Ingemar Ahlén[1], Lothar Bach[2], Hans J. Baagøe[3], and Jan Pettersson[4]; [1]SLU, Uppsala, Sweden; [2]Bach Freilandforschung, Bremen, Germany; [3]The Natural History Museum of Denmark, University of Copenhagen, Copenhagen, Denmark; [4]Färjestaden, Sweden

Bat migration has been observed along the Swedish coast since 1993. Bats migrated from several points along the southern coastlines. Since 2000 bat migration was studied at Falsterbo, on Gotland and especially on Öland. In 2005 and 2006 a more intensive study in late summer and early autumn was done in Kalmarsund in the Baltic Sea and in Öresund between Sweden and Denmark. Observations were made both from boats and at the coastal points where bats head off out to sea. We used ultrasound detectors, strong spotlights and also a thermal camera. Automatic recording devices were placed on land, on wind turbines in Kalmarsund, and on the boat. These methods resulted in 12,354 observations of bats—3830 over the sea and 8524 on land. Bats fly over the sea in winds up to about 10 m/s, although a major part of the activity took place at wind speeds less than 5 m/s. Ten species of bats were observed on the open sea. Most of them were migrating, but all of them were foraging at calm weather or light breeze. Some resident species also hunted far from the coasts. With radar on Utgrunden's lighthouse in Kalmarsund, movements of the larger bat species, mainly *Nyctalus noctula*, could be studied. Flyways, directions, and movement patterns when foraging were recorded. The measured altitudes showed that most activity (when not hunting) took place below 40 m above sea level. Bats did not avoid off-shore wind turbines, they seemed attracted and hunted insects accumulated by the windmills. Hunting close to the blades was observed, and suggests that the risk of collision is comparable to that with land-based turbines. Bats also used turbines for resting.
A full report of this study can be downloaded at: http://www.ekol.slu.se/ShowPage.cfm?OrgenhetSida_ID=8181

Microhabitat Structure and Prey Abundance in the Foraging Site Selection of *Myotis capaccinii*

David Almenar, Joxerra Aihartza, Urtzi Goiti, Egoitz Salsamendi, and Inazio Garin, University of the Basque Country, Bilbao, Basque Country, Spain

Long-fingered bats, *Myotis capaccinii*, are known to prefer rivers with smooth water surfaces to forage. Nonetheless, habitat selection behavior is unable to entirely explain the foraging behavior shown by this species. Large areas with suitable foraging habitat around roosts remain unused during some parts of the activity period. The foraging behavior of a population of the species was studied in the lower Xúquer Basin, Eastern Iberian Peninsula; 45 bats were radio-tracked during pre-parturition, lactation, and post-lactation, and their foraging sites were identified accurately. Prey abundance was sampled in the foraging sites simulating the two main foraging techniques described for the species (trawling and aerial hawking). Among the sites with preferred habitat features (rivers with smooth surfaces) bats selected those with more potential prey, so that foraging site selection resulted from a combination of microhabitat structure and prey abundance. Seasonal variation in the spatial pattern of foraging was influenced by local abundance of prey in different river sectors. Water temperature was the main factor leading to the emergence of insects with aquatic larva, and its variation in space and time resulted in sequential production of prey among river sectors, allowing, in turn, continuous exploitation of foraging ranges around roosts during the time of occupancy.

The Trend-setting Factors in the Foraging of a Specialized Insectivorous Bat

Michal Andreas[1], Antonín Reiter[2], and Petr Benda[3,4]; [1]The Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Průhonice, Czech Republic; [2]South Moravian Museum Znojmo, Znojmo, Czech Republic; [3]National Museum of Natural History, Prague, Czech Republic; [4]Charles University, Prague, Czech Republic

Regarding the current knowledge of foraging ecology and diet composition, we know only the most frequently consumed prey categories and prevailing foraging strategy of bat species. Seasonal dynamics of prey selection, trophic niche changes and its trend-setting factors remain poorly known. The main difficulty is a lack of material studied in association with a food supply and covering most of the active season. We netted bats from March to November and analyzed their feces under a microscope. Food supply was collected using UV light, beating and sweeping. Comparison of food supply and the diet of *Barbastella barbastellus* demonstrated considerable selectivity of middle-sized and larger moths and, furthermore, a trophic niche narrowing within a season of the highest moth abundance in accordance with the premises of optimal foraging theory. The present study demonstrated various trend-setting factors of diet composition and foraging behavior, the importance of which changes considerably during an activity season. These factors are: 1) absolute abundance of the preferred prey during summer; 2) opportunistic niche widening ability during periods of decreasing abundance of the preferred prey; 3) pool of available food supply during the season of low prey abundance; and 4) constraints resulting from foraging abilities—if the preferred prey cease to fly, an aerial hawker must hunt for alternative prey.

Multiple Morphological Characters Needed To Identify Cryptic Bat Species In The Field

Sohrab Ashrafi[1], Fabio Bontadina[1,2], Andreas Kiefer[3], Igor Pavlinic[4], and Raphaël Arlettaz[1]; [1]University of Bern, Bern, Switzerland; [2]SWILD – Urban Ecology and Wildlife Research, Zurich, Switzerland; [3]Johannes Gutenberg-University, Mainz, Germany; [4]Croatian Natural History Museum, Zagreb, Croatia

Discovery of cryptic species may significantly change the perspective on distribution, abundance, ecology, and hence conservation status of all species involved. In order to study the species' ecology, an unambiguous identification of specimens in the field is required. In European alpine regions, molecular studies revealed the existence of three species of plecotine bats: *Plecotus auritus* and *P. austriacus*, and only recently the cryptic *P. macrobullaris* was discovered. We captured 214 individual *Plecotus* bats from 29 sites in 4 bioregions of Switzerland, collected biopsy punches to conduct genetic analysis, and measured external morphological characters in order to investigate the reliability of already proposed morphological traits for species recognition and to build a multivariate model to identify species securely in the field. All three species were found in single-species colonies, except in one case where a church attic harbored a mixed colony. Qualitative traits alone did not reliably separate the three species but multivariate analysis of external measurements resulted in a discriminant function able to identify the correct species with a probability of 97.5%. Accuracy can even be improved by analyzing several individuals from a colony. For field identification of cryptic *Plecotus* species we suggest a multivariate morphological approach as a quick alternative to genetic analysis.

Bat Winter Activity: The Influence of Prey Abundance

Ana M. Augusto[1], Ana Rainho[1,2], and Jorge M. Palmeirim[1]; [1]Universidade de Lisboa, Lisboa, Portugal; [2]Instituto da Conservação da Natureza e da Biodiversidade, Lisboa, Portugal

In the temperate zones bats spend most of the winter in hibernation, but they are known to interrupt it for reasons that are not always understood. Our objective was to determine if foraging was a relevant activity during these interruptions in a part of the temperate zone with particularly mild winters—the Mediterranean. To do this, we used a colony of *Myotis myotis* located in southern Portugal as a model, and we 1) compared the abundance of prey during the winter with that of other seasons; 2) checked if bats frequently made potential foraging trips; and 3) verified if the fecal pellets produced in the winter contained prey. Bats often made potential foraging flights throughout the winter, and preliminary analyses of the content of fecal pellets confirmed that they are often foraging. The quantification of the abundance of prey in the major types of land cover demonstrated that there is much less prey during the winter than in autumn and spring. However, in winter prey were somewhat more abundant than in the summer, a season that is probably a food bottleneck for Mediterranean *M. myotis*. Consequently, our preliminary analysis suggests that, thanks to mild winters, there is sufficient prey to make winter foraging by Mediterranean *M. myotis* possible, but that food is not abundant at this time of the year. As winter feeding may be important for the survival of Mediterranean bats, management around key colonies should take into consideration the winter foraging needs of bats.

Bats in Romanian Philately: Caving Activities and Dracula's Shadow

Stephane Aulagnier, Société Française pour l'Etude et la Protection des Mammifères/Comportement et Ecologie de la Faune Sauvage, Castanet-Tolosan cedex, France

Although Romania has issued a number of topical stamps for a long time, the first bat was depicted only in 1997, as a secondary topic on a Dracula stamp. The first and unique set of six stamps depicting bat species was issued in 2006. The species are local representatives: *Rhinolophus hipposideros*, *Nyctalus lasiopterus*, *Pipistrellus pipistrellus*, *Barbastella barbastellus*, *Plecotus auritus*, and *Myotis myotis*. Possible explanations for this scarcity could be the bad image of bats in most of Europe, and also the more frequent use of stamp-printed envelopes in the country. A total of ten postal stationeries complete the Romanian issues. The main topic is the organization of symphonic concerts in Romanesti's Cave (5). Dracula—and Vlad Tepes—is second (3). Since 1984 Romanian philately has also included ca. 30 topical cancels, but these are more difficult to list than postal issues. The main topics are still concerts in the cave (7) and Dracula (6); they also include caving (7), Shakespeare festival (2), solar eclipse (2), etc. On the whole, bats are quite scarce in Romanian philately, but they illustrate the most famous local topics dealing with these mammals.

Zoogeography of Tunisian Bats: Synthesis and Perspectives

Stéphane Aulagnier and Ridha Dalhoumi; C.E.F.S., Castanet-Tolosan cedex, France; L.B.E., Faculté des Sciences, Bizerte, Tunisia

The first Tunisian bats, *Rhinolophus ferrumequinum* and *Miniopterus schreibersi*, were reported in 1868 by Hartmann, without any location. Then, Lataste (1885), Gadeau de Kerville (1908), and Olivier (1909) recorded seven more species. After an additional species by Laurent (1935) and a set of new locations by Blanc (1935), surveys in the 1950s and 1960s added three species to the list. Cockrum and Vesmanis reported respectively four and one species in 1976. Since that time, in contrast to the other countries of Maghreb, Tunisian bats have not been surveyed. Considering the taxonomy of the late 20th century, the 18 Tunisian bat species could be classified into 7 zoogeographical types. However recent taxonomic changes reduced the distribution of several species. *Myotis punicus* and *Eptesicus isabellinus* are now considered as separate species, and this could also be the case of *Hypsugo* cf *darwinii*. Then, faunistic types in Tunisian bats could be: Palaearctic (1), Western Palaearctic (5), Mediterranean (6), Western Mediterranean (2), Mediterraneo-turkes-tanian (1), and Saharo-sindian (3). These changes reinforce the Mediterranean affinity of the Tunisian bat fauna, but we can expect to find some Saharan species to slightly counterbalance this tendency. Finally, early records of *Rhinolophus euryale* and *Pipistrellus kuhlii* should be revised (possible confusion with, respectively, *R. mehelyi* and *P. deserti*). Moreover new surveys are needed in order to raise our current knowledge of Tunisian bat fauna to the level of the other Maghreb countries.

The Pond Bat, *Myotis dasycneme,* in Denmark: Distribution and Estimated Population Size

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The Atlas of Danish Mammals reveals two populations of pond bats in Denmark. Colonies and hunting localities of the larger population are found throughout eastern middle Jutland and in the area around the Limfjord. A small population is restricted to the area around Guldborgsund, a brackish sound in southeastern Denmark. Substantial numbers of pond bats hibernate in three limestone mines in Jutland. A few individuals ringed in the mines were recorded in the summer distribution area of the large population in Jutland. Since almost no other hibernation sites have been found for this species, and since the distribution in Jutland is limited to a distance of up to about 100 km from the mines, it seems most likely that the summer and winter populations are identical and of the same order of magnitude. In the smaller Smidie Mine it is possible to count the bats on walls and ceilings. But in the larger Daugbjerg and Mønsted Mines most bats hibernate hidden in fissures, etc. Every three or four nights through the departure period from the mines in April we harp-trapped all bats. Subsequently we could estimate the population size of pond bats in Jutland to be around 4500.

Green Bridges as Crossovers for Bats

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In Germany one of the major factors for habitat fragmentation is motorways. In 2005 we investigated the activity of bats at nine green bridges in a mosaic-like landscape in Baden-Württemberg (southern Germany) with detectors and automatic bat recording devices. Three tunnels and three street bridges were studied to compare the data between different constructions. The green bridges were not originally constructed for bats. We found 11 bat species using all of these bridges regularly. The results showed that the activity was higher in tunnels than green bridges, which was higher than the usual street bridges. We analyzed the factors wideness, structures on the green bridge, and connection to the surrounding landscape. The expected values for activity were higher when the green bridges were wide, contained good structures (e.g., hedgerows), and were connected to the surrounding landscape on both sides of the bridge. The reason for the factor combination might be that hedgerows protect the bats from light and noise. The results show that green bridges are suitable to lead bats across large roads. Important for their functionality is a good investigation of the land use of the bats before planning the bridge and to place it with good connection to the surrounding landscape, e.g., at regularly used flight paths.

Morphological Evidence of Hybridization in Two Sister Species, *Myotis myotis* and *Myotis oxygnathus* (Chiroptera: Vespertilionidae), in the Carpathian Basin

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Cranial specimens of *Myotis myotis* and *Myotis oxygnathus* obtained from localities throughout the Carpathian Basin (Slovakia, Hungary, Poland, Romania, and Ukraine) were used to apply multivariate techniques to determine whether significant variation exists in cranial morphometrics. Previous morphological evidence supported the view that the two species constitute two well-differentiated groups, but recent morphological analyses have shown that where they occur in sympatry, some individuals are intermediate in typical morphology. Twenty-two cranial measurements were made on each specimen and results were analyzed using Principal Component Analyses (PCA) and Discriminant Analyses (DA). PCA was used in order to establish the major morphological separation among *Myotis myotis* and *Myotis oxygnathus* and to reclassify each specimen into a group. From Discriminant Analyses of the 22 variables, 7 selected, and showed significant differences between the 3 groups *M. myotis* (123), *M. oxygnathus* (184), and animals of the examined specimens that were classified as intermediate individuals (6). Bats designated as intermediate are probable hybrids. Recent genetic evidences for gene flow between European *M. myotis* and *M. oxygnathus* indicate that these forms are not reproductively isolated and distinct biological species. Phylogenetic analyses have shown that the two species share some mtDNA haplotypes when they occur in sympatry. The current status of these two species awaits further morphological and genetic investigation.

Use of Bat Boxes by Nathusius' Pipistrelle, *Pipistrellus nathusii*, in Lithuania 2007

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Nathusius' pipistrelle is a seasonal migratory bat species that has its breeding areas mainly in northeastern Europe, i.e., the Baltic States, northwestern Russia, Belarus, Poland, and East Germany. In late summer and early autumn the populations migrate from their breeding areas to western and southern Europe. Mating takes place during the autumn migration. Males are maintaining their territorial position along the migration routes. This means that the migration routes can be identified by the presence of territorial males. During the mating season territorial males use tree holes, cavities in houses, spaces in hollow trees and behind bark, and other cavities, such as bat and bird boxes. The presence of the males cannot easily be seen when they are in tree holes and other non-accessible spaces. Bat boxes can provide mating sites for bats that can be easily checked at daytime for the presence of territorial males and mating groups, but also for maternity colonies in summer time. The purpose of the present study was to assess the occupancy rate of bat boxes by Nathusius' pipistrelle during the autumn migration season. The network includes all national and most regional parks and some strict nature reserves in Lithuania. In total, 791 bat boxes were erected in 35 areas during 2004–2007. The boxes were erected in clusters (20 boxes) in one site. The boxes were checked for bats on 14–30 August 2007. During the study, 252 bats belonging to 4 species were found in bat boxes. *Pipistrellus nathusii* constituted 96.8%. *Nyctalus noctula*, *Plecotus auritus*, and *Myotis dasycneme* together constituted the remaining 3.2%.

Acoustic Identification of the Three Species of *Plecotus* Occuring in France

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Identifying echolocation calls at the species level is essential for many studies on the ecology and conservation of bats. Whereas for some taxa like *Pipistrellus* the species identification is relatively easy, other taxa like *Plecotu*s are more difficult to recognize. Here, we focus on the three *Plecotus* species present in France: *P. auritus*, *P. austriacus*, and *P. macrobullaris*. In this study, we discriminated the three species based on simple traits (interval between two calls, duration, highest frequency, lowest frequency, and frequency of main energy) through canonical variate analyses and discriminant functions. Then, based on discriminant functions we provided operational criteria to identify these species two by two. All individuals recorded were marked using a chemiluminescent capsule (Cyalume) and tracked across different habitats, or recorded after leaving their roost. We succeeded in identifying individuals with 70% cross-validation rate in a general analysis including the three species. For the paired analyses we obtained 73% of cross-validation between *P. austriacus* and *P. macrobullaris*, 82% between *P. auritus* and *P. macrobullaris*, and 92% between *P. auritus* and *P. austriacus*. Our results suggest that it is possible to identify *Plecotus* species in France with good probabilities using relatively simple measurements.

Investigating the Population Genetics and Morphometrics of *Myotis punicus* in the Maltese Islands, Seeking Insight for an Effective Conservation Action Plan

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Using morphometric data for six variables collected over the past 20 years from ringed individuals of *Myotis punicus*, a statistical analysis was carried out to determine descriptives, sexual dimorphisms, and correlations, and to formulate models. These data were compared to data sets for the three species of the larger *Myotis* complex, from eight countries. Maltese samples of *Myotis punicus* showed the same averages as those in other countries but a much wider range of values, probably due to adaptations to the insular habitat. A preliminary study of the population structure of *Myotis punicus* in the Maltese Islands was carried out, on a subset of these samples, using cellulose acetate allozyme electrophoresis and non-lethal sampling. Nei's Genetic Distance values ranged from 0.0–0.047 indicating that the Maltese population is a single panmictic unit. However, not enough is currently known about the local ecology and requirements of this species, and the purpose of these studies is to stimulate interest in the Maltese chiropterofauna. The multitude of gaps in the available data and protection offer interesting challenges for future co-operation. The overall aim is to have enough reliable data to produce a reliable action plan before the local population declines beyond the point of recovery.

Bat Bugs (Cimicidae, Heteroptera): A Possible Cause of Roost Switching by Bats

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Previous results have shown frequent movements of crevice-dwelling bats among different shelters. Low roost fidelity of some bat species reduces the reproductive success of ectoparasites. Up to the present, studies concerning bat ectoparasites have dealt mainly with species that permanently live on their hosts' bodies, whereas the relations between bat species roosting in crevices, and their ectoparasites that live in the same shelters but mostly without physical contact with their hosts, are often based only on guesses. Sessions in a flight chamber equipped with two bat boxes were carried out. One of the boxes was loaded with ectoparasites (bat bugs, *Cimex* sp.), the other served as a control and as an alternative roost for bats that left the loaded box. The differences in the level of bat auto-grooming, movements inside experimental boxes, and vacating of boxes between experiments with bat bugs and with controls without bat bugs were significant. Allogrooming was observed only in few cases, and therefore the hypothesis of cooperation among individual bats in defense against bat bugs was rejected. Experiments with artificial parasitizing show that vacating the roost of a confined space occupied by a high number of ectoparasites—i.e., roost switching—is a natural behavior of crevice-dwelling bat species. [The study was supported by grants No. MSM0021622416 and 206/07/P098.]

Mass Wintering of *Nyctalus noctula* in the Lviv City Area (Western Ukraine)

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The Noctule bat is considered to be a forest and long-distance migratory bat. Usually it hibernates in southern, western, and southwestern parts of its range, occupying tree hollows and buildings. However, mass wintering of

noctules in urban areas has appeared recently and wintering individuals have been recorded in urban areas of many Central European countries. Large hibernacula were known only from the Transcarpathian region in Ukraine, but in recent years, wintering of the Noctule bat has been more common in Ukraine. The first hibernation colony was found in Lviv city in the winter of 2006–2007. Fourteen hibernation shelters were found in the sample plot of 100 ha during the following year. They were situated in prefabricated buildings (in wall crevices and behind the wall panels, rarely in the space under the window-sill). The average number of individuals per colony fluctuated between 25–300. Because of a warm winter, the beginning of hibernation was later, and animals were active until the end of December (i.e., until a heavy frost with evening temperatures -4 to -5 ºC) and during the thaws. Northward movement of the border of the noctule's wintering area indirectly supports the occurrence of global climate changes.

New Criteria for the Acoustic Identification of the Greater Noctule, *Nyctalus lasiopterus*, Lead to a Better Knowledge of Its Distribution in France

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Although several important features of *Nyctalus lasiopterus* biology are now well understood, its echolocation calls are not yet described in detail. Using automatic and long lasting recordings, we were able to gather typical search sequences of free flying animals that differ from the calls collected near the roost or from hand released individuals. The detection of this species has also been hampered by the high-pass filter present in many bat detectors as well as by a predominant use of the heterodyne technique for bat detection. The most characteristic and most frequent search calls can be described as shallow FM signals, lasting 20–35 ms, of limited bandwidth (no more than 2 kHz), and a final frequency of 11–13 kHz. Inter-calls intervals are long, with a mean value of 800 ms. As in *N. noctula* and *N. leisleri*, two alternating types are often present. As usual, in cluttered locations, calls tend to be higher, shorter, and less spaced. Confusion can then be made, not with *N. noctula* as previously reported, but with *Tadarida teniotis*. The new criteria of identification drawn from this study enabled us to extend and refine the distribution of the species in France, from new recordings as well as from ancient or misclassified sound sequences. The Greater Noctule now appears to occur in many wooded areas of the southern two-thirds of the country with three strongholds: Corsica Island, the Landes forest (southwest), and the south of the Central Massif.

What is the Level of Winter Bat Activity Inside the Natural Cave?

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The flying activity of bats inside the Katerinska Cave (Moravian Karst, Czech Republic) during the deep hibernation period was observed by sniperscope (Pathfinder 2000s). The research was carried out during the two winter seasons of 2006/07 and 2007/08. The activity was observed during three hours around sunset and sunrise. A census of bats was done before the evening observations, with the cave divided into four parts. *Myotis myotis* and *Rhinolophus hipposideros* were the most abundant species there. The morning activity was nearly zero-level; therefore the sunset activity was used for the analysis. There were statistically significant differences between the total level of activity in both seasons, but the model of activities was nearly the same. In both winters the second hour after sunset showed the highest level of activity and there were no statistical differences between the third hours in either case. The level of activity during deep hibernation (19 December–13 March) was low with more fluctuations in the first season caused by construction in the rear parts of the cave. There was no correlation between activity and number of bats. Previous experiences show that there are a lot of bats hidden in unreachable places where they cannot be seen and counted. Therefore, the number of hibernating bats would be underestimated. The beginning of bat emergence activity was observed in the same time interval in both winter seasons (half of March). The highest number of departing bats occurred in the period around 28 March, with an average of 4–5 bats per day.

On New Records of *Barbastella leucomelas* from Sinai, Egypt

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Barbastella leucomelas was described in 1830 on the basis of two specimens collected in 'Arabia Petraea.' According to our revision of the original description and other relevant literature, we restricted the type locality to southern Sinai. After 175 years since its description, *B. leucomelas* was again recorded at five sites in the southern part of the Sinai Peninsula. Genetic and morphological analyses clearly showed *Barbastella leucomelas* populations from Sinai and southern Israel to be an isolated unit within the genus, deserving separate species status. Other populations formerly assigned to *B. leucomelas* from Transcaucasia, Central Asia, Himalayas, Southwest China, and Taiwan belong to a different species, *B. darjelingensis*. Arid regions of Sinai and southern Israel are the only recently confirmed areas of occurrence for *B. leucomelas*. Such a range is among the smallest known in temperate bats. The analysis of *B. leucomelas* diet showed an extremely high proportion of Lepidoptera; i.e., the situation found also in *B. barbastellus* and *B. darjelingensis* inhabiting different habitats (in Central Europe and in Kirghizstan, respectively) and shows unique foraging specialization of the whole genus *Barbastella*. Echolocation parameters of *B. leucomelas* from Sinai were found to be nearly identical with those of *B. barbastellus* from Europe.

Movements of Marked *Myotis myotis* between Hibernacula and Summer Nursery Roosts and among Nursery Roosts

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We studied seasonal migration of *Myotis myotis* between summer nursery roosts and hibernacula, and among nursery roosts during the reproductive season, in a 30-km radius around Kateřinská Cave (Maravian Karst, Czech Republic). Between April and October 2001–2007, we made a total of 197 checks on 25 *M. myotis* maternity roosts and we ringed 363 *M. myotis* (212 female adults, 5 female subadults, 79 female juveniles, 7 male adults, 60 male juveniles) at 15 maternity roosts. Bats also were captured at the entrances to Kateřinská and Králova Cave in April and between August and October 2000–2007, using mist nets, and 414 *M. myotis* (145 female adults, 32 female subadults, 44 female juveniles, 95 male adults, 37 male subadults, 61 male juveniles) were ringed. We recaptured a total of 355 individuals of *M. myotis* (292 females and 63 males; 760 recaptures). Recaptures of ringed *M. myotis* showed that bats migrate from all known summer roosts to the same swarming cave and/or hibernaculum. The catchment area of Kateřinská Cave is large, extending at least 68 km to the southwest. Intercolonial movements occurred even during the reproductive season. Multiple movements were observed too. [The study was supported by grants GAČR 206/01/1555 and MŠM LC06073.]

Seasonal and Nightly Activity Patterns of Bats at the Entrance of a Natural Cave

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Nightly and seasonal activity with different activity levels and patterns was investigated: 1) Hibernation, 15 November–4 March; 2) Late hibernation, 5 March–14 April; 3) Departure and transition period, 15 April–4 June; 4) Summer, 5 June–26 July; and 5) Swarming and autumn migration, 27 July–14 November. We compared the data between autumn and spring netting samples and winter censuses. The number of bats hibernating inside the cave (estimated from logged data) is about 5 times higher than the number recorded during visual censuses. While *Myotis myotis* and *Rhinolophus hipposideros* are typically found hibernating inside (> 80%), *M. emarginatus*, *M. daubentonii*, *M. nattereri*, and *M. bechsteinii* are eudominant in both autumn and spring netting samples from the cave entrance. Our study shows that autumn surveys can provide more accurate information on bat population sizes than winter censuses, and underlines the importance of Kateřinská Cave both as a hibernation and swarming site for populations of six species from a large catchment area. [The study was supported by grants GAČR 206/01/1555 and MŠM LC06073.]

Cave Visitation by Bats: Effects of Climatic Factors

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Effects of climatic factors on nightly and seasonal activity patterns of bats were investigated at the entrance of a hibernaculum (Kateřinská Cave, the Czech Republic). Activity was recorded automatically with a double infrared-light logging system during five different activity patterns: 1—During hibernation (15 November–4 March), temperature was the best predictor of the general level of activity. 2—Flight activity during late hibernation (5 March–14 April) was positively affected by mean ambient temperature (T_{avg}), and negatively by rainfall and minimal temperature of the preceding day. 3—During the departure period (15 April–4 June), a significant positive relationship was found between total daily activity and T_{avg} and mean barometric pressure (P_{avg}). Rainfall during the preceding day caused a significant drop in activity level. 4—Summer activity (5 June–26 July) increased as the range of daily temperature ($T_{dif\ Max\text{-}Min}$) increased. Rainfall during the preceding day negatively affected the amount of activity, whereas rainfall during the study day caused an increase in activity. Differences were also apparent in the course of the night. 5—During the swarming period (5 September–14 November), flight activity was positively related to T_{avg} and P_{avg}. [The study was supported by grants GAČR 206/01/1555, MŠM LC06073 and MŠMT 0021622416.]

Molecular Key for Determination of European *Pipistrellus* Bats: A Restriction Analysis of mtDNA as a Cheap and Effective Alternative to Nucleotide Sequencing

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Comparative studies on biogeography and ecology of morphologically similar species are often hard to conduct, because reliable diagnostic features allowing the identification of individuals belonging to particular sibling taxa are few or lacking. Such features are usually very subtle and individually variable, resulting in determination based on field experience and a subjective decision of the researcher. An example is the two common European bat species, *Pipistrellus pipistrellus* and *P. pygmaeus*. Determination of flightless juveniles can also be hard or impossible in *P. nathusii* and *P. kuhlii* (or East European *P.* cf. *lepidus*). Until now, the only solution was DNA sequencing; however, its high costs hinder its application on a wider scale in, e.g., faunistic surveys conducted by non-governmental organizations. We developed a molecular key, based on restriction analysis of mtDNA, allowing determination of all Central European species of *Pipistrellus* for costs five-to-eight times lower. A four-step procedure was applied: 1) isolation of DNA from biopsy punches of wing membranes; 2) amplification of conservative fragment of mtDNA—cytochrome *b*; 3) digestion of PCR product using restriction enzymes; and 4) UV visualization of digestion product on agarose gel. The method can be developed further for cheap identification of subsequently described new pipistrelle species.

Bat Rabies and Population Genetics: A Case Study of *Eptesicus serotinus* in Poland

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Eptesicus serotinus is the most enrabied bat species in Europe. Nevertheless, there are no detailed studies on the prevalence of rabies infection of *E. serotinus* in Poland in particular, or in most European countries in general. To confirm rabies infection the detection of rabies virus RNA from oropharyngeal swabs was performed using RT-PCR method. Our results point unequivocally to the endemic status of EBLV within the studied population of bats in Poland. There was a 17% level of infection within the overall population of serotine bats studied. An appreciation of the potential for epidemiological spread and disease risk requires an understanding of the dispersal of the primary host, and any large-scale geographical barriers that may impede gene flow. That is why we also examined the spatial pattern of microsatellite (7 loci) and mitochondrial DNA (control region) variation to infer patterns of dispersal of bats among 12 subpopulations across Poland. Knowledge of colony relatedness and genetic differentiation helped to estimate the main directions of animal movements between colonies, integrity of investigated groups, and the potential threat of rabies virus spreading via migration of infected animals. In general, high levels of gene flow among studied groups were observed. There was some evidence for male-biased dispersal. Eleven individuals were identified as potential first generation migrants; their migration routes range from < 20 km up to almost 400 km.

Bats of the Smolinskaya Cave: Modern Condition and Dynamics of Number

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The Smolinskaya Cave is a wintering place for four species of bats: *Myotis dasycneme, M. daubentonii, M. brandtii,* and *Plecotus auritus*. In the 1990s we counted over 1800 wintering individuals in the cave—more than 1700 *M. dasycneme* and more than 100 *M. daubentonii*. During the 2007–2008 winter we repeated our count of wintering bats in the cave and counted about 600 individuals. This is evidence of a significant reduction in the number of wintering bats. Also reduction in the number of bats in the cave during summer months has been noted, and bats were not found in the Smolinskaya Cave in June of this year (2008). In recent years the cave has been actively visited by tourists and used by local travel agencies, and we connect the reduction in the number of bats living in the cave with intensive recreational use here.

Response of Bats to Chestnut Orchard Restoration

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Woodland has undergone major structural changes in Europe, with traditional forestry practices being progressively abandoned. In a comparative approach, we assessed the effect of the abandonment of chestnut orchards (*Castanea sativa*) on roosting and foraging activity of bats in southern Switzerland. The monitoring of 200 bat boxes showed that managed chestnut stands harbored four times more bats than abandoned stands, mainly of the migratory species *Nyctalus leisleri*. In order to explain this pattern we radio-tracked 18 of these bats and found them roosting mainly in live chestnut trees, with large diameter and with absence of vegetation around the roost entrance. Although *N. leisleri* positively selected deciduous woodlands as foraging areas, managed chestnut orchards were not significantly selected over other woodland types. Since roost temperature did not explain the preference of roosting in managed stands, we suggest that managed chestnut orchards may represent optimal lekking arenas for this fast flying species. The echolocation calls simultaneously collected in 28 pairs of managed and unmanaged stands revealed twice the number of bat species (12) and five times higher foraging activity (530 call sequences) in the managed chestnut orchards compared to the unmanaged ones. We conclude that restoring chestnut orchards contributes to the conservation of bat species and we derive recommendations for the management of chestnut orchards.

The Role of Climate in Cave Roost Selection

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Caves are one of the preferred roosts used by bats in different periods of their lives. In Romania, there are more than 12,000 registered caves, but only a few caves are inhabited by bat colonies. In order to understand why bats choose a cave for installing their colonies, a topoclimatic study was performed. Temperature and humidity were registered in two neighboring caves from the northwestern part of Romania during an annual cycle. The spatial distribution of the seasonal and annual values of measurements and also the thermal amplitudes were statistically processed. The results of the study were corroborated with the bat dynamics in the selected caves. In addition, these caves were characterized from a geomorphologic, hydrologic, and ventilation point of view and also from structural substrates offered to roosting bats.

Mitochondrial Phylogeography of the Leisler's Bat, *Nyctalus leisleri*, in Ireland and Across Europe: New Perspectives

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The Leisler's bat, *Nyctalus leisleri*, is a species of particular interest in Ireland. Across most of its range, which extends over the United Kingdom and most of Europe, the species is rare and considered vulnerable in many parts, with the exception of Ireland, where it is relatively common. Indeed, Ireland is considered to be the European stronghold for the species and is thus internationally important from a conservation viewpoint. In this study, we

examined a highly polymorphic portion of the mitochondrial DNA control region (D-loop), to assess the phylogeographic relationship of *N. leisleri* in Ireland with those across the rest of Europe, including the closely related species *N. azoreum* endemic to the Azores Islands. We also examined microsatellites for both Irish and continental *N. leisleri*. Results bring new perspectives to the phylogeography of the Leisler's bat in Europe, identifying two distinct lineages, and demonstrating a unique genetic makeup of these Irish populations, and thus have important implications for the conservation of this species in Ireland.

Habitat Preferences and Home Range Selection of Six British Bat Species

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The integration of bat habitat requirements into land-use policy is aided by national scale multi-species assessments. Here we aim to establish habitat associations for six British bat species, addressing both landscape composition and structure. We used data from a national survey of bat roosts to model habitat associations within the core foraging area surrounding each roost and across the home range as a whole. There was little difference in habitat associations between the two spatial scales investigated. Species demonstrated preferences for wooded and pastoral landscapes. Broadleaved woodland was important to all six species. All species showed a preference for a greater extent and/or closer proximity to broadleaved woodland. In contrast woodland quality was important to just two species (soprano pipistrelle, *Pipistrellus pygmaeus*, and brown long-eared bat, *Plecotus auritus*) while size of the nearest broadleaved patch was not important to any species. Landscapes containing a greater extent of improved grassland were selected by all species except the lesser horseshoe bat, *Rhinolophus hipposideros*. The preference for grassland-dominated landscapes may relate to both a greater insect abundance and the greater density of linear tree, hedge, and shrub features in pastoral compared to arable landscapes. This study emphasizes the vital important of the broadleaved woodland network for British bats. Across all six species the closest broadleaved patch was found on average just 180 m from the roost, with 90% of roosts located within 400 m of broadleaved woodland. Extensive broadleaved planting, especially in landscapes with little contiguous broadleaved cover, will provide the greatest landscape improvements for the species considered by this study. This accords with policies to improve connectivity but contrasts with guidance for woodland specialists that emphasizes buffering core woodland areas.

What Can Mites Tell Us about the Phylogeographic History of their Bat Hosts

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Recent studies highlighted the use of parasites as a tool to better understand the phylogeographic history of their hosts. Here, we compared the genetic patterns of one parasitic mite, *Spinturnix myoti*, with its two hosts, the Maghrebian and the greater mouse-eared bats. The Maghrebian bat, *Myotis punicus*, is widespread in North Africa and in some Mediterranean Islands, whereas its sister-species, *Myotis myotis*, is only present in Europe. Here we focused on Corsica, Sardinia, Morocco and Tunisia to compare the phylogenetic pattern and the population structure of both bat and mite. Host microsatellites and mtDNA analyses revealed the absence of genetic structure between colonies within Corsica, Sardinia, and North Africa whereas a high structure between these three areas was found. Similarly, mtDNA analyses of its specific mites, *S. myoti*, revealed that mites from Corsica, Sardinia, and North Africa are genetically distinct from each other. However, contrary to Sardinian and North African mites, Corsican ones are genetically identical to mites found on *M. myotis* from continental Europe. Our results suggest that open water may hamper gene flow. Mite genetic results confirmed this isolation. Indeed, no mite seemed to be exchanged between Corsica, Sardinia, and North Africa, suggesting no encounter between bats inhabiting these different areas. Moreover, as *M. myotis* is restricted to continental Europe and no contact zone between both species is currently known, mite genetic results suggested a host switch between *M. punicus* and *M. myotis* in the past. Mites give clues for a former contact between both bat species and for an ancient presence of *M. myotis* in Corsica.

Range-wide Population Genetic Structure of the *Pipistrellus pipistrellus* Complex based on Microsatellites

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In previous studies, we found that 1) both principal clades of *Pipistrellus pipistrellus* complex (corresponding to broadly defined *P. pipistrellus* and *P. pygmaeus*) demonstrate an unexpected amount of a mtDNA variation in the

Mediterranean area and almost homogenous populations in central Europe and 2) central European populations of both species show high microsatellite variation but very intense gene flow over very long distances (i.e., no genetic structure detectable over a distance of more than 1000 km). The aim of this study was to analyze: 1) whether range-wide population genetic structure identified on nuclear microsatellites corresponds to the phylogeographical pattern described previously by maternally inherited mtDNA, and 2) whether intensive gene flow (probably related to long-distance migrations) described in central Europe has some geographical limits, i.e., to analyze genetic differences between central European and Mediterranean populations. By using 11 microsatellites, we confirmed genetic distinction in 3 allopatric populations, where a representative population sample was available—from Libya (= *P. hanaki*), Cyprus (from *P. pygmaeus* group), and Morroco (from *P. pipistrellus* group). Further analysis also clearly separated the Levantine population of *P. pipistrellus* s. str. from the Near East. Central European populations showed distinct differentiation from populations in southern Europe, therefore suggesting that long distance gene flow has some limits at European scale.

First Assessment of the Status of the Threatened Bats of the Caucasus

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During 2006–2008, NGO Campester together with NGO Center for Biological Diversity (Azerbaijan), NGO Union of Armenian Nature Protectors (Armenia), and the Institute of Ecology of Mountain Territories (Russia) implemented the Project, "Development and Capacity Building of Transboundary Bat Monitoring Network in the Caucasus" through the financial support of Critical Ecosystem Partnership Fund (CEPF). Within the project dates, over 90 field trips were performed in all 4 countries, and 234 points were observed for bats. Fourteen bat species protected by the legislation of the participating countries or listed by IUCN Red List as vulnerable were objects of special observation; these species are: *Rhinolophus ferrumequinum*, *R. hipposideros*, *R. euryale*, *R. mehelyi*, *Myotis blythii*, *M. bechsteinii*, *M. dasycneme*, *M. emarginatus*, *M. schaubi*, *Nyctalus lasiopterus*, *Barbastella barbastellus*, *B. leucomelas*, *Miniopterus schreibersii*, and *Tadarida teniotis*. Within the Project, the first attempt to conduct joint research over a large portion of the Caucasus was made. As a result, it became possible to simultaneously evaluate the current status of bat species. Based on the project results we re-evaluated the status of 14 threatened species. Such re-evaluation, for the entire region and for each separate country, has been carried out in compliance with the IUCN Rules for drawing up regional Red Lists.

Activities of Beavers, *Castor fiber*, May Improve Habitat Quality for Foraging Vespertilionid Bats

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The beaver strongly modifies its environment not only by building dams and creating ponds, which slows the water flow, but also by selective cutting and removal of trees, which changes the spatial structure of forest. We aimed to test the hypothesis that beaver activity promotes new foraging sites for insectivorous bats. The beaver's influence can be especially significant on aerial hawkers, which prefer moderate structural clutter, such as *Pipistrellus* spp. (by creating new canopy gaps), and on water-surface foragers, such as *Myotis daubentonii* (by creating ponds with smooth water surface). The study was carried out on small streams in a forest area of northern Poland, settled by the European beaver (*Castor fiber*). Bat activity was recorded with a Pettersson D-980 ultrasound detector on line-transects. The number of bat passes was significantly higher in the stream sections modified by beavers (flooded and subjected to intensive tree cutting) than in untransformed sections (for *Pipistrellus nathusii*, *P. pipistrellus*, *P. pygmaeus*, *Nyctalus noctula*, and all species combined). Contrary to expectations, the activity of *Myotis* spp. was significantly lower on the transect with the largest beaver ponds, possibly due to the covering of duckweed (Lemnaceae), known to produce clutter echoes and reduce prey detection by echolocating *M. daubentonii*.

Phylogeography of Mouse-eared Bats, *Myotis myotis* and *Myotis blythii*, Present in Anatolia and Turkish Thrace

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It is generally accepted that the two sibling species, *Myotis myotis* and *M. blythii*, are present in the territory of Turkey. Although previous studies investigated the distribution of genetic diversity and structure for these two species in Europe, a comparison with samples from Turkey has not been done previously. Here we present distribution, phylogenetic trees, and statistical parsimony network of 122 samples collected in Turkish Thrace and Anatolia. Phylogenetic inferences were drawn from the PCR-amplified, 308-bp fragment of the hypervariable control region II of the mtDNA. We compared the Turkish haplotypes with the sequences of *M. myotis* and *M. blythii* from the GenBank. Out of the 43 unique haplotypes, 41 were not reported previously. Only two haplotypes, from the Thrace sampling, were the same as those deposited in the GenBank. In the Bayesian phylogenetic tree, all Turkish samples, except two, were grouped in the same clade. Furthermore, the clade with Turkish samples included few haplotypes found previously in Bulgaria and Greece. The statistical parsimony network analyses also showed no clear differentiation between the haplotypes from Turkish Thrace and Anatolia. These results indicate that the populations of *M. myotis* and *M. blythii* within the territory of Turkey do not show spatial structuring but are differentiated from those of Europe.

Long-term Changes of Hibernating Bats in Huda Lui Papara Cave (Apuseni Mountains, Romania)

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The Huda lui Papara Cave is an ascending, limestone cave with a length of about 2 km. We have monitored the winter colonies for 11 years and have identified 9 bat species, of which 3 were dominant every winter: *Miniopterus schreibersii*, *Pipistrellus pipistrellus*, and *Myotis myotis/blythii*. The first two colonize a common and well defined segment of the cave, leading to competition for space, which in turn makes the numerical ratio between them change from one winter to another. The total number of hibernating bats had a constant growth tendency during the monitoring, from 7500 in 1998 to 84,400 in 2008. This could be determined by one or more of the following causes: a natural numerical growth of the bat populations in the investigated geographical area, by eliminating the use of insecticides in agriculture; from the destruction of several steel structures (by powerful floods), which had facilitated winter tourism in the cave; by the intensification of tourist activity in other caves from the area, which caused the bats to seek safer shelters; a "snowball effect." The cave has a 37-m high entrance, making it possible for the external temperature fluctuations to reach even the maximum colonization area, which is why, in some winters, we have found hundreds or even thousands of dead individuals on the ground (exclusively *M. myotis/blythii* and *Nyctalus noctula*). The shape, size, place, and total number of individuals in the colony changes several times during one winter. Therefore, we can assume a high mortality rate in the bats leaving the cave, because there are no other caves or winter shelters in the vicinity. The maximum number of individuals, for the species that form winter colonies in this cave were: *M. schreibersii*—61,300 on 10 November 2006; *P.pipistrellus*—33,000 on 3 March 2005; *M. myotis/blytii*—6800 on 3 March 2005; *N. noctula*—1030 on 02 February 2008; and *Rhinolophus ferrumequinum*—1050 on 20 December 2002. This is why this sanctuary is the largest hibernacula in Europe.

Fringe for Foraging? Histology of the Bristle-like Hairs on the Tail Membrane of the Gleaning Bat, *Myotis nattereri*

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Many bats are specialized to detect and capture arthropods from vegetation. As echoes from sitting arthropods and vegetation background overlap strongly, it is difficult for those bats to detect prey by echolocation alone. Within the largest genus of bats, *Myotis*, at least three species from different sub-clades show a characteristic fringe of hairs on the trailing edge of their uropatagium. All three are well able to glean arthropods from vegetation with this tail membrane. Phylogenetic analyses strongly suggest that this specialization evolved convergently in these species. Therefore one can hypothesize that the hairs at the rim of the tail membrane have an important tactile and/or mechanical function for gleaning prey from substrate. To assess this question, we used light microscopic techniques to investigate the morphology and innervation of the bristle-like hair fringe in *Myotis nattereri*. The results revealed that the fringe possesses two types of hair: larger guard hairs and smaller vellus hairs. Both hair types are well

innervated underneath their sebaceous glands. They are encircled by a piloneural complex, which functions as a stretch and tension receptor. Although the bristle-like hairs are clearly not vibrissal follicle-sinus-complexes, their position, morphology, and innervation strongly support a sensory function for prey detection and capture. An additional mechanical function, e.g., brushing prey off substrate, is likely.

Identification Accuracy and Statistical Power Analysis of Long-term Acoustic Monitoring of Bat Populations in France

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In the framework of the SEBI 2010 European initiative, a long-term monitoring project of bat abundance trends has been launched by the French Museum of Natural History two years ago (see the abstract by C. Kerbiriou et al.). Using an iterative computer model fed with the data yielded by the pilot year (2006) and by the year 2007, we show that the national bat survey will enable us to detect annual temporal variations of abundance of about 5% over three and six years for the common pipistrelle and the Leisler's bat populations, respectively. In order to detect variations of less abundant species (e.g., the serotine bat) over the same duration, it would be necessary to enlarge the volunteer network. Such an increase seems to be within reach in 2008. The survey protocol, very similar and compatible with other bat monitoring programs such as iBats, represents a necessary trade-off between the quantity and the quality of data, taking into account the apparatus cost, the volunteer involvement, and the time spent to identify calls. We quantify the effect of the training session, and we organize for the volunteers based on their ability to identify species and the effect of identification accuracy on the monitoring power. It appears that even 20 or 30% percent of identification errors, e.g., species inversion between *Nyctalus leisleri* and *N. noctula* and/or *Eptesicus serotinus*, delays the trend detection for only one (*Pipistrellus pipistrellus*) or two (*Nyctalus leisleri)* years.

Comparison of Swarming and Hibernating Species and Numbers at Limestone Quarries in the Netherlands

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Abandoned limestone mines in the south of the Netherlands are major hibernation sites for bats in the Netherlands. In order to keep track of population changes, galleries of over 89 mine complexes have been surveyed for hibernating bats every winter since the early 1940s. Following the lifting of the ban on mist netting bats in the Netherlands, this method revealed that these mines are not only important hibernacula, but also serve as important swarming and mating sites in autumn. In the past seven years, volunteers and professionals of the Society for the Study and Conservation of Mammals have repeatedly sampled entrances to 19 limestone mines for swarming bats using mist nets. These surveys had spectacular results—species, such as *Myotis bechsteinii* and *M. brandtii* that are rarely encountered hibernating in winter, extensively use these sites for swarming in late summer and autumn. A more detailed analysis shows a differential, species-specific use of these hibernacula—the species composition varies with location, and the presence of different species varies over time. Surprisingly, relatively large numbers of sexually active males of species that have not been seen hibernating in the mines, such as *Eptesicus serotinus*, were captured at the mine entrances. In this paper, we present the results of these surveys and compare the numbers and species composition data of swarming bats and hibernating bats. The discrepancy between the local species composition in hibernating and swarming bats yields important questions with respect to the temporal patterns in dependency on these sites of different bat species.

Phylogeography of the Endangered Lesser Horseshoe Bat (*Rhinolophus hipposideros*)

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Little is known about Ireland's most endangered bat, *Rhinolophus hipposideros* (lesser horseshoe bat). The Irish population represents the most northwesterly range of this species, and Ireland contains one of the largest of the populations in Europe. To date, the geographic origin, dispersal route, and population structure of the Irish lesser horseshoe bat is unknown. To assess high priority sites, colonies, dispersal routes, and habitats for conservation, it is of utmost importance that the population structure and geographic origin of the Irish lesser horseshoe bat is established. To do this we amplified and sequenced two mitochondrial genes cytochrome *b* (842 bp) and D-loop (1 kb) from horseshoe bats throughout Ireland and Europe. Bats were sampled at maternity sites in Ireland during summer of 2007 and 2008. Bat researchers donated European samples and relevant sequences were extracted from

GenBank. We analyzed these data using NETWORK and TCS. The resultant network of the aligned D-loop sequences shows almost no variable haplotypes within Ireland, and low levels of diversity within Europe from the samples received to date. Cytochrome *b* sequences showed little-to-no diversity at all. This could indicate a recent and rapid colonization of Europe. A more rapidly evolving marker such as microsatellites, as well as additional samples, will be needed to further understand the phylogeography of this species.

Activity and Foraging Habitats of *Rhinolophus euryale* in Southern France: Implications for Species Conservation

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Effective conservation of bats implies the need for biologists to focus attention on foraging ecology. A four-year European program (LIFE-Nature "Conservation of three cave-dwelling bats in southern France") gave us the opportunity to study the autecology of *Rhinolophus euryale* in France, filling in the gaps in knowledge for this species (Eurobats Resolution 4.12). In three colonies of 200, 300, and 1400 adults, a total of 29 pregnant females and 35 lactating females were radio-tracked in 2005 and 2006. Foraging activity peaked at the beginning and the end of the night. Distances travelled by females to reach their feeding habitats were noteworthy—up to 13 km. A female was located in transit at 27 km from the roost. Home ranges for the colonies were ± 14,660 ha, 8,015 ha, and 24,643 ha, respectively. Females select interface habitats between woodland and open areas (meadows, pastures, dry grasslands), a complex horizontal structure with highly connected microhabitats. Conservation of colonies of *Rhinolophus euryale* implies large scale land management—up to 15 km from the roost. Priorities are to conserve complex and connected woodland habitats and to encourage nature-friendly agricultural practices.

***Pipistrellus pipistrellus*/*Pygmaeus* Complex: Skull Shape Variations in the Palaearctic Region**

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In order to investigate the variability among and within all lineages of the *Pipistrellus pipistrellus*/*Pygmaeus* complex, we defined 41 3D-landmarks on the lateral and ventral sides of the skull, and we analyzed them with geometric morphometric methods. All the lineages present statistical differences in their skull shape and show differences in their variability within groups. Using a sub-sample of specimens for which both molecular and morphometric data were available, we explore the relationships between genetic and phenotypic distances. Our first results do not demonstrate significant correlation between both sets suggesting that factors other than phylogenetic relationships act upon *Pipistrellus* skull shapes and explain the differentiation observed.

BIUS—Croatian Biology Students Organization: Presenting the Bat Section

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BIUS is a non-governmental student organization currently comprising 17 different sections engaged in a broad variety of biological subjects. The bat section has been a valuable part of the organization since its founding in 1999. Today the section includes ten active members participating in its projects and activities. In this work we present the most important bat projects and their results regarding bat research and conservation, as well as our educational and public outreach activities. Our main interests are research on bat fauna, distribution, biology, and conservation in different Croatian regions, mostly protected areas. Most of our fieldwork is a vital part of biological summer camps organized by BIUS. In that way we have contributed to the inventory of the bat fauna of several protected areas—both national (Paklenica, Mljet, North Velebit) and nature parks (Telašćica, Papuk, Učka, Lastovo Archipelago, and Island of Vis). Our independent projects include research on distribution and abundance of bat species in Nature Park Kopački Rit, and bat educational workshops held in schools and libraries. As a section we have assisted in research on bat ecology and long-term bat monitoring in the Veternica Cave (Medvednica Nature Park). Our cooperation with several scientific societies includes the Croatian Natural History Museum, Croatian Biospeleological Society, and also some government and non-government institutions. We have successful

international collaboration with the Slovenian bat organization, and Dutch student groups. We have presented our work at Croatian and European symposiums and workshops and we are actively participating in the European Bat Night celebration each year.

Molecular Phylogeny and Distribution of the Bent-winged Bat, *Miniopterus schreibersii pallidus,* (Chiroptera: Vespertilionidae)

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The *Miniopterus schreibersii* complex in Asia Minor and adjacent regions is represented by the nominate form, *M. schreibersii schreibersii*, and the subspecies, *M. schreibersii pallidus*. Genetic data analysis of the first hypervariable domain of the mitochondrial control region revealed that *M. s. schreibersii* and *M. s. pallidus* formed two reciprocally monophyletic lineages. The lineages show a considerable sequence divergence of about 9%, accompanied by a corresponding difference in forearm length. In Turkey, distributions of lineages are allopatric with a U-shaped separation zone passing through Central Anatolia. Based on the control region data, *M. s. schreibersii* and *M. s. pallidus* can be recognized as different evolutionary significant units. In the present work, we extend genetic analysis of *M. s. schreibersii* and *M. s. pallidus* to cytochrome-*b* and ND2 regions, and compare them with other *Miniopterus* data. We found that the cytochrome-*b* sequence divergence between *M. s. schreibersii* and *M. s. pallidus* is about 3%, the average value reported in literature for interspecific comparisons. Phylogenetic analysis placed *M. s. pallidus* (together with *M. s. schreibersii*) in the Ethiopian-Palearctic clade as opposed to the Oriental-Australasian clade. We also used forearm data reported by other researchers, to estimate the location of the separation zone between *M. s. schreibersii* and *M. s. pallidus*, outside Turkey. The estimate was based on calculated conditional probability, derived under the assumption that the forearm differences between these two subspecies observed in Turkey applied also to other geographical regions.

Is the Social Behavior of the Brown Long-eared Bat *Plecotus auritus* in Nursery Colonies Related to Between-individuals Information Transfer or Re-affirmation of Group Bonds?

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Bats are one of the most social and gregarious groups of mammals. In nursery colonies high social activity, including vocal mother-young and between-adults communications, is observed. Some species show specific and sometimes spectacular dawn swarming at colony roosts. I observed this behavior in an attic colony of the brown long-eared bat, *Plecotus auritus,* in southwest Poland. I used an infrared frame installed in the roost's opening and an ultrasound detector to record bats' flight and vocal activity. During departure from and return to the roost, bats emitted low frequency social calls. They swarmed intensively in front of and inside the roosts during morning returns. Returning bats emitted more social calls than emerging ones. From 30–50% of individuals emerged or returned in pairs or sometimes in groups of 3–5 individuals. I noted more group returns than group departures. The results suggest that dawn swarming behavior and vocalization of pairs of individuals coming back to the roosts are very important in bat communication. This may be related to re-affirmation of social bonds between colony members or information transfer about good foraging sites or roosts, facilitating their location.

Long-term Monitoring of Hibernating Barbastelles, *Barbastella barbastellus,* in Central Poland

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Monitoring of bats hibernating in central Poland was initiated in 1987. Since that time, in most roosts bats have been counted twice each hibernation season—first at the end of November/beginning of December, and again at the beginning of February. The barbastelle is the most abundant species in the area, especially in shelters of military origin. The poster shows changes in the numbers of wintering barbastelle bats in six hibernacula (disused military structures). In four shelters (Brody Fort, Debina Fort, Strubiny Fort, and large concrete bunkers near Tomaszow Mazowiecki) a significant increase in the number of barbastelles was noted. In the Blogoslawie Fort, the number of barbastelles decreased, probably due to the destruction of the bats' favorite roosting places in 2004. In the Osowiec Fort, no trends in the number of barbastelles were observed, but fluctuations occurred. These fluctuations seem to be more regular than those observed in other shelters.

New Status of *Myotis daubentonii* in the Caucasus

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Only four findings of *Myotis daubentonii* were known in the Caucasus before 1998, all of them in the territory of Russia. We studied the distribution of *M. daubentonii* in 1996–2008 by field surveys, and re-examined old specimens of small *Myotis* in the museums of our countries. We identified 48 new localities in Russian Caucasus and 14 in Georgia, including 5 nursery colonies. *M. daubentonii* was abundant in the west of North Caucasus and inhabits its central and eastern parts, and occurred both in East and West Georgia and along the Black Sea coast. New records from near the Azerbaijan border suggest that it should be found in this country as well. However, it was not recorded in the Crimean peninsula (Ukraine), or between the 45º and 49º parallels in the steppe belt of the Russian Plain. This isolation could result in genetic and ecological differences between the Caucasian and European populations. We found several specimens that were collected in the Caucasus during the first half of 20th century and then forgotten or misidentified. This contradicts former hypotheses about very recent occurrences of *M. daubentonii* in the Caucasus region. The final stage of this study was supported by the Russian Foundation for Basic Research (07-04-01215).

Banding Techniques, Dispersion, and Roost Fidelity of *Rhinolophus megaphyllus* at an Active Mine Site in Far North Queensland, Australia

David Gee, Wildtraces, Gol Gol, New South Wales, Australia

The dispersal of Eastern horseshoe bats, *Rhinolophus megaphyllus*, was monitored over a period of three years. The dispersal of *R. megaphyllus* was a result of the reworking of a mine adit in Far Northern Queensland, Australia. Site visits were a minimum of twice a year, once in the wet season and once in the dry season. The effect of the mining operations on the dispersal of *R. megaphyllus* to alternative roosting sites and the persistence of some individuals in an active mine adit is discussed. Because *R. megaphyllus* in Australia has not been banded for more than two decades due to band intolerance and injury, a trial of the newly developed bands was carried out. The trial showed that the new bands, combined with the careful application of the bands, caused no injury to *R. megaphyllus* and so now makes possible larger scale banding programs. The monitoring has shown that mining activity and bat fauna can co-exist and demonstrates the need to have alternate roosting sites when old mines are reworked.

***Barbastella barbastellus* (Schreber, 1774) Rediscovered in Norway**

Leif Gjerde, Nordic Chiroptera Information Center, Lillestrøm, Norway

A national bat atlas project was initiated in 1992, and a number of County Environmental Agencies have given their support to this work directly or indirectly. All data have been centralized in a database containing over 15,000 bat observations (BatBase). In general the coverage of the smacking bat species is quite good (e.g., *Nyctalus noctula*, *Vespertilio murinus*, *Eptesicus nilssonii*), while the coverage of *Pipistrellus* spp. is satisfactory. Many *Myotis* spp. are missed due to their choice of habitat and limited range of ultrasound. However, during systematic searches *M. daubentonii* has been found at waterways, resulting in satisfactory coverage, and *Plecotus* spp. have been found during an extensive national church project. Unfortunately, a systematic search for *Barbastella barbastellus* has never been successful, partly because there is lack of knowledge in fieldwork methods and partly because the species is difficult to find, resulting in time-consuming fieldwork. The status of *B. barbastellus* has always been unknown in Norway. Four observations confirm the species is present in Norway, but reveal no information on its abundance or distribution. These observations were made in 1896, 1911, 1913, and 1949. However, there is no evidence (i.e., fieldwork) that suggests the species has become extinct. During March 2004 an individual was discovered hibernating in a water tunnel in the municipality of Larvik, and an action plan was prepared and initiated. It was of the utmost importance that this information be restricted since the species was only found at this locality. The tunnel is well known amongst the local people and is easily accessible, and thus often visited during the summer. Unfortunately, during January 2008, another nature conservation organization accidentally discovered this species at the same locality and published the locality's details, thus exposing the species' hideout. Measures are now being taken to secure the local population.

The Importance of Churches for Bats (Chiroptera) North of the Arctic Circle

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During February and March 2008 a total of 42 churches were investigated for traces of bats. The churches were located in the counties of Nordland and Troms (Norway), all north of the Arctic Circle. The work was part of the national "Bats in Churches" project, which was initiated in 1995 as a part of the Norwegian EMMA project. The work was partly financed by the County Environmental Agencies of Troms and Nordland. The loft and towers were visited and checked for traces of bats, which included droppings, insect wings, and dead or live bats. Information was collected from the local human population by extensive media campaigns, in which all newspapers and several radio stations featured the project. Since only one bat species has been recorded this far north, it was presumed that all traces of bats belonged to *Eptesicus nilssonii*—the northern most distribution for *Myotis brandtii, M. daubentonii,* and *Plecotus auritus* is ca. 340 km to the southwest. Traces of bats were found in almost 50% of the investigated churches. This is lower than what has been found in south Norway (ca. 80%). The extent of droppings also indicated that churches are not very important to bats in this region. However, the results reveal the presence of bats in regions where they have never been previously observed, and thus support that bats visit both coastal areas and inland localities on occasion. Four regions revealed local dense bat populations. These include Beiarn/Saltfjell, Hammarøy, Narvik, and Inner Troms. However, bats seem to appear as strays in the entire region. The northernmost locality was found in Ullsfjord church (69°38'N 18°55'E).

Cave Selection and Use by Swarming Bat Species

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Caves are an important resource to a large proportion of temperate bat species, primarily as mating and hibernation sites. However, information on bat use exists for only a small fraction of caves in many parts of the temperate world, in part because current survey methods are inappropriate for many species. We surveyed the U.K.'s largest karst landscape, the Yorkshire Dales, by monitoring autumn swarming (mating) activity at 53 caves using automated echolocation call loggers, followed by trapping. Over 60% of caves surveyed were used by bats, but there was considerable variation in activity. Swarming activity was positively correlated with chamber development and negatively correlated with the amount of water the cave carried: together these two predictors explained 45% of the variance. Entrance orientation and shelter explained a further 10%. Activity was not correlated with entrance size, altitude, or connectivity to the nearest summer habitat. All five resident swarming species were caught at most sites: *Myotis brandtii, M. daubentonii, M. mystacinus, M. nattereri,* and *Plecotus auritus*. Behavior, species composition, and sex and age ratios were typical of swarming reported in other studies. Bat populations and catchment sizes were large and despite the proximity of other suitable caves, bats showed high fidelity to single sites. Our results show that the national importance of these caves has been overlooked. We suggest that survey for swarming activity is a quick and effective method of identifying underground bat sites and is likely to uncover many previously unknown and important sites throughout the temperate world.

Detection and Prevalence Patterns of Group I Corona Viruses in Bats, Northern Germany

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During an ongoing monitoring program 315 bats from 7 different bat species in Northern Germany were tested in summer 2007 for coronaviruses by reverse transcription–PCR. The overall prevalence was 9.8%. Four lineages of group I coronaviruses were found in association with four different species of vespertilionid bats (*Myotis dasycneme, M. daubentonii, Pipistrellus nathusii, P. pygmaeus*). The lineages formed a monophyletic clade of bat coronaviruses. This Northern Germany clade of bat coronaviruses has a sister relationship with a clade of Chinese type I coronaviruses that were also associated with the *Myotis* genus (*M. ricketti*). Young age and ongoing lactation, but not sex or pregnancy, correlated significantly with coronavirus detection. The virus is probably maintained at the population level by amplification and transmission in maternity colonies, rather than by being maintained in individual bats.

Geoinformational System "Bats of Ukraine"

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Databases and geoinformational systems (GIS) represent an important and integral basis of any nature conservation monitoring work, in order to determine future primal directions on gathering initial data. A GIS created by the author for all available information on bat records in the territory of Ukraine is based on the use of two software packages—MS Office Access (for entering and management of information data base) and MapInfo Professional (for geographical positioning of data and its spatial analyses). For entering data four types of sources were used: museum collections (~6500 specimens from 10 museums in Ukraine and Russia were considered); literary sources (information from more than 180 publications containing concrete data is inserted); original data (collected by the author on her own or with her immediate participation in 19 of the 25 provinces of the country); unpublished data provided by colleagues. Doubtful data were not included at all or, sometimes, were inserted separately. One record in the base corresponds to a record of a number of bats of the same species in one place at the same time (or during a certain time interval). Each record is described by 22 main fields and a few additional ones. At present the information system incorporates > 4700 records of 27 bat species of Ukrainian fauna and covers a period from 1811 to 2008. A major part of the records (> 25%) is from the last decade—a period of intensified and organized bat research in Ukraine.

***Vespertilio murinus* Autumn Display Song in Ukraine**

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Until recently *Vespertilio murinus* had been considered a migratory species of the Ukrainian fauna. The statement had been correct for, at least, the plains part of the country. In 2000 the species' autumn display song was registered in Kyiv for the first time. During 2000–2007 information on occasional and directed site and route observations of singing males of *V. murinus* has been gathered in Ukraine (especially in Kyiv City, which was extensively studied). Vocalizing males have been revealed in six geographically separate parts of Ukraine, in localities with natural rocks and in city districts with 9–24-story buildings, entirely avoiding forests, parks, areas of family houses, and 3–7-story buildings. All display song sites are characterized generally by a series of common traits, which allows us to identify the males' choice of the most profitable, special acoustic environment for singing. It was observed that the same vocalization sites were used for many years (up to 6 years). Aggregation of vocalization sites was marked (e.g., in Kyiv City there are four song fields located 5–20 km from each other); this allows presumed existence of leks in *V. murinus*. The earliest date of *V. murinus*'s display song in autumn was 3 October, and the latest was 25 November. Songs have been recorded at temperatures from –1 to +16 ºC, including light snowy and rainy nights. Silent periods occurred with frosts and heavy winds, but then the song began again. The longest fixed time interval of a song in one place was 2 hours during one night (almost without break) and 41 days during one season (including silent nights). As the autumn song may be considered as proof of the species wintering in places of vocalization, one may assert that the whole of Ukraine is now a part of the wintering area of *V. murinus*. This fact, specifically for Kiev, is supported by immediate records of wintering females. In view of the revealed association of the species with multi-storied buildings, one may say that considerable changes in its migratory status have occurred following mass appearance of anthropogenic "rocks" in plain regions.

Current State of Cave-dwelling Bats of Podillya and the Dniester River Region (Ukraine)

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During the summer and winter of 2006–2007 the first full-scale bat census in underground cavities of Podillya and the Dniester River region was carried out. Fifty-three underground units (limestone, chalk and phosphorite mines, natural caves and grottoes, sacral and fortification cavities) were examined. Most of them were checked by bat workers for the first time. Fourteen bat species were found in 39 underground units. In total 5517 bats were counted (the number is not absolute as many cavities were not completely surveyed because of their considerable length—up to 210 km). Differences in the general bat number in winter (4659 individuals) and in summer (858 individuals) are evidently caused by the comparatively low average temperature (+9+10 ºC) of cavities for summer occupancy; most of them are well isolated from the outside environment. The most abundant species, both in summer and winter, were *Myotis myotis* (59% and 33%, respectively) and *Rhinolophus hipposideros* (30% and 29%, respectively). By number of records the dominants are: in summer, *R. hipposideros* (36% of inhabited sites); in

winter, *R. hipposideros* (69%), *M. daubentonii* (51%), and *M. myotis* (44%). Maternity colonies were found for *M. myotis* (one colony, ~500 individuals with offspring), *R. hipposideros* (three colonies with 50 and 120 adult females). Also, pregnant females of *Plecotus austriacus* were netted at the entrances to a few surveyed cavities. Large winter aggregations (≥ 100 individuals per site) were located for *R. hipposideros*, *M. myotis*, *M. daubentonii*, *Barbastella barbastellus*, *P. auritus*, *Eptesicus serotinus*, and *Pipistrellus* sp. The maximum overall bat number per site was 1013 individuals (of 10 species) in winter. Other species found during the census included *M. blythii*, *M. mystacinus*, and four rare species in Ukraine—*M. bechsteinii*, *M. dasycneme*, *M. nattereri*, and *M. brandtii*. Ten key sites important for conservation and monitoring of bats in Europe were determined. In 2007, the authors implemented some practical measures for conservation of the sites.

Semi-open Habitat, Tree Edge, and *Rhinolophus euryale*: A Successful Combination

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Foraging activity of the Mediterranean horseshoe bat, *Rhinolophus euryale*, was studied in order to investigate how this behavior is driven at a habitat scale. Radio-tracking (n = 50 bats by the homing-in method) revealed that bats always foraged around trees, preferably in semi-cluttered habitats (hedgerows, woodland edge, and isolated trees), comprising 73% of the total foraging time (n = 1144 locations). These results were tested at a demographic scale using GIS data by correlating the habitat availability around 10 breeding colonies. Interestingly, all sites were surrounded by a semi-open landscape, and the only significant parameter was an index of the amount of tree edge available. A thorough diet analysis (n = 168 bats; 810 fecal pellets) showed moths were the most important prey (overall 87% by volume; seasonal range: 68–99%). Moth availability varied seasonally but not between habitats, probably due to the high landscape heterogeneity and small average patch size. Therefore, the preference of *R. euryale* to forage on the edge of trees and to prefer semi-open landscapes cannot be completely explained by the distribution of prey, and thus morphofunctional constraints may exert an important effect. This result is in agreement with the presumed origin of the species in a loosely forested habitat: the northern African savannah.

Review of the Reproduction of *Nyctalus noctula* (Schreber, 1774) in Hungary

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The range of *Nyctalus noctula* extends from the Iberian Peninsula to Japan. Its occurrence was confirmed also in North Africa. Strelkov defined the southern border of the main part of the nursing area on average at the 48–49° N latitude. Some authors noted isolated breeding populations south of this line, from Italy, the Iberian Peninsula, Bulgaria. and Slovenia. In 2003 the presence of a nursery colony was also proven in Slovakia, only a few kilometres from the Hungarian border. *Nyctalus noctula* is the most common bat species in Hungary. Despite the significant amounts of data, the sex ratio and the reproductive status of the species were examined in detail only in the Bükk and Mátra Mountains, where no lactating females or nurseries were found except for two earlier sporadic records. In our present publication we discuss the breeding status of the species in Hungary based on our new results. Mist netting and monitoring of bat boxes were conducted to collect data on the reproductive characteristics of the species. Captures of subadult and lactating female specimens or the observation of them in their roost during the breeding period was considered to indicate the breeding of the species. The breeding period was determined from 15 June to 15 July in each year, because before and after this term—according to our observations—the subadult and the adult female specimens are leaving their breeding areas. We have found significant breeding records in the wetland forests of the Lower-Danube Valley, southern Hungary. One breeding colony with 20–25 specimens was observed in a bat box in a protected park near a village in south Hungary. Several lactating females and juveniles were mist-netted in the Zemplén Mountains and one lactating female specimen was caught on a backwater in the Bodrogköz, northeast Hungary.

The Distribution Patterns of *Pipistrellus kuhlii* (Kuhl, 1817) and *Hypsugo savii* (Bonaparte, 1837) in Hungary

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Pipistrellus kuhlii was first observed in Hungary in 1993, when lactating females were mist-netted in Keszthely, southwest Hungary. In the last 15 years the species has became widely distributed in the country. The first data on

the occurrence of *Hypsugo savii* were recorded in 1991 from the Bükk Mountains and since then 12 more localities have been recorded, all of them in or near settlements. A bat detector survey was started in 2008 to gather fundamental information in order to study the distributional patterns of these species. During this research we recorded the presence or absence of the species in different types of settlements all over the country using bat detectors. We stopped for 10 min at each location and recorded bat ultrasounds, which were later analyzed on a computer. We examined the effects of the size of the settlements, the latitude, and the altitude. Preliminary results suggest that *Pipistrellus kuhlii* is one of the most abundant bat species in populated places in south Hungary. The presence of lactating female and subadult *Hypsugo savii* specimens indicate that the species has nursery colonies in Hungary. The significant change in the area of these originally Mediterranean species raises many questions about the conditions of spreading, the species composition of local bat assemblages, and the causes and the limits of this progress.

Bats and Viruses

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Bats are involved in the cycle of more than 90 different viruses, some of which are responsible for diseases in humans and animals (rabies, Nipah, etc.). The prevalence studies and characterization of viruses from bats started a century ago and have recently been reactivated after the emergence of human diseases from the wild such as SARS or Ebola fever. The detection of viruses in the wild and the study of their transmission and dispersal processes is an important step towards understanding and preventing the emergence of new epizootic diseases. The isolation of the virus via a wide variety of techniques of molecular and cell biology is usually a difficult task but it is a crucial step in any virological study. The development of bat cell lines, for example, can be an important guidance in discovering viruses and a key step for virus isolation and study. Host ecology, new biological tools, and cutting-edge technology, combined together in an integrative vision, will allow the detection of endemic viruses and their characterization in order to assess epizootic risks.

Radio-tracking of Lactating Female Geoffroy's Bats, *Myotis emarginatus*, in the Southwestern Iberian Peninsula

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Geoffroy's bat, *Myotis emarginatus*, is a hover-gleaner species, which in central Europe is known to forage in forests and forest edges. Even though it is an endangered species, studies on its habitat needs are still scarce, particularly in south Europe. During 2007 we carried out preliminary research on the habitat selection and spatial ecology of this species in the southwest of the Iberian Peninsula. We radio-tracked seven lactating females from two breeding colonies located in the Villuercas range, in Extremadura. The main surrounding habitats are riparian forest, conifer plantation, pasture, scrub, eucalyptus plantation, and arable land. Bats were tracked from 7–27 June, and 1130 minutes of foraging activity were recorded. Foraging occurred on average within 5.91 km of the roost (SD 2.9) with a maximum radius close to 10 km, and individual foraging areas larger than 10 ha. We studied their habitat selection by both compositional analysis, and Chi-square goodness-of-fit and Bailey's intervals. Both methods showed that the riparian forests were the most preferred habitats, followed by coniferous woodland and pasture. All the preferred foraging habitats were cluttered ones, as expected in accordance with the species' wing morphology and echolocation calls.

Habitat Selection and Landscape Use by Bats in and around the Expanding Antwerp Harbor: Threats, Opportunities, and Implications for Land Management

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Landscape modification is often considered as the principal cause of population decline in many bat species. Harbor expansion changes the landscape very rapidly, and can therefore be a major threat to local bat communities. However, it can also offer new opportunities by creation of new bodies of water. Habitat use by bats was investigated in the Antwerp harbor region (Flanders, Belgium) by counting bat passes as a measure of bat activity at 252 observation points. Habitat selection and niche breadth were calculated, and used to focus on tree line use, canal

use, and a comparison of the center of the harbor, its borders, and the surrounding agricultural area. In the center of the harbor region natural habitat is still available, but bat activity and number of species was lower than outside. This can partly be attributed to poorer habitat quality, but also to fragmentation and illumination. The outer parts of the harbor, on the other hand, showed high bat activity and high species richness. Harbor expansion creates a landscape with diminished opportunities for bat foraging, and thus can be a threat to bat communities. However, creation of bodies of water on its outer margins can offer new opportunities for bats if attention is paid to the connection with the surroundings and the conservation of its commuting routes in the landscape structure. Habitat analysis can deliver important information for such mitigation measures. In our study tree lines were shown to be a heterogeneous habitat type. Age of trees, vegetation underneath, and connection to villages affected *Pipistrellus pipistrellus* activity. Along canals, width of the bordering tree stand affected *P. pipistrellus* activity. *Myotis daubentonii* seemed to be more influenced by darkness over the water surface.

The Role of the Long-fingered Bat, *Myotis capaccinii*, as an Indicator Species for Dinaric Karst: Bridging the Gap between Terrestrial and Aquatic Ecosystems

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Global climate change has been recognized recently by the United Nations. One of the major negative impacts is expected to be on freshwater ecosystems that guarantee not only the survival of humanity but also significant biodiversity of the Planet. Globally, Dinaric Karst is one of the most fragile and biodiversity-rich habitats. It runs from Italy, through Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Serbia, Kosovo, and ends in Albania. It is characterized by extensive underground systems composed of caves, pits, and groundwater, and by huge mountain chains and freshwater rivers and lakes on its surface. This is also the habitat of the long-fingered bat, one of the most endangered bat species both in Croatia (EN) and Europe (VU). Key habitat components sustaining long-fingered bat populations are also the key factors sustaining a range of karst biodiversity and this makes it one of the better indicator species of the general 'health' of the Karst itself. Karstic freshwaters have high socio-economic importance because they are the main suppliers of drinking water and electricity in the region. The major threats affecting the survival of long-fingered bats are disturbance in caves with nurseries, water pollution, and diversification and inappropriate landscape planning. This paper demonstrates the vital links between clean water that sustains high densities of a variety of aquatic insects, which in turn sustain long-fingered bat populations especially during their breeding season. Importantly it has identified critical ecosystem elements that can be evaluated cost-effectively at the national (Croatian) level and then may be adapted at a Pan-European Dinaric Karst level. Acceptance of the long-fingered bat as an indicator species would significantly improve the conservation efforts for the species in the region.

Croatian Biospeleological Society: Cave-dwelling Bats Research and Conservation Activities

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The Croatian Biospeleological Society was founded in 1996. It is an umbrella organization for research and conservation of subterranean fauna in Croatia. It is also acknowledged, registered, and supported by Croatian Ministry of Science Education and Sport. Croatian Karst covers around 50% of Croatian territory and is one of the most fragile and biodiversity-rich habitats. Our members are scientists from various fields, students, cavers, and local community members. The Society's projects (past and ongoing) take into account true cave fauna (troglobionts) as well as species that are not true cave animals (troglophiles) such as bats. There are many bat species that depend on caves especially during the breeding season or hibernation (around 14 out of 35 recorded for Croatia). The most endangered bat species in Croatia, *Miniopterus schreibersii* and *Myotis capaccinii*, roost strictly in caves. Bat section activities focus on bat ecology research of cave-dwelling bat species, evaluation of threat to the

bats in caves, protection measures to be undertaken, and education, as well as involvement of local community members. We propose sites for Natura 2000 network (subterranean fauna included) and we work closely with all parties involved in nature conservation as well as Croatian main stakeholders. We give an overview of some of our most important bat projects: long-fingered bat conservation; Veternica Cave bat research and monitoring; inventory of bats in Vrana Lake Nature Park, and research on the subterranean fauna and bats around Dobra River (to propose mitigation, compensation, and protection measures for a future storage lake). Also we present our leaflets and posters on cave-dwelling bat species and educational activities held at local schools in the vicinity of our most important cave nurseries that hold thousands of bats. The Society also takes part in the European Bat Night celebration day.

Developing a Methodology for Using Bats as Indicator Species

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Pledges by governments to significantly reduce or, in the case of the European Union, halt the rate of biodiversity loss by 2010 have created a need for biodiversity indicators that measure progress towards the target. Such indicators should provide accurate, robust, summary statistics for policymakers and the public. Selected species from a small number of taxa, mainly birds and butterflies, have been used to represent trends in the abundance and distribution of specific groups in the United Kingdom and Europe. Data have been drawn from surveillance programs such as the Pan-European Bird Monitoring scheme (PECBM) or species status assessments such as the IUCN Red List. Recently there have been moves to expand the suite of taxa used as indicators. The U.K. government adopted several new indicators, including an indicator of trends in widespread bat populations, in May 2008. The European Environment Agency commissioned a study on developing a methodology for using bats as indicator species, with a view to increasing the number of taxa contributing to the SEBI 2010 ("Streamlining European 2010 Biodiversity Indicators") project. This study examined the scientific relevance of bats as biodiversity indicators, gathered information on the availability of surveillance data that could underpin a European bat indicator, and proposed a methodology for indicator development, drawing on experience gained from other taxa. This paper outlines the rationale for bat biodiversity indicators, demonstrates the U.K. bat biodiversity indicator, and discusses a potential methodology for developing a Europe-scale indicator.

Systematic Surveys of Bats in Woodlands

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Woodlands are important habitats for bats and should be a major focus for conservation efforts. In fact, we know relatively little about the conservation status of bats in woodlands, because they are difficult habitats to survey using standard techniques. Consequently, data on the distribution of woodland specialist species, such as *Myotis bechsteinii*, are very incomplete. Similarly, we know little about the ways in which woodland characteristics, such as patch size, species composition, and woodland structure, influence the diversity of the bat community. In this paper we present some examples of the use of an acoustic lure (the Sussex Autobat) to make rapid assessments of bat diversity in woodlands. Through the systematic application of this technique in woods in the southeast of England we have: 1) established a coarse-grained regional distribution map for *M. bechsteinii*, 2) developed a survey protocol for this species that is now being applied in a national survey, and 3) provided evidence that common woodland management practices, such as the clearance of understorey and thinning of canopy, may have detrimental effects on woodland bat communities. Future applications of the technique will be discussed in the light of these findings.

Home Range Size, Spatial Organization, and Site Fidelity in Female Barbastelle Bats, *Barbastella barbastellus*

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In recent field studies the habitat use and ranging patterns of bat species were examined, but the factors affecting the spatial organization (traditional range use vs. intraspecific competition) are still poorly understood. We investigated the home range sizes and distribution of a maternity colony of the barbastelle bat via radiotelemetry in four consecutive tracking sessions (2004–2007). We specifically ask: 1) how colony members partition the population home range (home range overlap analysis), and 2) if individuals tracked in consecutive years exhibit site fidelity. We used a total of 19 data sets and 2605 fixes in our home range analyses obtained from 11 females. Five

female barbastelle bats were tracked in two or three years. Home range size varied from 124 to 2551 ha (mean: 735 ha). The mean number of core areas was 2 (range: 1–5 core areas per individual and year). The core area sizes ranged from 5.01 to 285.30 ha (mean: 81 ha). The annual home ranges of females tracked in two or three consecutive years showed a significantly higher overlap than home ranges of different individuals tracked in the same year.

Bats of the Eastern Mediterranean: Change of the Picture during the Past Decade?

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We created a database of all records of bats from the eastern Mediterranean (Albania to Lebanon and Syria) and analyzed them with a series of multivariate techniques, once in 1997 and then in 2007. Thanks to intensive field studies, the number of records increased nearly two-fold: from 2770 in 1997 to 5381 in 2007 (7086 records of 63 species when extended with southern regions, from Iran to Libya). An increase in number of species from 38 to 44 is due to: 1) new taxa revealed by taxonomic studies of "traditional" species, and 2) records of extralimital species in the region, which are briefly surveyed. Despite that and slight changes in percentages of particular species (e.g., an increase in *Pipistrellus kuhlii*), the two data sets revealed nearly the same major patterns in regional aspects of species contributions, structures of chorologic units, and/or biogeography of chorologic clusters, etc. A role of certain climatic variables (aridity) was demonstrated, although they were found less important than the effects of historical biogeography responsible for distinct differences in faunal structure and species composition between the Euro-Mediterranean region (including west and central Anatolia and Pontic areas) and the Afro-Mediterranean. The key role of the Levant, including Hatay and Cyprus, in the evolution of the eastern Mediterranean bat fauna is demonstrated.

Bats in the Austrian Alps

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We studied the bats of four national parks and their surroundings in the Austrian Alps at altitudes of between 500–2000 m above sea level, namely Hohe Tauern (Salzburg, Carinthia, Tyrol), Gesäuse (Styria), Kalkalpen (Upper Austria), and Nockberge (Carinthia). The following methods were used: survey of buildings, survey of caves, mist netting, and ultrasonic recordings. We found a total of 17 species: *Rhinolophus hipposideros, Myotis daubentonii, M. brandtii, M. mystacinus, M. nattereri, M. emarginatus, M. myotis, Nyctalus noctula, Eptesicus nilssonii, Vespertilio murinus, Pipistrellus pipistrellus, P. pygmaeus, P. kuhlii/nathusii, Plecotus auritus, Pl. auritus/macrobullaris,* and *Barbastella barbastellus* (*M. bechsteinii,* only bones found in Kalkalpen). The species composition varied between the four regions with whiskered bats (*M. mystacinus/brandtii*) dominating in Hohe Tauern and Nockberge, followed by *Eptesicus nilssonii.* In Kalkalpen *Rhinolophus hipposideros* was the most common species. Highest records of hunting bats were made at elevations of around 2300 m. The number of buildings with indirect or direct proof of bat presence decreased with increasing altitudes. Within a species, individuals were found at higher altitudes in the southern parts than in the northern parts of the Alps. As the roosts in Hohe Tauern, Gesäuse, and Nockberge predominantly hold single individuals, the potential threats for the bats are not as obvious as in the surrounding valleys, yet these valleys are very important for the bats of these regions. As the caves in Gesäuse and Kalkalpen play a vital role during the autumn swarming period and during winter, their protection is essential for the conservation of the bats of the region.

"Winged Wonders": A Tuitional Concept to Discover the Phenomenon of Flying

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A number of animals have evolved aerial locomotion. It has evolved at least four times—in insects, birds, bats, and pterosaurs. In the course of evolution flying animals have developed diverse and elaborate aeronautical techniques. In this context the gliding flight of an eagle is as astonishing as the buzzing flight of a midge. The step into the sky has been a source of fascination to humans for several hundred years. Numerous attempts to overcome the force of gravity are documented and what is striking is that all flying machines created by man are inspired by nature. Although birds, bats, and insects fly by flapping their wings—and have done so for millions of years—we

still do not completely understand the technical mechanisms of wing beats. “Winged Wonders” is an experimental course for secondary school students (children aged 9–12 years). The course covers the basic phenomenon of flying in nature and of the fundamentals of technical aviation. The key subjects are: 1) studying anatomical and physiological modifications for flapping flight in birds, bats, and insects; 2) discovering the principles of aerodynamics of animal and airplane flight; and 3) exploring the physical and chemical properties of the air. During the course we will challenge the creativity, interest, and team spirit of the students by carrying out various experiments and methods to study the topics mentioned above.

Cryptic Sympatric Diversity at a Deep Phylogenetic Level in Endangered Tube-nosed Bats, Nyctimeninae

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Body size variation and limited taxon sampling has obscured true species borders and relationships among species of Nyctimeninae (*Nyctimene*, *Paranyctimene*). Previous systematic analyses have conflated multiple species within OTUs and limited geographic sampling has not helped. Here, mtDNA on the entire subfamily across 115 localities, together with a complete morphological reassessment and reanalysis of allozymes, now shows congruence. Widespread new species were found, confounding taxonomy on mainland Papua New Guinea and the Bismarks. Formerly proposed tribes are not supported; instead, a cryptic clade with several species is recognized that needs to be erected as a new genus. This new genus and *Nyctimene* (*sensu stricto*) seem to occupy the same morphological space sympatrically and have undergone parallel evolution, thus causing much of the taxonomic woes.

Lek Pattern and Social Organization in European Bats

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The mating system of European bats is often reported as “resource-defense polygyny” where the resource is a roost of a male and its adjacent territory. Nevertheless, in many species, spatial dispersal of males does not correspond to predictions of that model. The multi-male groups of *Vespertilio murinus* or lek-like aggregations in *Myotis myotis* or *M. blythii* are typical examples. We analyzed spatial dispersal of males in a migratory species, *Pipistrellus nathusii*, well known for conspicuous advertising vocalization of males during the mating season. The study (conducted on a resident population in southern Bohemia throughout nine seasons 1999–2007) revealed a pronounced aggregation of male roosts and vocalization sites responding to 1) vicinity of breeding colony and 2) dyadic or triadic aggregation of certain resident males roosting close to each other within a common vocalization site. The particular dyadic or triadic groups share the neighborhood for several seasons as a rule (up to seven successive years), do not show agonistic behavior to other group members, and even synchronize their activity pattern and advertisement vocalization. We propose that similar phenomena that do not correspond entirely to “resource-defense polygyny” are more typical than exceptional in European bats and suggest an essential role of female choice in mating system.

Swarming Activity of Bats in the Vârghiş Gorge: An Important Site for the Eastern Carpathians (Romania)

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During 2000–2008, in the second part of August to the first part of September, regular mist netting was carried out in the Vârghis Gorge, in order to collect data about species composition and abundance of mating bats at different underground roosts. The study area (~1000 ha) is a Nature Reserve, and is one of the most important karstic areas of the Eastern Carpathians (more than 120 caves of variable length). During the study, bats were caught at five sites, and had lengths of 90–1527 m. Altogether 18 different species were identified (1678 individuals total), representing 58% of the Romanian bat fauna. The most frequent species were the greater mouse-eared bat *Myotis myotis* (36.5% of all captured specimens), the noctule *Nyctalus noctula* (27.2%), the barbastelle *Barbastella barbastellus* (13.8%), the lesser mouse-eared bat *M. oxygnathus* (11.6%), and Bechstein’s bat *M. bechsteinii* (4.1%). Our results show that some caves in the Gorge have an important role in the mating activity of bats and an important number of specimens, probably from a relatively large area, come here during this period. Some of the studied caves are unpopulated during summer and winter, but they become extremely well visited during the mating period. Consequently, these caves could have an important role in bat conservation. Differences in species composition and

abundance at different sites may suggest that certain bat species have their preferred mating places in a relatively restricted area with many suitable roosts. Our results also suggest that mist netting at swarming sites could be used for the monitoring of some forest-dwelling bat species, which appear in great numbers at underground swarming sites during the autumn mating period.

Differences in *Antrozous pallidus* Foraging Styles

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We captured and tagged six pallid bats (*Antrozous pallidus*) from a colony on the California coast, and five others from Death Valley, California. The dietary history of each bat was known from fecal analyses. Using these bats, we tested for individual and population differences in foraging behavior and learning abilities. Results indicated that the desert population spent more time roosting and less time on the ground searching than did the coastal population. Two behavioral styles, crawlers and non-crawlers, were also observed in both populations. A correlation was made between dietary preferences and time spent crawling on the ground for the desert and coastal populations, but the slopes of these interactions were different for the two populations. Coastal bats, from an environment of more uniform distribution of prey than desert bats, had significantly faster latency rates of learning. Coastal bats also showed no individual differences in latency rates of learning, but desert bats did. This study suggests that animals' learning ability is more highly selected in populations found in more uniform environments, such as those found along the California coast.

Differences in Swimming in Bats

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We predicted that bat species that forage over watercourses will have different swimming styles and different anatomical features that facilitate them to leave the water's surface. Observations of seven species (*Noctilio leporinus, Pteronotus personatus, Myotis yumanensis, M. vivesi, Antrozous pallidus, Lasiurus ega, and Tadarida brasiliensis*) representing four families (Noctilionidae, Mormoopidae, Vespertilionidae, and Molossidae), were conducted for position of wings during swimming, density and thickness of body hair, buoyancy of body in water, and when possible, swimming speed. Three species—*P. personatus, M. vivesi,* and *L. ega*—jumped out of the water from a floating position. Each positioned its wings at narrow angles from the body before pushing into the water with the axial end of the forearm before becoming airborne. *P. personatus, M. yumanensis,* and *T. brasiliensis* had dense erect underfur that trapped air, preventing water penetration. *L. ega* had flat hair and underfur that repelled water. *N. leporinus* had erect guard hairs that allowed water to come in contact with the body integument. Using a 250-frames/second camera, we compared the speed and analyzed the swimming movements of *A. pallidus* and *T. brasiliensis*, and found that *T. brasiliensis* swam faster and more efficiently than *A. pallidus*.

Different Patterns of Roosting Behavior in Two Cryptic Pipistrelle Bats (*Pipistrellus pipistrellus* and *P. pygmaeus*)

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Large hibernating aggregations and behavior called "autumn invasions" when flocks of bats enter buildings are known in pipistrelles. We looked for differences in roosting behavior between two cryptic species (*Pipistrellus pipistrellus* and *P. pygmaeus*) during late summer, autumn, and winter periods. Altogether 463 bats were sampled in caves as well as in buildings with temporary occurrence during the period of mating and presumable migrations from late July–September (10 sites) and in all types of hibernacula from late November–March (34 sites) in the area of the sympatric summer occurrence of the two species in the Czech Republic, Slovakia, Serbia, and Romania. Using DNA-based identification method, all but four individuals were identified as *P. pipistrellus*. Three individuals of *P. pygmaeus* were admixed with a large colony of *P. pipistrellus* hibernating in a castle cellar in Nový Hrádek and a single individual was found in a village Samotíšky near Olomouc (both localities in the Czech Republic). Thus the winter roosts of *P. pygmaeus* remain largely unknown. All bats found during "autumn invasions" were *P. pipistrellus*. The records of very abundant groups of *P. pipistrellus* in underground hibernacula and of its exclusive occurrence in "autumn invasions" suggest that the roosting behavior of the two pipistrelles is species-specific. [The

project was supported by grants from the Czech Science Foundation No. 206/06/0954 and the Long-term Research Project of the Ministry of Education, Youth and Sports of the Czech Republic No. MSM0021622416.]

From Long-term Trends in the Monitoring of Bats, to Their Habitat Preferences

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In order to reach the European goal for significant decrease in the rate of biodiversity loss by the end of 2010, the use of biodiversity indicators is necessary to monitor the actual loss and determine the necessary actions to take in the following years. In this context, the National History Museum of Paris initiated a set of national monitoring programs, focusing on common species of birds, butterflies, amphibians, and bats. The program of common bat species was officially started in 2007 after being tested for a year. Being high in the food chain, bats can serve as sensitive indicators of various ecosystem perturbations such as agriculture intensification or climate change. This national monitoring program is based on standardized recordings of time-expanded bat echolocation calls. Two types of protocols have been developed: point counts and car road survey. About 100 sites were surveyed in 2007 (4000 km), allowing 15,000 individual bat contacts, for a total of 15 species. In 2008, the number of sites has been doubled. The influence of meteorological parameters within season or among years and biases coming from observer's identification errors were taken into account in our analysis. Power analysis carried out on the 2007 data of the commonest species indicated that we are able to detect an annual variation of abundance of 2% over 10 years. Furthermore, we analyzed the spatial aggregation characteristics of each species. We defined the habitat preference and specialization degree of each recorded species thanks to the Corine Land Cover habitat database but also to our own detailed habitat reports. By integrating global monitoring results and habitat-activity relationships at the species level we should be able not only to detect the abundance trends but also to reveal some of their causal factors.

Bat Fauna at Two Croatian Islands Distant from the Coast: The Island of Vis and the Island of Lastovo

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The islands of Lastovo and Vis belong to the central Dalmatian archipelago and are situated in the Adriatic Sea. Lastovo archipelago is situated more toward the south and acts as a border between the northern shallower and the southern deeper parts of the Adriatic Sea. It has been a nature park since September 2006. The largest island of the archipelago is the island of Lastovo with an area of 40.86 km^2. Vis is the furthest inhabited island with an area of 90.26 km^2. Typical vegetation of both islands is mixed forests of Holm oak and Aleppo pines with a mozaic of Mediterranean underbrush. The islands are still mostly untouched with massive tourism since they were military bases from 1945–1992. Bat research, mostly from 50 years ago, listed 7 bat species for the island of Vis and 15 bat species for the island of Lastovo. Inventories of both flora and fauna are not yet complete for these islands, so BIUS (Biology Students Organization) conducted comprehensive flora and fauna inventory during ten days of an interdisciplinary camp. The camp was held in October on the islands of Vis (2005) and Lastovo (2007). The year of 2005 was drier than 2007 so the number of freshwater bodies, mostly ponds, was much higher on the island of Lastovo than on the island of Vis. BIUS bat section recorded six bat species for the island of Vis and seven bat species for the island of Lastovo. Bat fauna was identical for five species: *Tadarida teniotis*, *Rhinolophus ferrumequinum*, *Pipistrellus kuhlii*, *Plecotus kolombatovici*, and *Miniopterus schreibersii*. Species that we found only on the island of Lastovo were *Nyctalus leisleri* and *Hypsugo savii* whereas for the island of Vis we recorded *R. hipposideros*. We recorded two caves with colonies of *M. schreibersii* (one per island) with around 150 individuals. *Miniopterus schreibersii* is listed as endangered in the Croatian Red Mammal Book so further research on the type of colonies with conservation and monitoring proposals is necessary.

Preliminary Results of a Bat Survey in Mejanger Zone, Southwestern Ethiopia

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A short-term bat survey was conducted in spring, 2007, by the Joint Ethio-Russian Biological Expedition in the Mejanger Zone of the Gambela, southwestern Ethiopia. The survey was carried out on the border of the Godare forest massif, one of the most lowland forests of Ethiopia. About 100 individual bats were captured representing at least 15 species from 10 genera and 6 families. One of the most important records was represented by the third capture of *Kerivoula lanosa* from Ethiopia. The two previous records (both made more than 100 years ago) of the woolly bat

from Ethiopia are located in northern Ethiopia in the foothills of the Simien mountains, and in the Great Rift Valley north of Lake Abaya. Our record was made at least 320 km west from the former locality. Capture of *Myotis bocagei* also represents the third record from the country. *Micropteropus pusillus*, *Triaenops persicus*, *Neoromicia nanus*, *N. guineensis*, and *Scotophilus dinganii* were the most common and abundant among the observed bats. Together with published records made in 2000, the total bat community in Godare forest amounts to at least 19 bat species.

Towards Recovering Cryptic Taxonomic Diversity in Russian Bats

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The introduction of new techniques in taxonomic research provided valuable insights into chiropteran species diversity and provided grounds for reconsidering the taxonomic structure of complex species groups. The recent application of combined molecular and refined morphological approaches to the study of Russian bats enabled new insights to be gained into their alpha-taxonomic structure and increased the overall species count. Deep genetic divergence between *Myotis daubentonii* and *M. petax* was confirmed, the status of *Myotis aurascens* and its subspecies was supported, a cryptic lineage was found within *Plecotus auritus* in Siberia, and a putative cryptic species was found within *M. brandtii* based on mtDNA. Both *Pipistrellus pipistrellus* and *P. pygmaeus* were documented for European Russia; moreover, the latter was shown to be the most abundant and widespread in the area. Molecular data also suggest that the easternmost populations of *Eptesicus serotinus* avoided historical introgression with *E. nilssonii*, thereby retaining their original haplotypes. Several other new taxa of the subspecies level were described or confirmed. It is expected that bat taxonomy in Russia will further benefit from continued in-depth morphological research and broad introduction of high through-output molecular approaches, such as DNA-barcoding.

Are River Valleys Migration Corridors for Bats?

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We studied migration of bats along the Odra River valley in southwestern Poland, once a week or two weeks, from March–November 2007. We carried out all-night acoustical surveys and a series of 10-min visual observations of bats flying at the river. The direction of bats' movements were determined on the basis of visual sessions and sequences of echolocation calls recorded by two frequency division ultrasound detectors. We noted migration for three species: *Myotis daubentonii*, *Nyctalus noctula*, and *Pipistrellus nathusii*. Lower and not statistically significant movements were observed in *P. pipistrellus* and *P. pygmaeus*. The pattern of migration activity was species and seasonally specific. In spring most bats were flying northward, whereas in autumn they were flying southward. Spring migration was dominated by *M. daubentonii* and lasted from the end of March till the beginning of May. Autumn migration was longer than in spring and it started in mid-autumn and continued until the end of October. *N. noctula* began their movement about one month later than *P. nathusii*. The southward movement of *M. daubentonii* was not statistically significant. Our results show that river valleys are migration corridors for long-range and short-range migratory bats. We did not study other habitats, but is seems that rivers provide migrating animals with suitable orientation landmarks such as banks or vegetation lines or other cues. The study will be continued, since it has important implications for bat conservation and our understanding of bat migration.

Feeding Habitats of Brown Long-eared Bats, *Plecotus auritus*, in Southern Finland

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The feeding habitats and home range of the brown long-eared bat (*Plecotus auritus)* was studied using radio-tracking in southern Finland. Altogether 12 females from a colony roosting in a church attic were fitted with lightweight radiotransmitters (Biotrack) and followed during the summers of 2006 and 2007. Data from three or more nights were obtained from nine individuals. Bats used mostly forested areas and riparian habitats near the roost. Some individuals commuted up to ca. 2 km from the church to feed. Edge habitat of forest and clear-cut areas also was used as foraging areas. Usually the tagged individuals returned to the attic roost in the morning but occasionally other roosts also were used. The length of foraging time is restricted by the very light summer nights in northern Europe. In this study, the shortest time a bat spent outside the roost was only 50 minutes.

Trends in Molecular Diversity and Genetic Structure of Afro-Malagasy Molossidae

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We investigate trends in molecular diversity of Afrotropical and Malagasy molossid taxa, with a wide range of body sizes (30–70 g). The within-species cytochrome *b* sequence diversity ranges from 0.10–0.75% (mean 0.46%), whilst levels of population sub-structure (Fst) range from 0.05–1.00. We investigate whether these variations are correlated with flight and therefore dispersal ability. Forearm length was significantly inversely correlated ($P < 0.05$) with the average number of pairwise nucleotide differences within a species, and with Fst. There was no significant correlation with haplotype diversity (Hd) or nucleotide diversity (Nd). Larger bats appear associated with unstructured panmictic populations whilst, in smaller less-vagile bat species, mutations may more frequently become fixed in local demes, giving rise to greater diversity and fixation indices. We have also created a provisional phylogeny of these and some other molossid taxa. All Molossidae in our sample form a single monophyletic clade. New World molossids are not monophyletic and are nested within Old World molossids. The genus *Otomops* is monophyletic and is sister to *Mops* and *Chaerephon*. The genera *Mormopterus*, *Mops*, and *Chaerephon* are all paraphyletic.

An Opportunistic Predator, the Tawny Owl *Strix aluco*, Can Reveal Long-term Changes in Bat Abundance

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The study is based on all available published accounts of the tawny owl's diet in Poland and on the pellet samples analyzed by the author (total number of samples = 43, each containing at least 100 vertebrate prey items). As the bird is an opportunistic predator, it can be expected that the share of bats in its diet reflects their abundance in the owls' hunting areas. In accordance with the drastic changes in bat abundance (decline as well as increase) between 1950–2008, the frequency of bat captures by owls varied markedly. Before 1963 the median share of bats among vertebrate prey was 2.4%; between 1976–1992, 0.2%; and between 1993–2008, 0.7%. It seems to correspond with the fact that the lowest numbers of bats occurred in Poland in the 1980s. A slight upward trend has been noted since the early 1990s. The analysis of samples collected at the same six sites in the period 1975–1992 and again in 2000–2008 confirms the increase in the proportion of bats to other vertebrates captured by tawny owls.

Within-season Variation and Evidence for Gleaning in the Brandt's Bat in Southwestern Finland

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Northerly latitudes favor a more generalist life history strategy. The strong seasonality and short growth season favor this strategy above a more specialist strategy. In this study we examined the feeding habits and the within-season variation in the diet of Brandt's bats in southern Finland. We analyzed Brandt's bat feces from a maternity roost in Ruissalo, Turku in southwest Finland, during the summer of 2007. Altogether 11 invertebrate orders were recorded in the samples. The most frequent remains in the diet were Lepidoptera, Trichoptera, Coleoptera, and Diptera (Culicidae/Chaoboridae and Chironomidae). Apart from these groups, there were significant differences in the frequencies of other groups in the fecal samples during the sampling period. We also found evidence of gleaning with non-flying taxa in the feces. This suggests that Brandt's bat is a generalist that feeds on temporally abundant groups.

Bat Activity Patterns and Habitat Use within Lowland Agricultural Landscapes

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Bat activity was monitored across 24 x 1 km^2 lowland farmland study sites and 6 x 50 km car transect routes within the Upper Thames catchment area in the United Kingdom. Echolocation calls were continuously recorded during 180 bat detector transects, followed by sonogram analysis to enable species identification and quantification of bat activity. Total bat activity was influenced by habitat composition along survey routes, indicating selection of riparian corridors and hedgerows containing mature trees. Patterns of habitat use also varied between bat species, with the common pipistrelle, *Pipistrellus pipistrellus*, being the most frequently encountered and widely distributed

species, whilst the soprano pipistrelle, *P. pygmaeus,* and *Myotis* spp. displayed strong preferences for riparian corridors and woodland habitats.

'Batsnatcher': The Development of a New Bat Counter

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Countryside Council for Wales (CCW) has built on the innovative work of Dr. P. Andrews to develop a cost effective bat counter that uses infrared light beams to record numbers, direction, and time of travel of bats at roost entrances. This can be run in conjunction with an acoustic detector for species identification or with climate loggers to record weather conditions and should improve the efficiency with which we undertake bat roost monitoring in Wales. The counter was tested during the condition assessment of the lesser horseshoe bat, *Rhinolophus hipposideros*, on the Gwydir Forest Mines Special Area of Conservation (SAC), Wales. Five hundred and eighty-seven passes occurred in thirty-five nights during two periods in the spring of 2006; only 1% of these were logged as data errors. This suggested the software and array design were well targeted for logging bat transits. Data were effective at highlighting light sampling and night-time activity. The array coped with poor spring weather conditions including snow and heavy rain. CCW is working to enable faster data analysis and will calibrate the system with older counters currently used at five roosts in Wales to allow their replacement.

Which Factors Regulate the Reproduction of Ectoparasites of Temperate-zone Bats?

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Reproduction is an energetically demanding phase of the complex life-cycle of parasites during which they are entirely supported by their hosts. It is thus to be expected that host-dependent factors play an important role in regulating the reproductive biology of parasites, although environmental conditions may also be involved. Our main objective was to determine which factors regulate the reproduction of ectoparasites of temperate-zone bats. As a model we used the cave-dwelling Schreiber's bat, *Miniopterus schreibersii*, and its ectoparasites. We searched 969 bats throughout 2003 and 2004 and found 4 ectoparasite species regularly occurring on them: 2 nycteribiids (*Nycteribia schmidlii, Penicillidia conspicua*), 1 mite (*Spinturnix psi*), and 1 tick (*Ixodes simplex*). These species were present throughout the yearly cycle, but their reproduction fluctuated seasonally. We also found that sex, age, and reproductive status of the bat host strongly influenced the pregnancy rates of their parasites. Overall, the four species showed similar reproductive patterns, reproducing intensively during the pregnancy and nursing seasons of hosts, and mainly on pregnant and juvenile bats. Moreover, parasites ceased reproduction while bats hibernated. We conclude that reproduction of ectoparasites of temperate bats is strongly regulated by the reproductive cycle of bat hosts, and that environmental temperature acts as a constraint during the winter. The fact that the reproductive cycles of parasites of very distinct taxonomic groups are similarly adjusted to the reproduction of their hosts suggests that this is a highly adaptive trait.

Exceptional Warmth of the European Winter of 2006/2007 and Its Impact on the Phenology of Reproduction of the Daubenton's Bat, *Myotis daubentonii*

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Recent climate is characterized by positive trends in global temperatures and rising incidence of climatic extremes. While impact of climate on phenology has mostly been studied in plants where long-term data from phenological gardens are available, information on some other groups of organisms, such as vertebrates, remain very scarce. This holds true particularly for bats, which are very difficult to study since most of their life-performances take place either on the wing during the night or in daytime roosts that are difficult of access. Here we analyze the impact of the exceptionally warm European winter of 2006/2007 (the warmest for at least 500 years) on timing of reproduction in Daubenton's bats, *Myotis daubentonii*, in the context of long-term observation within a single study area (South Bohemia, Czech Republic). While parturition occurred synchronically in the first half of June during most seasons, onset of parturition was advanced by more than 40 days in 2007. However, the last gravid females were observed as late as mid-June. Thus, exceptionally warm winters may result not only in advancement of reproduction but also strongly disrupts synchronicity of parturition in Daubenton's bats. This fact implies a significant impact of climatic extremes on social organization of bats.

Changes in the Structure of Species Assemblage of European Tree-dwelling Bats: A Long-term Study

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In contrast to cave-dwelling bats, tree-roosting bat species are difficult to study since they display much more cryptic roosting behavior and thus, long-term studies are very scarce. Here we present results of a study covering 40 years (1968–2007) in a single model study area in Třeboňsko Landscape Protected Area (Southern Bohemia, Czech Republic). Based on data from 1) direct captures of bats emerging from tree hollows (over 340 capture events and ca. 3000 captured bats), and 2) visual and acoustic inspections of tree roosts (over 160 roost controls), we infer changes in numbers of noctule bats (*Nyctalus noctula*) and Daubenton's bats (*Myotis daubentonii*)—the only two species frequently occupying tree hollows in the study area. While numbers of roosts occupied by Daubenton's bats have steadily increased, the population of noctule bats actually declined toward the second half of the study period. Increase in the recorded numbers of Daubenton's bats well reflects its population trends in Europe. Decline in noctules most probably corresponds to a shift in their roosting preferences toward synanthropic types of roosts (e.g., prefabricated houses).

First Data on Ecology of the Alcathoe Bat (*Myotis alcathoe*): One of the Least Known European Bat Species

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Between 2001–2007, we recorded *Myotis alcathoe* at nine sites within three separate areas in the Czech Republic. All localities exhibit surprisingly uniform habitat characteristics, which are: 1) old full-grown oak-hornbeam forests, 2) numerous large trees in advanced stages of decay, and 3) a very small-to-large bodies of water and/or patches of riparian vegetation surrounded by the forest. Day roosts were recorded in fissures of a tree trunk high in the canopy. Two of the three roosts contained small groups of seven and eight *M. alcathoe*, respectively. In contrast to sympatric *M. mystacinus* and *M. brandtii*, *M. alcathoe* most probably does not use roosts in man-made structures. Preliminary observations of foraging behavior indicate that *M. alcathoe* is a typical aerial hawker obtaining its prey a few meters above the ground in open or slightly cluttered spaces close to ecotonal habitats in the vicinity of riparian vegetation. In the observed ecological and behavioral characteristics, *M. alcathoe* markedly differs from other European species of the genus *Myotis.* Restricted habitat requirements are perhaps responsible for an islet-like pattern of its distribution and suggest an essential conservation value of the habitats of its occurrence.

Bat Protection in Sibiu County, Romania

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Sibiu–Romanian Bat Protection Association is a volunteer-based organization that has worked for the past five years on bat research and public awareness campaigns on bat protection, mostly in Sibiu County. Research has been focused on finding new species, identifying species composition, distribution, and relative abundance of bats in the area of interest. We are conducting studies on suitable anthropogenic roosts for bats, and human behavior and patterns with a negative impact on bats. Methods used comprise mist netting, observation, using heterodyne bat detector, and also time expansion ultrasonic detectors to capture bat echolocation calls along car transects. Due to the limited knowledge of the general public and negative myths regarding bats and their role in nature, our organization focused on raising public awareness with a series of campaigns, public events, and school presentations. Public knowledge about bats was measured in the last three years with a questionnaire survey showing that 80% of respondents from a total of 400 have minimum information or a negative perception about bats. Applying the same questionnaire after a bat presentation, 90% of respondents showed improvement regarding perception and general knowledge about bats.

The Batcorder System: Autonomous Recording Device for Bat Calls and Software for Automatic Parameter Extraction and Species Discrimination

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The batcorder system constitutes an all-in-one solution for the acquisition of bat activity and the analysis of bat calls. It consists of a recording device and optional software especially designed to cooperate with the hardware. It was developed for the quantitative and qualitative acquisition of bat activity data (bat species and phenology, synecological data) in the field. The hardware takes sound recordings and is triggered by bat calls. Other sound sources usually do not start a recording. Files are written with 500 kHz sample rate and 16-bit amplitude resolution onto a SDHC card. The recorder runtime is about three to four nights with the supplied battery pack. The recordings and metadata can be managed in a database through the application bcAdmin. This application allows the automatic measuring of each call of each sequence. These measurements can be fed into bcDiscriminator, an open-source tool for the statistical discrimination of bat calls (currently Central Europe only). Each call of a sequence is analyzed in a step-wise algorithm resulting in a group or species entry and a discrimination probability. Using these discrimination results bcAdmin calculates summaries for activity at locations, nights, or studies. Due to the calibrated sensitivity and the automated and fast handling of the data, the batcorder system makes comparative studies of bat activity possible in the first place.

Microhabitat Use by Bats in Beech Forests Sampled with Acoustical Methods

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Using a synecological study design, the activity of forest bats in relation to different forest stands and within-stand structures in a Bavarian beech forest was investigated. Based on mobile detector transects 15 locations for automatic call recording with batcorders were chosen. Four sites were equipped with a microphone chain to sample activity at up to eight different heights. On these sites the 3D-structure of the vegetation was acquired using a terrestrial laser. Such forest "tomographies" were used to describe and find measurements for clutterness. Sampling took place from 2003–2006. A high preference for less dense forest stands and structures was found for all species. Old even-aged forest had the highest bat diversity and played a crucial role for all species supplying roosts and prey. Linear edge elements like forest roads and forest edge were also used by most species. With higher forest density—measured in trees per hectare as well as clutterness—activity declined. Only species of the genus *Myotis* were regularly found in denser forests, but even those showed a negative correlation of activity with tree density. The results suggest that the available flight space within a forest plays a crucial role in allowing bats to access these habitats. Habitat clutterness seems not to play a major role in niche differentiation of "forest bats." The data also imply that modern silviculture with faster harvesting cycles has a strongly negative impact on the composition of bat communities and their abundance.

Zero-to-Sixty in Five Years: Developing a National Bat Monitoring Program for Ireland

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Ten species of bats occur in Ireland. Before 2003 there was no coordinated approach to their monitoring. Protocols are now in place for six species. In 2003, a pilot study was carried out to assess the potential for car-based monitoring. This scheme was found to work for three common species—*Pipistrellus pipistrellus, P. pygmaeus*, and *Nyctalus leisleri*—and has expanded year-on-year since. A comprehensive database of all *Rhinolophus hipposideros* roosts was also begun in 2003, followed in 2005 by the first coordinated monitoring at winter and summer roosts throughout its range in Ireland. This monitoring has continued annually. In 2006 a pilot waterways survey generated considerable public interest; 134 waterways were surveyed in the first year, and in 2007, 199 transects were completed providing robust nationwide data on *Myotis daubentonii*. In 2007 a pilot scheme to monitor *Plecotus auritus* was initiated at a small number of sites. The success of this pilot has resulted in a 3-year contract to expand the scheme to 50 sites across the country by 2010. Trials to monitor woodland bats (*M. nattereri, M. mystacinus*, and *M. brandtii*) in 2007 were less successful. A three-year research agreement has begun to investigate further the ecology of these species in Ireland and to advise on an appropriate monitoring methodology. Sixty percent of Ireland's bats are now monitored on an annual basis and a program is in place to inform a monitoring scheme for three more. The final species—*P. nathusii*—has only recently been identified from Ireland and is insufficiently known for a monitoring strategy.

Importance of Amazonian Riparian Forest for Foraging Frugivorous Bats

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Lowland Amazonian forests have a mostly continuous and dense cover, but along watercourses the canopy is interrupted, and abundant light penetrates to the ground. This availability of light, and the proximity of water, is likely to influence not just the floristic composition of the vegetation, but also its fruiting phenology and productivity. Consequently, these riparian areas could represent a distinct foraging habitat for the rich guild of Amazonian frugivorous bats. We studied the importance of such riparian forests in the production of fruit resources for frugivorous bats in the Amanã Sustainable Development Reserve (Amazonas, Brazil). We examined the diet of frugivorous bats and compared the fruit production of riparian vegetation with that of the adjacent forest. To do this we captured bats at ten sites and collected fecal pellets to study their diet. Fruit production in each site was estimated by counting fruits along 1-km transects both in riparian vegetation and in the adjacent forest. The most common bats were *Carollia perspicillata*, *Artibeus planirostris*, *Glossophaga soricina*, and *Rhinophila pumilio*, and the most consumed fruits were *Ficus* sp., *Cecropia* sp., *Vismia* sp., and *Piper* sp. Fruit production was greater during the wet season, and riparian areas were more productive in both seasons. Riparian areas also had higher production of the most important fruits identified in the bat diet study. Our main conclusion is that riparian vegetation may provide high quality foraging habitat for frugivorous bats in Amazonian forests.

The Diet of Bechstein's Bat in Degraded Habitat in Southern England

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Bechstein's bat is one of five *Myotis* bats resident in the United Kingdom, where it is believed to be one of the rarer mammals. This bat is a tree-dwelling species, so roosts have been difficult to study in the past. Then, in 1998 the first maternity colony of Bechstein's bat to be discovered in over 150 years was found in a building in southern England. The Vincent Wildlife Trust subsequently leased this site in order to protect it. However, the surrounding habitat is extremely poor, lacking large areas of semi-natural or ancient oak woodland. Therefore, droppings were collected monthly during the summer of 2004 to determine what the bats were eating. The diet was found to be primarily ground-dwelling arthropods that contributed 67–92% of the diet throughout the summer. The main arthropods eaten were the Chilopoda (centipedes), Dermaptera (earwigs), Coleoptera (nocturnal ground or darkling beetles), and Arachnida (harvestmen). The high occurrence of the remains of beetles and earwigs, considered 'noisy' when foraging amongst vegetation, provides more evidence to support the suggestion that Bechstein's bat uses its long ears in a similar way to long-eared bats to detect prey-generated sounds.

Using Bat Indices in the Netherlands

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The Netherlands has a long history in monitoring bats. The first bat counts from hibernation sites were already registered around World War II. The intensity of monitoring has gradually grown and monitoring methodology became more and more standardized. Statistics Netherlands (SN) is a large government institute supporting national policy and for many years has been involved in the analysis of species distribution and population data. Thanks to the involvement of SN, natural statistics in the Netherlands has developed quickly to a relatively high quality level. For this reason we are nowadays able to produce wintering bat population trends and indices from the year 1986 onward for seven out of the fifteen bats species in the Netherlands. Stimulated by the developments in the European Union Habitat Directive we are now extending our monitoring program with two summer survey projects: counts in church (and church-like) attics for *Myotis emarginatus* and *Plecotus austriacus*, and auto-route surveys. Our statistical analysis is mainly focused on calculating national trends and indices as indicators of bats' population development. But the dataset is large enough and contains sufficient additional information to calculate regional indicators and indicators for different categories of hibernation sites or several other classifications of count sites. This means our analysis not only provides information on conservation status, but may also be used to test regional and categorical differences, or influences of management measures. And last but not least, our methods provide opportunities for calculating European indicators based on national trends and indices. In recent years we have successfully applied this for two different bird indicators. This has lead to acceptance of these indicators as membership state obligations for European Union nature policy.

Diseases in Native Bats from Germany

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Chiroptera are among the most successful and diverse of mammals on earth. They are of special scientific interest because of their susceptibility to several infectious agents that can cause diseases in other animals and humans. Worldwide much information about biology and ecology is known, while the knowledge of diseases and the impact of infectious agents on bats are rather deficient. In a study of diseases and infectious agents in native bats from Germany about 150 individuals from 12 different microchiropteran species were examined. For sampling, deceased or euthanized bats were collected in different German regions in cooperation with active bat conservationists and stored in common freezers at –20° C. The frozen carcasses were subjected to a post-mortem exploration and examined histopathologically. In addition 95% of these bats were also suitable for bacteriology and virology. A total of 30 different bacterial species were isolated from the tissue samples of 102 native bats. Thirty-four percent of the animals examined bacteriologically had unspecific mixed flora; in 29% no bacteria were detected. Predominant histopathological findings were mild to severe interstitial pneumonia (34%), mild to marked inflammatory changes in liver, heart, kidney, or intestine (30%), and follicular hyperplasia of the spleen (45%). Bacteriological and histopathological examinations revealed that pathological changes of at least 16% were directly associated with bacteria detected in culture and that these bats had died because of bacterial infection. Focused on these first results we will present some special case reports of fatal bacterial infections in German bat species.

Fatal Case of *Yersinia pseudotuberculosis* Infection in a German Greater Mouse-eared Bat, *Myotis myotis*

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In a study of diseases in German microchiropteran species, an adult female greater mouse-eared bat (*Myotis myotis*) found dead was submitted to the Leibniz Institute for Zoo and Wildlife Research, Berlin, Germany, for histopathological and bacteriological examinations. At necropsy the bat revealed a hemoperitoneum and severe enlargement of the liver. Predominant histological findings were multiple large necrotic areas within the liver and spleen associated with high numbers of bacterial colonies, moderate to marked interstitial pneumonia as well as moderate follicular hyperplasia of the spleen. Gram-staining of liver sections comprised numerous intralesional Gram-negative rods and a few Gram-positive coccoid bacteria. Bacteriologically, *Yersinia pseudotuberculosis* was isolated from lung, liver, heart, kidney, and intestine. *Y. pseudotuberculosis* is a non-host-adapted bacterial organism frequently isolated from a variety of wild and domestic animals but infection has also been described sporadically in humans. Fourteen serogroups of *Y. pseudotuberculosis* are known to occur but only serogroups I–V contain strains that are pathogenic to humans and animals. In our case, *Y. pseudotuberculosis* serogroup I, biovar 5 was identified in all tissue samples of the adult greater mouse-eared bat. Based on histopathological and bacteriological findings the death of the animal was attributed to yersiniosis caused by *Y. pseudotuberculosis*. Transmission generally occurs after ingestion of fecal-contaminated food or water. All of the German bat species are insectivorous and insects can be infected with various infectious agents, including bacteria. We suggest that insects or fecal-contaminated water are the most likely transmitters of *Yersinia*. To our knowledge, this is the first case of systemic yersiniosis caused by *Y. pseudotuberculosis* in microchiroptera.

Restoration of the Nursery and Hibernating Colonies of Bats in the Touristic Muierii Cave Roost, Baia De Fier, Romania

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The most visited speleological site in Romania is Muierii Cave. Up until 1960, there were important colonies of five bat species: *Rhinolophus ferrumequinum, R. hipposideros, Myotis myotis, Plecotus austriacus/auritus*, and *Miniopterus schreibersii*. After 1962, the cave was adapted for intensive tourism, and hibernating bat colonies suffered a drastic decline and nursery colonies disappeared totally. Increasing anthropogenic pressure on this roost opposed conservation of bat species according to Romanian Law 90/2000. Application of this law (prohibiting tourism in the roost) would affect the local community interest—loss of jobs and financial benefits from the tourism and infrastructure nearby. To avoid this situation we suggest a new solution, which allows both tourism and

conservation of bat species. This solution involves the restoration of the primary environmental conditions in order to encourage the reformation of the nursery colonies of the last century. At the same time hibernating colonies will increase both in the number of individuals and of possible new species: *M. bechsteinii, M. daubentonii, M. capaccinii,* and *M. nattereri.*

Patterns of Social Calls in Brown Long-eared Bats, *Plecotus auritus*, in Southern England

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'Social' calls are vocalizations produced in addition to echolocation calls, and differ from echolocation calls by their solely communicative function. However, in contrast to echolocation calls, far fewer studies have been carried out on the function of these calls. Information on the repertoire of communication calls in brown long-eared bats, *Plecotus auritus*, in particular, is fragmentary. We describe and analyze 11,464 brown long-eared bat social calls recorded monthly at 20 maternity sites across southern England from May to September 2007. Our aim was to investigate the variation in social call structure within and between roosts. We describe a number of different call structures and discuss how there is significant variation within call structure, and also evidence of patterns of call sequences. We also examined the temporal, seasonal, and geographic distribution of the social calls. There was evidence of seasonal differences in the call sequences as well as evidence of temporal patterns of call distribution throughout the recording period.

Maternity Roosts of *Myotis bechsteinii* (Kuhl, 1817) in Southwestern Iberian Peninsula

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The Bechstein's bat is a forest-dwelling European species, with preference for mature deciduous forests in lowlands, and considered rare nearly everywhere. Roosts play a crucial role in bats' ecology, and survival is partially dependent on the extent to which roosts protect bats from predators and harsh weather. Adequate roost selection is especially relevant for maternity colonies, due to the higher energetic demands imposed by reproduction and their importance for populations and species abundance. We approached the study of roost selection by maternity colonies of *Myotis bechsteinii* in southwestern Spain at four levels of detail (cavity, tree, stand, and landscape). Twenty-eight lactating females were radio-tracked, which allowed us to locate and census thirteen maternity colonies. All the roosts occurred in *Quercus pyrenaica* trees, within stands of the same species of very diverse characteristics. Ten of the roosts were former woodpecker holes, among which seven had their entrance externally modified with mud by nuthatch. Roost trees had a higher proportion of dead branches, and were inside the forest and close (< 620 m) to a permanent water source. Other variables explored, such as tree height, orientation, leaf cover, or elevation did not explain distribution of roosts at any scale. The species' roosting ecology is described for the first time in their natural roosts in Mediterranean areas.

Preliminary Data on Molecular Taxonomy of Romanian Bats

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A fragment of the 16S mitochondrial gene has been sequenced for bats of the genera *Myotis*, *Nyctalus*, and *Rhinolophus* from several places around Romania. The aims of this study were to: 1) validate the identification of the specimens based on morphological characters by using molecular taxonomy; and 2) attempt to separate the sibling species *Myotis myotis* and *M. oxygnathus*, similar and hard to identify based strictly on morphological characters. Our data were integrated into a wide geographic context of similar taxa from Europe; the tree obtained suggests that the identification of bats is in accordance with the equivalent sequences from specimens.

Final Report of the LIFE-Nature Program "Conservation of Three Cave-dwelling Bats in Southern France"

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The LIFE-Nature program, "Conservation of three cave-dwelling bats in southern France" (LIFE04NAT/FR/000080), was carried out from 2004 to 2008 in order to preserve populations of three threatened cave-dwelling bat species: *Rhinolophus euryale*, *Myotis capaccinii*, and *Miniopterus schreibersii*. This project resulted from the collaboration between the French Mammal Society and 12 French partners, and was supported by

the European Commission and 17 co-financiers. The global budget amounted to 1,136,088 euros. The program was based on a network of 26 bat roosts, all located in 13 sites of community importance of southern France. Thirty-one actions have been set out and they enabled the study of diet and habitat use of the three species from six main roosts and to elaborate management recommendations that are summarized in a handbook, "Understanding and conserving roosts and foraging areas of three cave-dwelling bats." These actions also led to the provision of physical protection of 12 main bat roosts, to protect 11 other roosts by a management agreement, and to acquire one roost. Finally they also enabled the creation of communication tools, such as a travelling exhibition, and the first French film on bats and on actions relevant to their conservation, in order to inform the general public and the local people.

Activity and Foraging Habitats of *Myotis capaccinii* in Southern France: Implications for Species Conservation

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Effective conservation of bats needs biologists to focus attention on foraging ecology. A four-year European program (LIFE-Nature "Conservation of three cave-dwelling bats in southern France") has enabled the study of *Myotis capaccinii* autoecology in France to fill in the gaps in knowledge (Eurobats Resolution). In two colonies of 600 and 1000 adults, a total of 33 females were radio-tracked in 2005 and 2006 during gestation and/or lactation periods. These studies and diet analyses enabled the confirmation that *M. capaccinii* feeding areas are aquatic (rivers, lakes, natural or artificial ponds). *M. capaccinii* feeds on Diptera (55%), Trichoptera (25%) and Lepidoptera (10–15%). Females frequently use several feeding areas per night (up to five), which can be more than 25 km (max: 34 km) distant from the roost. Each feeding area can be used by several *M. capaccinii* or other bat species (up to 50 individuals observed). Females select aquatic habitats with a smooth water surface, bordered by well-developed riparian vegetation with a wealth of insects. Habitat use by *M. capaccinii* probably depends on seasonal insect availability. Conservation of colonies of *M. capaccinii* requires that land managers work on the scale of the catchment area in order to preserve or improve water quality and abundance, and consequently the diversity and wealth of insects. Conservation of the associated riparian vegetation is also a priority.

Activity and Foraging Habitats of *Miniopterus schreibersii* in Southern France: Implications for Species Conservation

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Comprehensive knowledge of roosting and foraging ecology is essential for conserving bats. A four-year program funded by the European Community (LIFE Nature "Conservation of three cave-dwelling bats in southern France") included an autoecological study of *Miniopterus schreibersii* to fill in some gaps in knowledge. *M. schreibersii* is a gregarious species that uses different cave roosts through the year, and females switch roosts even during the breeding season. This behavior necessitates the simultaneous monitoring of all roosts in an area to obtain a realistic estimate of populations. In a colony of 4000 adults, 21 females were radio-tracked during gestation and lactation periods. Every night, for about 6 hours, each bat moved between several small feeding areas, as far as 40 km from the roost. Mean individual home-range estimation averaged 10,800 ha for pregnant females and 22,300 ha for lactating females. Urban areas lit by white street lamps were used extensively. Some bats also foraged in deciduous Mediterranean woods and in orchards. Preying on Lepidoptera (95% of the diet) *M. schreibersii* used, as a priority, areas where food was abundant and adapted their foraging behavior in response to changes in food dispersal and possibly physiological requirements. Conservation of *M. schreibersii* must be planned at a very large scale. The priority is to protect a network of roosts. Efforts should also focus on maintaining deciduous forests and traditional orchards, and promoting nature-friendly agricultural practices.

The Aversive Effect of Electromagnetic Radiation on Bats

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Many bats are killed by collisions with wind turbines and there is no direct method of reducing or preventing this mortality. Following our demonstration that bat activity is reduced in the vicinity of large radar installations, we tested the hypothesis that electromagnetic radiation from a small portable radar can exert an aversive effect on

foraging bats. From June to September 2007, bat activity was monitored at 20 foraging sites in Scotland, with a control (no radar) and experimental trial (radar on) at each. Bat activity was recorded for 30 minutes and the order of trials alternated between nights. The experiment was repeated at each site using two different pulse length/pulse repetition rates (0.08 μs/2100 Hz, 0.3 μs/1200 Hz). Bat activity and foraging effort were significantly reduced during experimental trials and more so when the radar antenna was fixed to produce a unidirectional signal, thus maximizing the time for which foraging bats were in the beam. However, although bat activity was significantly reduced during experimental trials, substantial numbers continued to forage within the beam. Further experimentation is necessary to establish whether the observed reduction in bat activity is a direct response to electromagnetic radiation or an indirect response to a localized reduction in insect density.

Bat Species Acoustic Detectability and Site Occupancy Rates Determine Swiss Red List Sampling Design

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Despite their active orientation, the probability of acoustic detection varies considerably between bat species, depending, e.g., on habitat type, site occupancy, temperature. To design a national, acoustic survey for the IUCN-compliant revision of the Red List, we evaluated data from repeated recordings performed in 2003 and 2006 with complementary methods (4844 bat identifications, 65 locations, 26 dates), deriving presence-absence data for 16 species. Bat species detection probabilities (*p*) and site occupancy rates (*Psi*) calculated from these data ranged for *p* from 0.08 (*Eptesicus nilssonii*) to 1.00 (*Pipistrellus pipistrellus*) and for *Psi* from 0.05 (*Vespertilio murinus*) to 0.95 (*Pipistrellus pipistrellus*). With different values for *p* and *Psi* we evaluated sampling designs, varying the number of sites and repetitions per survey (fixed total sample = 360). We aimed for an increased accuracy of the occupancy estimator *Psi*, trying to minimize its standard error. Models varied strongly with detectability *p* of species, attaining best results with 60–120 sites and 3–6 repetitions. Based on these estimations the survey for the revision of the Swiss Red List of Bats is currently under way on 100 sites, which are to be sampled four times between 2007 and 2010 with two complementary acoustic methods, and twice with mist nets.

Research on the Blood of Bats in the Middle Urals

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During 2005 and 2007 we carried out research of blood leukocytes ratio of bats, *Myotis dasycneme*, wintering in the Smolinskaya Cave (Middle Ural Mountains). The blood sampling for preparation of smears was carried out on 45 individuals. Then smears were stained in laboratories by a standard technique. The subsequent optical microscopy research of blood preparations has shown following results. Morphology of blood corpuscles of bats does not differ from human blood cells, but their ratio is different. Basophils and young neutrophils are completely absent. Eosinophils are seen very rarely. Stab neutrophils and monocytes are present in small amounts (2–7%). Lymphocytes are most numerous (20–40%) and especially segmentonuclear neutrophils (40–80%). It is noted that the leukocyte ratio in bat blood varies a little bit through the wintering period (November to May). The authors thank physicians of laboratory-diagnostic branch of the Yekaterinburg clinical hospital No. 6 for their help with this research.

Hibernating *Rhinolophus ferrumequinum* in the Comarnic Cave (Anina Mountains, Romania): Emerging Patterns of Microhabitat Choice

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Bat activity in the Comarnic Cave has been studied over two hibernation periods and the period between, on seven occasions. The data have been analyzed using ArcView, a very efficient method for bat study and for maintaining a database. Observations show that the cave is purely a hibernaculum, being used by 200–500 *Rhinolophus ferrumequinum*, making it an important site. The cave is a reserve, but it is also a tourism site from May to September. The data gathered showed some recent changes in the occupation of the shelter: bats have started to use an area much closer to one of the entrances, which, according to the small amount of data available, has not been used before. This may be due to the gate change made in 2004. The new gate is solid steel, as opposed to the

previous one, which had vertical and horizontal bars. The new gate does not seem to affect bat access to the cave, since there are six more entrances, but the way they are dispersed inside the cave suggests that access is made through that area. Most definitely it has affected airflow and increased the temperature, making it suitable for hibernating bats. Air and rock temperature measurements have been used to create a predictive occupation model for hibernacula, which still needs further work. The optimal temperature zone for this species has been determined by using scatter plots of air and rock temperature and the difference between them. These show the optimal temperature zone to be much narrower than the tolerable one. Interestingly the active part of the cave is seldom used by bats, only the dry fossil part is used. Probably percolating water and lack of ventilation compensates for a lower humidity. The Comarnic Cave is an important hibernaculum and the first thoroughly studied cave in the Banat region (southwestern Romania), for which there is little data available.

Greater Horseshoe Bat Distribution in the Territory of the Republic of Armenia

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Mapping of the greater horseshoe bat in the territory of Armenia was carried out in 2006–2007 in the framework of compilation of mapping the Chiroptera in Armenia. Particular attention was paid to altitudinal distribution of this species and on identification of new roosting sites. More than 25 caves and grottoes both of volcanic and karst origin from 8–10 m up to 2 km in length were investigated. The observations were made during both daytime and nighttime. As a result, new roosting sites of the greater horseshoe bat were found, including a newly opened cave, David Bek (1100 m above-sea level), where a colony of more than 150 individuals was observed. Among permanent roosting sites, observations were made in Mageli Cave, where a colony consists of more than 2000 individuals. The research demonstrated that the largest number of animals in the colony is reached at the end of April–May. The greater horseshoe bat is the only species overwintering in caves. In terms of altitudinal distribution, in Armenia this bat is recorded from 550–2250 m above-sea level. The research results allow for identification of cave-dwelling sites of the greater horseshoe bat in Armenia as well as definition of key sites for future conservation.

Use of Various Habitat Types by Bats (Chiroptera: Vespertilionidae) in Moldavia and Danube Delta (Romania)

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Our investigations were carried out in Moldavia and the Danube Delta areas during the summer periods of 2006–2007. The importance of various habitat types to bats was assessed according to the mean numbers of the recorded species and according to the frequency of occurrence of each bat species. Various habitat types were important for 13 bat species (*Barbastella barbastellus, Eptesicus serotinus, E. nilssonii, Hypsugo savii, Myotis* sp., *Nyctalus noctula, N. leisleri, N. lasiopterus, Pipistrellus pipistrellus, P. pygmaeus, P. nathusii/P. kuhlii, Plecotus* sp., and *Vespertilio murinus*). The habitat types investigated were: 10 humid areas (channels from Letea, Sulina, Sf. Gheorghe – Danube Delta; Galati, Danude River, Prut River, Bahlui River, Rosu Lake – Moldavia); 5 woodlands (Letea Forest – Danube Delta; Cheile Bicazului, near Prut River, Natural Park Vanatori/Neamt – Moldavia); 3 settlements with streetlamps (Letea village, Sulina town, and Secu Monastery) and 11 car surveys. Woodlands and humid areas are the most important habitat types for the majority of bat species, whereas the habitats along roads (mostly made in open areas) are less important. In the humid areas *Myotis* sp. (30.3%) and *P. nathusii/P. kuhlii* (29.2%) are the most abundant species, followed by *N. noctula* (12.3%), *P. pygmaeus* (9.8%) and *P. pipistrellus* (4.4%). In the woodlands, the most abundant species is *P. pipistrellus* (19.3%), followed by *N. noctula* (13.7%), *P. pygmaeus* (12.5%), *P. nathusii/P. kuhlii* (11%), and *Myotis* sp. (10.8%). Along the roads the most abundant species are *N. noctula* (31%) and *N. leisleri* (21%), followed by *E. serotinus* (19%), *V. murinus* (18.5%), and P. *nathusii/P. kuhlii* (4%). At the streetlamps *N. noctula* (46.7%) and *N. leisleri* (17.3%) are the most abundant species, followed by *E. serotinus* (10.4%), *V. murinus* (10.1%), *P. pygmaeus* (7.2%), *N. lasiopterus* (4.7%), and *E. nilssonii* (2.6%). According to the frequency, *P. nathusii/P. kuhlii, N. noctula, E. serotinus, V. murinus*, and *Myotis* sp. are very common, *N. leisleri, P. pipistrellus*, and *P. pygmaeus* are common, while *E. nilssonii, N. lasiopterus, P. auritus/P. austriacus, B. barbastellus*, and *H. savii* are considered rare bat species in the habitat types of the primary importance.

Unfavorable Conservation Status of *Rhinolophus ferrumequinum* in Slovenia

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Rhinolophus ferrumequinum is found in approximately 40% of Slovenia. It is common in southern regions, but rare in the Alps and missing in the northeast. Maternity roosts are located both in caves and in attics. The estimated population size is roughly 2000–3000 individuals. Its hibernacula have been monitored for the longest period of time in Slovenia, although regular surveys of a few sites only started in the early 1990s. A large number of hibernacula geographically covering the whole of the species' range has been monitored since 2002 when surveys of maternity roosts also began. Data analysis has shown more than a 20% decline ($P < 0.05$) in the numbers over the past six years; a decline especially evident in hibernation roosts at the northern edge of the distribution (e.g., in the Huda luknja pri Gornjem Doliču caves and the Predjamski cave system). *R. ferrumequinum* in Slovenia therefore meets two of the conditions for unfavorable conservation status. If the negative population trend continues 1) the species cannot maintain itself on a long-term basis—in the next 25 years a decline of more than 50% is expected (red alert!), and 2) the natural range of the species will be reduced within a decade or two. The causes of the decline are not clear and are, apparently, specific for *R. ferrumequinum*, as *R. euyale* (estimated 500–1000 specimens in eastern Slovenia) shows stable numbers in hibernacula, and the population of *R. hipposideros* (27,000–33,000 specimens in Slovenia) is increasing ($P < 0.05$). To gain a good insight into the ecological requirements of *R. ferrumequinum*, its threat factors and possible mitigation measures for specific colonies, research should focus on foraging habitats, migration routes, and a search for undiscovered maternity or hibernation roosts of the known colonies.

When Bats and Buildings Collide: The Protection of Overground Roosts in Buildings of Cultural Heritage Importance

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Achieving and maintaining favorable conservation status for bats requires that their breeding and resting sites, i.e., roosts, are also protected. In Europe, a high percentage of bat species roost for at least part of each year in buildings. Buildings of cultural heritage importance are often of particular importance for bats. These structures may be protected in their own right, and conflict between building conservation work and bat conservation can arise. To examine this issue UNEP Eurobats established a working group in 2004 to gather information on bat species using overground buildings, the types of roosts and methods used to protect roosts, particularly those in buildings of cultural heritage interest. A questionnaire addressing these topics was circulated and answers were received from approximately 50 experts from 38 countries. Analysis of the results reveals that across different Eurobats-range countries at least 34 bat species (76% of known species in the Eurobats zone) are considered to have high or medium dependency on roosts in castles and fortifications; 33 species (73%) on roosts in churches, and houses or blocks of flats; 27 species (60%) on roosts in barns or stables; and 23 species (51%) on roosts in bridges. We estimate that the conservation of approximately 75% of bat species across Eurobats-range countries rely for at least part of their life cycle on roosts in buildings of cultural heritage importance. Arising from this work Eurobats has published a report on the protection of overground bat roosts. This report provides practical advice, illustrated by seven case studies, on how to manage bat roosts in buildings including those of cultural heritage importance. The report is available on: http://www.eurobats.org/publications/publication_series.htm

The Start of a Bat Monitoring Scheme in Slovenia

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The Bonn Convention and the EU Habitats Directive require that each member state undertake surveys of the conservation status of natural habitats and species. To address this issue the Ministry of the Environment and Spatial Planning of the Republic of Slovenia commissioned a study with the aim of establishing a monitoring scheme for all bats species in Slovenia. Between 2006–2007 comprehensive fieldwork was carried out to assess the best methods for monitoring specific bat species in the field. The results were complemented with the results of the project Conservation of Amphibians and Bats in the Alps-Adriatic Region INTERREG IIIA Slovenia-Austria 2000–2006. Over 70 people surveyed 1150 potential roosts. In 220 hibernacula and 930 summer roosts, 12 and 13 bat species, respectively, were recorded. Approximately 50 mist-netting sessions (21 bat species recorded) and 54 transect counts (15 bat species recorded) were carried out. Altogether, 27 out of the 28 bat species currently recorded for Slovenia were found. Based on field data 7(8) bat species were judged suitable for monitoring by hibernation counts

and 63 sites (mostly caves) were chosen. The monitoring of 371 selected maternity roosts (mostly churches) is expected to give a good insight on the conservation status of 12 bat species. Mist netting at 20 proposed sites could monitor 14 bat species and 11(13) bat species could be monitored by 24 ultrasound detector transect counts. In total, 467 detailed reports also dealing with an estimation of the quality of bat habitat were made. A lack of suitable data prevented an estimation of population size at the start of the monitoring for the majority of proposed sites and consequently for the whole scheme for particular species. An additional problem is that some areas of Slovenia still lack the data needed to propose an adequate grid of monitoring sites covering particular species distribution. Therefore, intensive continuous monitoring of proposed sites and additional bat surveys are necessary.

Is Adaptation Driving Speciation in *Craseonycteris thonglongyai*: A Genetic Perspective

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Identifying factors influencing speciation is a long-standing question in evolutionary biology. Bats are an important group with which to address this question, since sensory ecology may play a determinant role in their speciation processes. *Craseonycteris thonglongyai* (bumble-bee bat), the world's smallest mammal, is the sole representative of the family Craseonycteridae and was originally found only in Thailand. The recent discovery of a new population in Myanmar, which showed a difference in echolocation call peak frequency but no morphological differences, indicated the possible presence of a cryptic species in Myanmar. In 2006–2008, echolocation calls and environmental and genetic data including sequences of mitochondrial DNA, NUMTs, autosomal, X- and Y-chromosome, and 16 polymorphic microsatellites were gathered from the entire distribution of the species covering the allopatric populations found in Thailand and Myanmar. Genetic data show a clear isolation of the two populations suggesting that they might be different species. Likewise, echolocation data show a similar pattern, suggesting that variation in sensory ecology might play a key role in the speciation process. However, caution is needed as intrapopulation and interpopulation analyses show different results.

Bats and Bridges in Austria

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We studied the importance of bridges as roosting sites for bats in Carinthia and Salzburg, Austria, in 2003. We examined a total of 328 bridges for the presence of bats. In addition, four bridges already known as bat roosts were checked on a monthly basis to get data on the phenology of different species. In Carinthia nine species of bats were found: lesser horseshoe bat, *Rhinolophus hipposideros*; Daubenton's bat, *Myotis daubentonii*; Geoffroy's bat, *M. emarginatus*; greater mouse-eared bat, *M. myotis*; noctule, *Nyctalus noctula*; particolored bat, *Vespertilio murinus*; brown long-eared bat, *Plecotus auritus*; barbastelle, *Barbastellus barbastellus*; and common pipistrelle, *Pipistrellus pipistrellus*. In Salzburg we found the same species with the exception of Geoffroy's bat and barbastelle. In total we found 594 bats (486 alive, 108 dead), and together with evidence from bat droppings, 95 out of 328 bridges examined (30%) had been used as bat roosts. The lesser horseshoe bat was the most abundant species (377 bats in 23 bridges), followed by mouse-eared bats (*M. myotis/oxygnathus)*. The latter species were found in a greater number of bridges (n = 33), but amounted to fewer individuals (n = 97) than the lesser horseshoe bats. In Carinthia four bridges served as maternity roosts for lesser horseshoe bats, one for Daubenton's bats, and one for brown long-eared bats. In Salzburg only one maternity roost of lesser horseshoe bats was found. From the following species only dead specimens were found at the randomly sampled bridges: *V. murinus, N. noctula,* and *P. pipistrellus/pygmaeus*. Hollow motorway bridges and bridges next to woodland were preferred by bats, especially by lesser horseshoe and brown long-eared bats. In contrast, mouse-eared and Daubenton's bats were also discovered in culverts of bridges.

Influence of Vegetation Clutter on the Capacity of a Ground Foraging Bat, *Myotis myotis*, to Detect and Capture Prey: A Case for Grazing

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Spatial and temporal patterns in the availability of food are key elements in the foraging ecology of bats, but the mechanisms of food limitation in insectivorous bats are poorly understood. In general prey abundance is used as a surrogate for prey availability, but there may be an important difference between the two if there are habitat factors

that make the access to prey difficult. Ground vegetation clutter is likely to be such a factor for ground foraging bats, and we studied how grass density affects the foraging ability of *Myotis myotis*. The results of short-captivity experiments, in which bats were given crickets in different types of ground cover (sparse, intermediate, and dense), demonstrated that vegetation clutter greatly affected their capacity to forage. They captured crickets in the three treatments, but they often ignored them in the densest grass. They were equally efficient at locating prey in the intermediate and sparse treatments, but were far more efficient at capturing them in the sparse grass. Grasslands, natural and managed, are important foraging habitat for *M. myotis* in much of its range, but in the absence of natural grazers the vegetation may become too dense to allow effective access to its prey. Consequently, the management of foraging habitats of *M. myotis* in some regions should involve the use of grazing by domestic ungulates.

The Role of Seasonal Flooding and Water Nutrient Load in the Structuring of Amazonian Bat Communities

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Amazonian forests harbor extremely diverse bat communities, but the environmental factors that structure them are still poorly known. Several studies have focused on the importance of factors associated with anthropogenic disturbance, but natural disturbance regimes, such as seasonal inundation and productivity, have received little attention. The seasonal flooding of Neotropical forests by nutrient-rich or nutrient-poor waters results in large scale ecological heterogeneity, mainly due to differentiated phenological tree responses. We studied the role of flooding and water nutrient load in the structuring of Amazonian bat assemblages. In 2007 we captured bats in forest seasonally flooded by nutrient-rich water, forest flooded by nutrient-poor water, and unflooded forests, at the Amanã Sustainable Development Reserve (Brazil). The species composition of bat communities of the three types of forest was substantially different, and both flooding and nutrient load of water were found to affect the structure of communities. Flooding acted as a constraint to the abundance and diversity of species that depend on understorey plants to feed or roost. This is possibly due to the fact that this stratum is less developed because it is underwater much of the year. As a result, unflooded forests are the most species diverse. Forests flooded by nutrient-rich waters are the least diverse but, as expected, have superior carrying capacity and greater abundances of bats.

Related Greater Horseshoe Bats Associate in the Mid-hibernation Period: Implications for Survival and Matriline Success

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Associations among related bats have been reported at both feeding and maternity sites. However, it is not known whether relatives preferentially share hibernation sites. We traced bats from known matrilines to two main hibernacula in late January. Over an 11-year period 250 captures were made, 60% of which were of females. In 105 cases, bats were found with a close relative (R = 0.125 or above) at the same site on the same date. Most close-relative pairs involved only females (62%); with female and male pairs (32%) next, and few male pairs (6%). The most common single association at hibernacula was aunt-niece (25%) followed by sisters (18.5%), and thirdly, equal numbers of mother-daughter pairs and brother-sister pairs (11%). Female/male pairs were between sister/brother (11%), mother/son (7.4%), cousins (3.7%), uncle/niece (3.7%), and aunt/nephew (2.5%) pairs. Male/male pairs were between uncle/nephew and cousins (both 3.7%). Only three matrilines formed aunt/niece pairs. The trends were dominated by a single female bat and two of her nieces, whose matriline increased in numbers from 12.5% of the breeding females in 1993 to 26% in 2003. The significance of these matrilineal associations at hibernacula will be discussed in relation to survival and long-term matriline success.

Impact of Climate Change on European Bats According to their Biogeographical Patterns

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Recently, as more data on climate change become available, there has been an increase in the number of studies on the impact of climate change on a wide range of taxa. It has been shown that the magnitude of the impact alters according to future socio-economic scenarios, as well as in relation to each species' ecology. Little is known about how bats may respond to these impacts. Our main aim was to study how global warming will affect the distribution of 28 European bat species grouped by their biogeographic patterns as determined by a spatial Principal Component Analysis. Using presence-only modelling techniques and climatic data (minimum temperature, average temperature,

precipitation, humidity, and daily temperature range) for four different global warming scenarios (A1FI, A2, B1, and B2), we present the potential geographic distribution in Europe for those species according to their biogeographic patterns for the years 2020–2030, 2050–2060, and 2090–2100. Our results show that species more associated with colder climates, hence northern latitudes, could be more severely affected than their Mediterranean counter-parts. In the latter case, we may even expect that some species could have their geographical range increased. However, these models only took into account climatic envelopes whereas available habitat will also probably play an important role in delimiting distribution patterns. The models may therefore generate 'best case' predictions about future changes in the distribution of European bats.

Geoffroy's Bat, *Myotis emarginatus,* in the Province Noord-Brabant (The Netherlands)

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Myotis emarginatus is a species that is difficult to detect. In the Netherlands *M. emarginatus* is only known in the southern provinces. In the period 1980–2008 there was only one male found in the attic of a church in the Province Noord-Brabant. Just 3 km from the Netherlands, in Belgium, there is a colony with about 75 individuals. Otherwise, there is only one colony known in the Netherlands, in the Province Limburg, about 50 km away. In the period 1980–2008 the winter population has increased by 1700%. Noticing the growing population in the wintertime and the colony in Belgium near the Netherlands, we suspected that there must be more *M. emarginatus* in Noord-Brabant. Therefore, in the summer of 2008 we carried out a project to know more about *M. emarginatus* in Noord-Brabant. We searched in barns using bat-detectors, looked at attics, caught them with mist nets, and radio-tagged them. The aim of this research was to find new colonies and to find out how *M. emarginatus* uses the landscape.

Bat Casualties on Roads: Is Mortality of Bats Correlated with their Flight Activity?

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The impact of truck transport on bat mortality along the existing road E461, Brno-Vienna, was studied with the goal of predicting this impact after the road has been reconstructed and turned into highway R52. Two model sections of the road, 4.5 km and 3.5 km long, divided into 100 m segments, were selected where 1) bat carcasses were picked up from emergency stopping lanes, and 2) bat activity was recorded by ultrasound detectors along the road and 100 m away on both sides from the central strip. From May to October 2007, 25 checks of bat mortality were performed at weekly intervals. In 19 checks a total of 119 bat carcasses were found representing 11 or 12 species. *Pipistrellus nathusii*, *P. pygmaeus*, and *Myotis daubentonii* were the most frequent traffic casualties. Bat detector surveys yielded 12 bat species and 3 species pairs, mostly the same taxa as found dead on the road. By both carcass collecting and sound detecting, significantly greater bat activity was revealed in the first 4.5 km section where the road was situated between two artificial lakes, as compared to the second 3.5 km section without large water bodies or woods directly adjacent to the road. In the former section, significant correlation between the number of carcasses and the flight activity of bats detected was found. The highest number of bats killed was found from early July to mid-October, with the peak in September. The reasons (fledged young, migrating bats, etc.) are discussed. Some measures to decrease bat mortality are proposed, such as the construction of protecting screens, reaching at least up to the height of trucks, on either or one side of the road in segments where the probability of collision of bats with trucks was high due to the greatest flight activity of bats. [The project was supported by the Long-term Research Project of the Ministry of Education, Youth and Sports of the Czech Republic No. MSM0021622416, the Grant of the Czech Science Foundation No. 206/06/0954, and the Czech Bat Conservation Trust.]

Investigating a Swarming Site in the Southern Alps of Austria

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The Eggerloch is a well-known natural cave near Villach, Carinthia (Austria) and is part of the Natura 2000 site Schütt-Graschelitzen (AT2120000). Swarming behavior of bats was investigated during late summer and autumn 2006 and 2007, as well as at the end of winter 2008. Bats were mist-netted and marked with rings during 30 nights in total. Over the course of the study a total of 267 bats were captured comprising 212 different individuals (55 recaptures). Despite the relatively low capture rate we found 16 of the 26 species presently known to occur in Austria: *Rhinolophus hipposideros*, *Myotis daubentonii*, *M. mystacinus*, *M. emarginatus*, *M. nattereri*, *M. bechsteinii*, *M. myotis*, *Pipistrellus pipistrellus*, *P. pygmaeus*, *P. nathusii*, *Hypsugo savii*, *Eptesicus serotinus*,

Vespertilio murinus, *Barbastella barbastellus*, *Plecotus auritus*, and *Pl. macrobullaris*. The most frequent species were *P. pipistrellus* (37% of captures, 45% of individuals) and *M. myotis* (28% of captures, 19% of individuals). For most species more males than females were observed, and most of the males were sexually active. The Eggerloch was identified as a swarming site for the following species: *R. hipposideros*, *M. daubentonii*, *M. emarginatus*, *M. myotis*, *P. pipistrellus*, *H. savii*, and *B. barbastellus*. We estimate that more than 700 bats visit the cave each year between the end of July and mid-October. This is in strong contrast to the hibernation counts yielding up to only 30 individuals of 2–3 species. During the study we witnessed frequent campfires in the entrance of, as well as vandalism in the cave. For both problems we suggest conservation measures for the protection of the bats.

Migrations of *Miniopterus schreibersii*: When, Where, and Why Do Cave Bats Migrate?

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Regional migrations are important, but poorly understood, elements of the biology of bats. Using a dataset of 8000 recoveries of ringed *Miniopterus schreibersii*, we studied the patterns and drivers of migration of this Mediterranean cave-dwelling bat in Portugal. In average years bats hibernated, and few movements were recorded during winter. Afterwards, females migrated to spring roosts, and just before parturition to maternity roosts. Late arrival at nurseries may avoid a harmful build-up of parasites. After the juveniles were weaned, mothers migrated to roosts where they spent autumn, and sometimes winter. Juveniles remained in the nurseries longer, presumably because high roost temperatures accelerate growth. Males' migration pattern was similar, but they left hibernacula later and remained more mobile during the maternity season. They also arrived at the hibernacula later, possibly because they needed to recover fat stores after the mating season. We tested two potential drivers for migration—temperature in the roosts and at the foraging areas—but our results supported only the first one. Bats migrated to reach the roosts most thermally suited for each phase of their life cycle, which supports the prevailing theory that roost temperature and associated metabolic advantages are key drivers for regional migrations of cave-dwelling bats.

Does Sensory Limitation Promote Sociality in Bats?

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Tree cavities are critical resources for forest-dwelling bats. Bats carefully select the size, thermal quality, and placement of roosts. Bats frequently (every few days) change roost trees. Therefore they have to find many tree cavities. Until now there have been no studies testing how bats locate these cavities and whether it is a difficult task or not. We evaluated the importance of different sensory channels for the detection of tree roosts by three species of bats. Specifically, we tested the role of three nonsocial cues (echo information, visual information, and temperature-related cues) and two social sensory cues (con-specific echolocation calls and the presence of bat olfactory cues). We measured the bats' hole-finding performance based on echolocation cues alone and then presented the bat with one of four additional sensory cues. Our data show that con-specific echolocation calls clearly improved the bats' performance in finding tree holes. The other cues we presented had no, or only weak, effects on performance, implying that detection of new cavities from a distance is difficult if no additional social cues, in particular calls from con-specifics, are present. We conclude that sensory constraints strongly limit the effectiveness in finding new cavities and may in turn promote sociality and acoustic information transfer among bats.

DNA Barcoding of Western Palaearctic Bats

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Bats represent the second most speciose order of mammals, and species are often similar and difficult to discriminate by their morphology. Other independent characters such as DNA nucleotides are valuable to resolve identification problems of cryptic species, but a prerequisite is to rely on a solid reference standard for comparisons, composed of vouchered, well-identified specimens. We present here the first comprehensive survey of mtDNA COI variation of nearly all bat species known to occur in the West Palaearctic region. The geographic coverage also extends, for the first time, through all major areas in this region, i.e., Europe, North Africa, and the Middle East. The final sampling includes 343 sequences of 68 species from 22 countries. This broad molecular survey confirms that

the barcoding approach is highly efficient to identify > 90% of the described species. The only exceptions include hybridizing species and pairs of taxa of uncertain taxonomic rank. The broad geographic coverage of this sampling further indicates that most species are genetically more variable than anticipated, and that the major genetic discontinuities better correspond to major geographic breaks than to classical taxonomic subdivisions (e.g., subspecies). Thus these major genetic lineages, when analyzed in such a broad geographic context, do not necessarily suggest the existence of undescribed biological species, although some of them undeniably warrant species rank.

Diet and Prey Selection in *Rhinolophus mehelyi* in the Southwestern Iberian Peninsula

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We studied diet and prey selection in Mehelyi's horseshoe bats *Rhinolophus mehelyi* in the southwestern Iberian Peninsula, during the breeding season in 2003, 2006, and 2007. Fecal pellets were collected individually and arthropod fragments identified to family level, where possible. Arthropod availability was assessed using Malaise traps. Selection analyses were performed using Compositional Analysis and Chi-square goodness-of-fit test. The bulk of the diet of *R. mehelyi* consisted of Lepidoptera, representing more than 80% of the consumed volume on average, and more than 90% of the average percentage occurrence, and this pattern was consistent at all localities. Neuroptera and Tipulidae were locally abundant. Other important prey categories were Chrysomelidae, Muscidae, and Chironomidae. An ANOVA test showed that there was no significant difference between males and females in consumed prey categories, whereas juveniles consumed significantly less Lepidoptera than adults. Compositional Analysis revealed Lepidoptera as the first prey category in the preference rank, followed by Myrmeleontidae, Chrysopidae, and Tipulidae. Chi-square revealed that these four categories were consumed more than expected by chance. This work showed that Lepidoptera was the most consumed and most preferred prey category, and it was positively selected, suggesting that *R. mehelyi* is a moth specialist.

Red List Status Determined by Area of Distribution: A Case Study on *Pipistrellus pygmaeus*

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Attribution to IUCN Red List categories is based upon quantitative data. For bat species easily countable at roosts, the criteria regarding population size, reduction, or viability can be applied, but for most species such counts are lacking or incomplete. In such situations, evaluation can be assessed indirectly through the geographical distribution of the species, which is measured as the *extent of occurrence* or as the *area of occupancy*. Based on 580 observations, we estimated the geographical distribution of *Pipistrellus pygmaeus* in Switzerland and compared quantitatively the distribution areas obtained with different methods. The simplest methods were to consider Minimum Convex Polygons and the number of occupied grid cells, while more advanced GIS-methods used the Ecological Niche Factor Analysis ENFA. We show that the estimated geographic distribution of *P. pygmaeus* in Switzerland, and hence its assignment to red list categories, critically depends upon the method chosen, e.g., 2439 km^2 obtained with occupied grid cells and 158 km^2 as calculated with the ENFA model restricted to areas with field evidence. Attribution to different red list categories might have strong impact on the resources allocated to conservation actions for the target species. Our results therefore underline the importance of using appropriate methods to infer distribution areas from single observation points.

Excretion of Microcontaminants with Feces in Four Species of Chiroptera Inhabiting Different Habitats of Central and Northern Italy

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The exposure to and the potential effect of heavy metals on wildlife health status have been clearly proved for a long time. Despite the fact that bats—being among the common vertebrates in agricultural and urban areas—can potentially accumulate high amounts of pollutants, little work has been done to assess contaminant burden in these species. The present work reports on the evaluation of heavy metal excretion with feces in four different bat species inhabiting different habitats of central and northern Italy. Fecal samples were collected from *Myotis myotis*, *Miniopterus schreibersii*, *M. emarginatus*, and *Nyctalus noctula* colonies located in four completely different

habitats: *M. myotis* in a small village in Alps area, *Min. schreibersii* and *M. emarginatus* in caves of hills from central Apennines, and *N. noctula* from a highly busy central roadway in a coastal town. Only one fecal sample was available for *M. myotis*, *M. emarginatus*, and *N. noctula* (2006 and 2007, respectively), so only a spot evaluation could be performed for these species. Regarding *M. schreibersii*, a time trend evaluation could be performed, as samples from three different years were available (2003, 2007, and 2008). Habitat, feeding habits, and ecology were taken into consideration for data analysis. Differences between species were observed, while no difference among years for *M. schreibersii* was found.

The Successful Adaptation and Development of Buildings as Maternity Roosts for the Lesser Horseshoe Bat, *Rhinolophus hipposideros*, in the British Isles

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For 18 years the Vincent Wildlife Trust has been acquiring and adapting buildings as nature reserves for the lesser horseshoe bat, *Rhinolophus hipposideros*. The Trust now has 36 bat reserves for this species, ranging from small cottages to disused churches. Significant proportions of the populations of this species in England, Wales, and Ireland are now protected in these reserves. At each site the same general techniques have been employed, applying the knowledge of the animal's roosting ecology to modify or redesign the site and make it into an optimal roost. In this process, extraneous problems such as predators, nesting birds blocking entrances, and human disturbance have been encountered, and a suite of techniques have been developed for dealing with these problems. The success of the design is augmented by improvements to the habitat surrounding the building. The key features in successfully designing roosts for *R. hipposideros* are discussed and examples are presented.

Roads and Bats: Insights from Studies on Low Flying Lesser Horseshoe Bats

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In recent years growing concern arises from conflicts of bats and roads. Besides the problems of habitat deterioration and fragmentation, bats with low wing loading cross open gaps low over the ground and are affected by collisions. Do roads have a significant impact on bat populations? We investigated lesser horseshoe bats, *Rhinolophus hipposideros*, at the new highway A17 in Germany by radio-tracking, acoustical and optical observations and we applied stochastic population and habitat models. Our results indicate that already an additional mortality of 5–7% of the adult population questions the long-term viability of the colony. Possible conflict zones with the planned road were identified by a habitat suitability analysis and subsequently validated by acoustical field data. Underpasses, green bridges, and protection fences were implemented at crossing points to mitigate collision risk. In field experiments we showed that lesser horseshoe bats may be guided by hedgerows to crossing points and protection fences may keep the bats from crossing the highway if alternatives are nearby. We present first results of a multi-stage, long-term monitoring scheme. There is a clear need for evidence-based solutions to mitigate problems for bats caused by newly built roads. Much baseline data are still required and we strongly suggest thorough monitoring of the effectiveness of mitigation measures implemented.

Ecological and Communicative Role of Echolocation in Horseshoe Bats

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Within communities of horseshoe bats, each species tends to use its own, overlap-free frequency channel for echolocation. The evolution of these call frequency bands can in part be explained by scaling of call frequency with body size. Investigation of the echolocation calls of the European horseshoe bat community showed that one of the five species, *Rhinolophus mehelyi*, clearly deviates from this trend. Furthermore, its peak echolocation frequency overlaps with two other sympatric species of horseshoe bats. Thus, scaling alone cannot satisfactorily explain the allocation of horseshoe bat echolocation call frequency. Alternatively, the "ecological adaption hypothesis" aims at explaining the evolution of echolocation call parameters as adaptations to species-specific foraging tasks. Besides echolocation call frequency, call amplitude also importantly contributes to detection distance, but is often an unattended parameter. Therefore, we measured maximum call amplitudes within the European horseshoe bat community. Although we found significantly different call amplitudes among the species, there was no clear relation between body size or call frequency and call amplitude. Thus, the ecological adaption hypothesis as an explanation for the allocation of the horseshoe bat call frequency bands is also not sufficient. The "social communication

hypothesis" predicts that a strong selection pressure for partitioning of frequency bands could exist to assure effective intraspecific communication. In a habituation/dishabituation paradigm, we investigated how the overlap of call frequency bands affects the acoustic species-recognition behavior.

Predator Recognition: Bats and Birds Compared

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The order Chiroptera shows striking diversity in feeding ecologies, food types, and foraging modes. By contrast, bats are astonishingly uniform in their temporal activity patterns: nearly all species are strictly nocturnal. Avian predation has been suggested as a major selection pressure that counteracts the evolution of diurnality in bats. Here, we assessed the sensory and cognitive ability of bats to recognize birds of prey. This is the first study to measure predator recognition in several bat species (*Myotis myotis*, *M. mystacinus*, and *Pipistrellus pipistrellus*), and, for comparison, in a diurnal bird (*Hirundo rustica*). In the flyways of test animals, we presented both a nocturnal (*Tyto alba*) and a diurnal raptor (*Accipiter nisus*), stuffed in inflight posture, as well as a neutral new object (control). Although the birds reacted significantly more to the raptors than to the control object, the bats did not. These results suggest that bats are not able to recognize an avian predator as such by echolocation or vision. Hence, they are not able to take appropriate evasive action. We conclude that sensory limitations in predator recognition might be an important constraint on the evolution of diurnal activity in bats.

Big Ears for Bats: Absolute Size Matters for Foraging Efficiency

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Many bat species that hunt in cluttered environments find their food by listening for prey sounds. Within the largest genus of bats, *Myotis*, this "passive listening" strategy evolved several times convergently. In a comparative study comprising 31 *Myotis* species, we found that the absolute ear size of all six of the included "passive listening" species was quite similar, irrespective of their body size. Thus, smaller "passive listening" species have ears much larger than predicted by the genus regression line for scaling of ear size with body size, whereas larger species do not. This suggests that a certain absolute ear size is required and sufficient for efficient detection and localization of rustling arthropods. To test the influence of ear size on the received sound amplitude, we acoustically measured idealized bat ears below, at, and above the size found in "passive listening" *Myotis* species. Indeed, the typical ear size of "passive listening" species resulted in an increased sensitivity for the sonic frequencies that dominate arthropod rustling sounds. We conclude that absolute ear size matters to pick up and localize these sounds efficiently. Smaller species that specialized in "passive listening" foraging behavior thus had to evolve very large ears relative to their body size.

Fast Hawking by Pond Bats, *Myotis dasycneme*, Hunting on Tympanate Moths Low over Open Water

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Pond bat hunting behavior and insect availability was studied in Flanders (Belgium) using an ultrasound detector, image intensifier, and light trap. In March–April when prey was limited to small midges, only trawling was observed. In May–October when large insects were also present, pond bats also used a fast hawking strategy including rapid linear flight low over the midline of large waterways. Sudden rises and multiple attacks on moths 2–5 m in the air were observed as well as tympanate moth evasive reactions (i.e., power dives). A mixture of short FM and long FM-QCF-FM signals (max 23 ms) was used. Sonar emission was discontinuous as groups of 3–20 pulses were alternated by silences or stealth mode gaps as long as 3500 ms. Moth hunting can be facilitated by the long QCF-signals, the combination of fast flight, and discontinuous emissions (which is likely to eliminate the reactions of moths to distant bats in spite of a peak frequency within the audible range of the moths) and the fact that the reactions of moths to nearby bats are not really efficient over open water due to lack of shelter. At canal and riverbanks in open landscapes moth species were caught that live on nettle, reed, iris, grasses, etc.

Factors Influencing Carcass Removal at Wind Farms, in Mountain Areas of the North-central Region of Portugal

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Bats fatalities are frequently associated with wind farms. Following studies that estimated these fatalities at several wind farms in mountain areas of north-central Portugal, carcass removal trials were conducted in order to estimate the removal rate of bat carcasses and to evaluate the influence of different factors over this rate. During spring, summer, and autumn of 2006 and 2007, 17 trials were made in different areas, using a total of 413 bats, mice (white and medium brown), and parakeet carcasses. No differences were detected in carcass removal regarding the type of carcass used, season of the year, lithology, and visibility of the carcasses. Eighty-six percent of the carcasses were removed and on average, carcasses remained in place for 3.07 ± 0.28 days. The removal rate is higher during the first days, with 20% of the carcasses being removed in the first 24 h of the trial. This rate follows a negative exponential distribution, yet it has been noticed that rain reduces the probability of removal. In this case, the removal rate will follow a linear distribution due to increased removal time. The implications of these results in the methodologies for future studies of bat mortality estimates are discussed.

Phylogenetics and Phylogeographic Patterns in *Myotis daubentonii daubentonii* and *Myotis d. nathalinae* Based in mtDNA and nDNA Data

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Daubenton's bat, *Myotis daubentonii,* is a species in which cryptic diversity is a distinct possibility. One species of the Daubenton's bat complex, *M. petax*, was recently revalidated; however, the current taxonomic status of several subspecies within this group is still unknown. We used cytochrome *b* to infer the phylogenetic relationships between two morphotypes of *M. daubentonii* present in the Iberian Peninsula, *M. d. daubentonii* and *M. d. nathalinae*. Our phylogenetic data show that these two morphotypes correspond to two different mitochondrial lineages. Our results also demonstrate a "refugia within refugia" phylogeographic pattern where *M. d. daubentonii* spread north and *M. d. nathalinae* became an Iberian endemic. Current and historical gene flow between several European populations of *M. d. daubentonii* was detected and phylogeographic substructure was found in *M. d. nathalinae.* A mixed roost of the two lineages was detected. This phylogeographic pattern was further examined by amplifying and sequencing a fragment of a biparentally inherited nuclear gene in these bats.

Bats of the Bryansk Region (European Part of Russia): Results of the Faunal Survey

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The Bryansk region is situated in the central part of the East-European plain (51º40′–54º05′N and 31º10′–35º20′E) on the border of the Central-Russian heights and Poles'ye plain; its main part belongs to the sub-zone of mixed coniferous/broad-leaf forests. Its known bat fauna now comprises 14 species. Direct research on the bats of this area was started in summer 2003. Since that time field investigations were carried out at 34 sites in 17 districts, and 259 individual bats were captured. The presence of eight previously recorded species, namely *Myotis brandtii, M. daubentonii, Plecotus auritus, Pipistrellus nathusii, P. pygmaeus, Nyctalus noctula, N. leisleri*, and *Vespertilio murinus,* was confirmed. Three species, *Eptesicus serotinus, E. nilssoni*, and *P. kuhlii,* were reported in the region for the first time (in 2003, 2006, and 2007, respectively). Three more species, *Nyctalus lasiopterus, M. nattereri*, and *M. dasycneme*, are known from published data; records of the latter two were made about a century ago. The occurrence of *P. pipistrellus* is supposed but not yet confirmed. Six species are included in the Regional Red Data Book.

Virological and Histopathological Investigations in Native Bat Species from Germany

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Despite many worldwide efforts to identify infectious agents within bat species, investigations concerning the possible direct impact of these agents on the individual bat are rather sparse to nonexistent. The same is true for Europe, where most of such research projects concentrate on zoonotic diseases like rabies viruses. A broad study

regarding the occurrence of bacterial and viral infectious agents and their impact on bats from Germany is currently performed by the Leibniz Institute of Zoo and Wildlife Research, Berlin, in cooperation with the Federal Robert Koch Institute. Carcasses of bats, which were found dead by bat researchers or protectionists, are necropsied and examined histopathologically while remaining organ tissues are investigated bacteriologically and virologically. For virology, tissue homogenates are inoculated onto cell culture to isolate potential viral agents. Additionally, various nucleic acid amplification and sequencing techniques are performed to identify further viral infections, i.e., adeno-, corona-, flavi-, hanta-, herpes-, influenza-, parainfluenza-, paramyxoviruses. Furthermore, virology results are compared with histopathological findings to verify whether a detected virus causes pathological changes in the bat or whether the virus is carried by the animal without harming it. The first results of virus isolates from German bats will be presented.

Pasteurella Infection in Native Bats from Germany

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Pasteurellosis refers to a variety of infections caused by bacteria of the genus *Mannheimia* and *Pasteurella*. Widely distributed among mammals, these opportunistic bacteria may also serve as primary pathogens. Occasionally they account for peracute death due to their potent endotoxins. In a study on diseases and causes of death in German bats, culture of lung, liver, spleen, heart, and kidney from eight pipistrelle bats (*Pipistrellus* spp.), one brown long-eared bat (*Plecotus auritus*), and one parti-colored bat (*Vespertilio murinus*) revealed moderate to heavy growth of *Pasteurella multocida* subsp. *multocida* or subsp. *septica* and *Mannheimia haemolytica*. Most of these bats suffered traumatic injuries. Small lacerations within the wing membranes were visible in three animals. Histopathological findings were interstitial pneumonia (n = 6), hyperplasia of the spleen (n = 5), purulent-necrotizing myocarditis (n = 1), and an intrathoracical abscess. In four bats *Pasteurella* and *Mannheimia* were grown in pure cultures from all organs. The remaining bats revealed pure cultures only in some organs. As there is a high incidence of pathogenic *Pasteurella* in gingival scrapings of cats, it seems likely that most of the bats in our study were attacked by cats (particularly as many of the carcasses had evidence of traumatic injury), and subsequently the bats died from septicemia caused by *Pasteurella* and *Mannheimia*. To our knowledge, this is the first report of systemic Pasteurellosis in free-ranging bats from Germany.

Mapping of Bats in Central Norway 1995–2007

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Mapping of the bat fauna in central Norway (62˚ - 65˚ N) started in 1995. Seven species have been found since then. *Eptesicus nilssonii, Plecotus auritus, Myotis mystacinus, M. brandtii*, and *M. daubentonii* are species reproducing in the area. *Vespertilio murinus* and *Pipistrellus pygmaeus* are probably just visitors. Searching houses seems to be the best method for finding *P. auritus* and for assessing how common the three *Myotis* species are.

Species Composition and Activity of Bats Over Open Water

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Species composition and activity of bats flying over open water of a large lake (distances to the shore: 300 m and 1 km) and at different riparian vegetation types (wood and reed) was studied from June to September 2007 at lake Chiemsee (Bavaria, Germany). Bats were observed by using an ultrasound detector. Dominant species were *Pipistrellus nathusii* (42.8% of all recordings), *Pipistrellus pipistrellus* (15.8%), and *Myotis daubentonii* (12.8%). The other records included the species *Eptesicus nilssonii, Nyctalus noctula, P. pygmaeus, Hypsugo savii*, the species groups *N. leisleri/Vespertilio murinus, M. brandtii/mystacinus*, and also minimal cases of *Barbastella barbastellus* and *M. myotis.* All bat species foraged not only at the shore but also over open water. The open water with a distance of 1 km to the shore was especially attractive for *N. noctula*, *E. nilssonii*, and the species group *V. murinus/N. leisleri*, which foraged here more often than over the open water close (300 m) to the shoreline. The species group *M. brandtii/mystacinus* used the open water at 300 m from shore more than other species, whereas *M. daubentonii* and all three *Pipistrelle* spp. preferred the shore as foraging habitat (predominantly riparian woodland). Except for *H. savii* (riparian woodland) and *E. nilssonii* (riparian woodland) no habitat preferences could be proven. Overall, the bat activity was most intense close to the riparian woodland and lowest over the open water, where minimal variation occurred between the 300 m and 1 km from shore. When bat activity occurred, the number of terminal buzzes was highest over open water. This indicates an intense hunting activity in a relatively short time,

whereas the riparian vegetation was obviously also used for orientation. The species composition and the level of activity were the highest at nutrient-rich coves and lowest at nutrient-poor coves.

Swarming of Northern Bats, *Eptesicus nilssonii*, at Underground Hibernacula in Latvia

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The northern bat is one of the most common bat species in Latvia, and hibernates in various underground sites. At the end of summer and in autumn underground hibernacula are also used by many bat species for a social flying behavior termed 'swarming.' The aim of this study was to describe general peculiarities of this behavior for northern bats in Latvia. Three hibernacula where chosen for this study where mist netting was conducted once per fortnight from the end of June until the beginning of November in 2005–2007. Northern bats visited the study sites from the beginning of July until the end of August. In the beginning adult males predominated, the proportion of adult females and subadult individuals increased as the season progressed and at the end subadult individuals of both sexes prevailed. The greatest swarming activity was observed in August. Most visitations occurred between 2400 and 0200 h. Some individuals were caught in October and November, when study sites were used as day roosts or hibernacula. The results of this study support the hypothesis that swarming behavior for northern bats is related to hibernacula assessment or information transfer by means of showing the location of hibernacula to other individuals.

How Can a Proper Natura 2000 Site Designation Contribute to the Conservation of Bats?

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The Habitat Directive of the EU gives new opportunities for the protection of bats in Romania. Natura 2000 sites designated in a proper way could assure the protection of feeding areas and roosting places of bat species. The site proposals made by the Romanian Government, the results of research done by the Romanian Bat Protection Association, and the published distribution data were compared and a national population estimate of the 13 Annex II species has been prepared in the present work. As a result of comparing the data provided by the Romanian Ministry of Environment and Sustainable Development with the data of the Romanian Bat Protection Association, we consider that it would be very important to designate more sites for conservation in order to assure the better protection of the feeding and roosting areas of bats and to assure the coherence of the Natura 2000 network. In our proposal we suggest designation of more areas, the modification of the border of five currently proposed territories, the fusion of the border of some sites, and inclusion of bats as reference species in those proposed SCIs where data on bats are missing or deficient.

Indicator Bats: Establishing the First National Monitoring Program for Romania's Bats

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Bats show the potential to be useful biodiversity monitoring indicator species as they are distributed widely, use a wide range of landscapes and play an important role in ecosystem functioning (controlling insect populations, pollination, and dispersing seeds) and their population declines reflect changes in climate, water quality, and agricultural practices. However, attempts to establish bats as indicator species are hampered by the lack of basic information on how species abundances and distributions change in response to global change. Here we present the progress in establishing the first national bat monitoring program in Romania using a network of 77 volunteers to generate distributions and abundances of 14 species from over 1600 acoustic records collected along road transects from 2006–2008. We discuss the results to date, compare relative species abundance rates with the United Kingdom and other neighboring countries, and the potential of the project to provide national biodiversity monitoring statistics to meet Romania's obligations to the Convention on Biological Diversity.

Parasitic Mites (Acari) of Bats (Chiroptera): A Review of Trophical and Topical Relations to the Host

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There are as many as 21 families of mites that parasitize bats. These mites show plenty of adaptations, living on the external surfaces of the host body, in the respiratory tracts, or in the digestive system as well. Of the order

Mesostigmata bat parasitizing species are known from families such as: Spinturnicidae, Macronyssidae, Spelaeorhynchidae, and Laelapidae; from the order Ixodida—families Ixodidae and Argasidae; from the order Prostigmata—families Cheyletidae, Demodecidae, Myobiidae, Ereynetidae, Trombiculidae, Leeuwenhoekiidae, and Psorergatidae; from the order Astigmata—families Listrophoridae, Chirodiscidae, Labidocarpidae, Sarcoptidae, Teinocoptidae, Bakerocoptidae, Chirorhynchobiidae, and Gastronyssidae. These parasites show distinct preferences to different parts of the host body and respective topical and trophical relations to the host. They can be classified as ectoparasites (e.g., Spinturnicidae, Myobidae, Chirodiscidae) and endoparasites (e.g., Gastronyssidae, Ereynetidae) as well. Furthermore, bat parasites are also diverse in terms of trophical character. They can feed on keratin and mucus (e. g., Psorergatidae, Sarcoptidae, Demodecidae), keratin and collagen (Labidocarpidae), blood and mucus (Gastronyssidae, Ereynetidae), blood (Trombiculidae, Macronyssidae, Ixodidae, Argasidae), or blood and lymph (Myobiidae, Spinturnicidae). In addition, the recorded mites are known for their ability to evolve different reproductive strategies: from permanent parasitism (e.g., Gastronyssidae, Spinturnicidae) to temporary parasitism (e.g., Ixodidae, Trombiculidae).

Center for Irish Bat Research

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The Center for Irish Bat Research in Ireland was newly established in May 2008. This is a cross-border initiative based at both University College Dublin in the Republic of Ireland and Queen's University Belfast, Northern Ireland, and funded by the National Parks and Wildlife Service. Compared to continental Europe and Britain, Ireland has a relatively impoverished fauna, most likely resulting from its recent glacial history, small land area, island status, and position at the northwestern edge of the European land mass. Currently, there are approximately 35 terrestrial species of mammals in Ireland, of which 10 are bats. All Irish bat species are protected under Irish Wildlife Acts [1976 and 2000] and are listed in Annex IV of the E.U. Habitats Directive [92/43/EEC]. Ireland is also a signatory of the European Bat Agreement (EUROBATS), which promotes research into the conservation and management of European bat populations. This center aims at providing relevant biological, ecological, and genetic information on Irish bat fauna for policy makers and conservation managers to meet the legal obligations under European directives and other international agreements for Ireland as a whole. Here we introduce our vision for this new Center for Irish Bat Research and outline the current research being undertaken.

The Tallinn Mammal Project: Bats

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Tallinn (area 159.2 km^2, population 402,586), the capital of Estonia, is located in northern Europe in the northeastern part of the Baltic Sea region. In order to provide information on the city's fauna (species composition, abundance, fauna connection to surrounding areas) and to increase awareness, the Tallinn Mammal Project was initiated in 2008, a 3-year project by Tallinn University in cooperation with Tallinn City Departments. The territory of Tallinn was divided into 1 km^2 UTM grid, and habitat and land use maps were established dividing the city-area into different types of areas, such as inhabited, parks, wild areas, industrial areas. To establish the species composition and range of bats in Tallinn the following methods were used: bat detectors along transects in different habitats, collecting information from the public, and exploring potential roost sites (e.g., churches, wooden houses, old parks). A telephone number and Internet site will be publicized for the public to contact the team. Also bat-nights will be organized by volunteers and students to make contact with people and to raise awareness about bats. Compiled maps, website draft, information sheet drafts, and the first results in terms of bat species composition and distribution will be presented.

Movement in Frosted Dark: Bats in Laagri Hibernaculum, Estonia

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The study focuses on Laagri hibernaculum at the border of Tallinn, Estonia. The aim of the study was to investigate the changes in species abundance and movement of bats during hibernation. Surveys were carried out monthly in the winter 2007/2008 recording abundance of bats by species and by the roost typology in 20-m long

sectors. In Laagri tunnels there were five species present, listed according to dominance: *Myotis daubentonii* (82%), *Plecotus auritus* (8%), *M. brandtii/mystacinus* (6%), *M. dasycneme* (3%), and *Eptesicus nilssonii* (1%). The abundance increased until February (November 169, December 258, January 291, February 299), then started to decrease (March 265, April 100). The mean temperature outside was below 3° C from November to March. Interspecies differences appeared in increment. Different trends were established in the movement of bats by species during winter. The study focused on changes of numbers of *M. daubentonii*, as the dominant species, in sectors to illustrate the movement of bats during hibernation. All trends can be related to differences in microclimate and tunnel typology. Correlating trends of bat movements and abundance changes with climate conditions can provide interesting models for future studies trying to understand the possible influence of global warming on bat ecology.

Are There Population Adaptations for Breeding in Different Habitats? A Case Study of *Myotis myotis*

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The population characteristics of two *Myotis myotis* maternity colonies in habitats with extremely different microclimates were compared. Data collection was carried out in Drienovská jaskyňa Cave (DJ) and a church attic in Rochovce village (RO) in the 2006–2008 summer periods. The distance between these shelters was only 47 km (southern Slovakia), which allows potential contacts between the colonies. The cave provided a stable microclimate in contrast to the church—mean temperature was 12.0° C (min.–max. 10.7–12.8° C) at DJ, vs. 20.8° C (10.0–30.8° C) at RO; humidity was constantly 100% at DJ, but was 83, 54, and 100% at RO. Regular 2-week sampling intervals provided data about bat phenology. Body Condition Index (BCI), parasite load, and parasite species composition were registered in three categories of bats (n = 263 in DJ; n = 231 in RO): adult females before parturition (F_{pre}), after parturition (F_{post}), and juveniles (J). Four ectoparasite species were found: *Nycteribia latreillii* (exclusively on bats at DJ), *Ichoronyssus scutatus*, *Penicillidia dufourii*, and *Spinturnix myoti*. Significant differences in BCI and parasite load in F_{post} and J categories ($P < 0.001$) were detected. The general pattern follows better fitness in cave-dwelling bats despite higher parasite load there. Population genetics as well as measurement of immune-competence are going to be future steps of the study.

Mitochondrial Phylogeny of *Hipposideros caffer* Complex and Implications for Taxonomy of Its Cryptic Forms

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The Afrotropical roundleaf (or leaf-nosed) bat *Hipposideros caffer* has been traditionally regarded as a complex of populations, currently pertaining to two recognized cryptic species, *H. caffer* and *H. ruber*. Concerns have recently arisen that perception of the complex based on morphology might not reflect the true phylogenetic relationships. This suspicion was confirmed for the first time by our molecular phylogenetic analysis based on sequences of the mitochondrial cytochrome *b* gene. Genetic structure revealed within the *H. caffer* complex challenged the hypothesis of two cryptic species. Instead of two monophyletic lineages, we identified six distinct lineages of potentially specific status. Two current subspecies of *H. caffer* can be considered two distinct species, the nominotypical *H. caffer* restricted to South Africa and *H. tephrus* inhabiting the northern extreme limits of distribution. Two Central African forms sympatric in the coast of the Gulf of Guinea and a third form from West Africa presumably belonging to *H. ruber* may represent three distinct species. Although they may correspond to known taxa, their proper taxonomic assignation has yet to be carefully checked. Least understood remains a lineage originally defined as *H. caffer* from West and East Africa, showing paraphyletic relationship to both *H. caffer* and *H. ruber*. [This study was supported by grants of the GAASCR (IAA6093404), GACR (206/05/2334), and CONACYT (39709).]

Ecology of a Summer Colony of Daubenton's Bat, *Myotis daubentonii* (Kuhl, 1817) (Chiroptera: Vespertilionidae) in the Icehouse of an Historic Park in the Municipality of Dolo-Venezia (N.E. Italy)

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In recent years Daubenton's bat, *Myotis daubentonii*, was found in many places in the Veneto region, but the number of known colonies remains low. In the province of Venezia, this bat was found in several historical parks, connected to romantic parks of Venetian villas. Roosts were found in artificial underground tunnels or icehouses, constructed in artificial hills, built in a flat habitat. This work presents the results of a three-year study (2004–2006) on the ecology of a summer colony of *M. daubentonii*, located in an icehouse of the romantic park of Villa Brusoni-Scalella in Dolo (Venezia), in an area (Riviera del Brenta) with typical hunting habitats and artificial underground sites suitable as roosts for these bats. This research has given new information on the dynamics of summer colonies of this bat species in Italy. The colony under study, composed only of males, but with a limited number of females in the year 2005, occupies the roost from March to October. The structure of the colony seems to be characterized by high mobility of individuals; in one season a small group of pregnant females, which joined the main group for only four weeks, was observed. Data from fecal pellet analyses are presented here and demonstrate that this bat is specialized on predation of Diptera and Lepidoptera, with several minor groups represented (Dermaptera, Hemiptera, Trichoptera, Neuroptera). This research also demonstrates the importance of icehouses of Venetian villas as typical roosts for bats in a totally flat habitat.

Distribution and Population Estimate of the Pond Bat, *Myotis dasycneme*, in Latvia

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Several research and conservation projects on the pond bat, *Myotis dasycneme*, have been carried out in Latvia since 2002. In 2007 an inventory of all known summer and winter roosts of the species was compiled. We used counts in winter roosts once per winter and counts of emerging adult females at breeding colonies in summer to estimate the population size in Latvia. The pond bat is distributed throughout the whole territory of Latvia; however, most of the known breeding colonies are located in churches in the eastern part of the country. A total of 1113 adult females were counted in 21 inhabited breeding colonies. Colony size varied from 2–238 adult females. In winter 2007/2008 we found 84 pond bats in 10 of the known 27 hibernation sites. Wintering sites for most of the Latvian pond bat population remain unknown. The population estimate for the whole Latvian population of the pond bat is therefore based purely on the summer population. The calculated population size is roughly 3800–7700 adult females or 7600–15,400 individuals, assuming that the numbers of males and females in the population are approximately equal.

The Mystery of the Lesser Horseshoe Bat

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The lesser horseshoe bat presents some puzzling facts concerning its genetic data and systematic status. For karyological reasons it is very likely that *Rhinolophus hipposideros* (RHI) comprises more than one species. Up to now, not less than five different karyotypes have been described for specimens assigned to RHI. Most frequently, a karyotype with a diploid chromosome number of 2n = 56 has been reported. These specimens originated from Italy, the Czech Republic, and Greece. Diploid numbers of 2n = 58 and 2n = 54 were described for specimens from Jordan and Turkey, respectively. Recently, a different 2n = 54 karyotype was reported for Spanish specimens. The highest number, 2n = 62 was found for RHI-like specimens from Kyrgystan. In contrast to karyology, a recent molecular genetic survey for cryptic species in Europe, examining five RHI specimens from Spain (four) and Greece (one), gave no indication for sibling species. One possible explanation for the discrepancy between both data sets is the assumption of a sympatric occurrence of at least two sibling species in Europe. A phylogeny of the genus *Rhinolophus* based on molecular data placed all three studied populations of RHI in a basal position. Our own cytogenetic results confirm this view as the RHI specimen from Greece (2n = 56) has one ancestral chromosome in common with *R. pearsoni* and the genus *Hipposideros*. However, karyology proposes a closer relationship of the 2n = 56 RHI and the remaining European *Rhinolophus* species as suggested by the DNA data of the studied three *R. hipposideros* populations.

Translocation as a Conservation Tool to Supplement Relict Bat Colonies: A Pilot Study with Endangered Horseshoe Bats

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Translocation has become an important tool in conservation biology in recent years. Yet, there is only little information about the possibility and success of translocations in highly mobile mammals like bats. In this study, we tried to assess the parameters for successful translocations of two highly endangered bat species in Switzerland: the greater horseshoe bat (*Rhinolophus ferrumequinum*) and the lesser horseshoe bat (*R. hipposideros*). In 2006, we conducted translocation experiments with greater horseshoe bats (n = 12) and lesser horseshoe bats (n = 7) within Switzerland in order to augment relict colonies. Bats were captured from large colonies and released individually into nursery roosts of small colonies of the same species at distances of < 20 km and > 40 km from their native roost. Subsequently animals were radio-tracked for up to ten days. Of the 14 animals released at distances < 20 km, 11 animals demonstrated travel movements directed towards their native home range, though only 10 homed successfully. Of the five animals released at distances > 40 km, none demonstrated homing tendencies. Within the first three days, one greater and one lesser horseshoe bat were found to be predated, and two lesser horseshoe bats died due to shock. Although sample size in lesser horseshoe bats is too small to draw final conclusions, this species seems very susceptible to stress. For greater horseshoe bats, the short-term monitoring revealed that translocation might be a promising conservation tool but survival of the release generation has to be confirmed by long-term monitoring.

Biogeographic Origins of *Miniopterus* Bats from the Comoro Archipelago Inferred from mtDNA

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The endemic fauna of the Comoro Archipelago is a complex mixture of taxa originating from mainland Africa and Madagascar. Bats are the only native mammals from this archipelago, but their biogeographic origins are unknown. We report here genetic analyses based on two mitochondrial DNA markers to infer the origin of a species complex of small *Miniopterus* bats that is distributed across Africa, the Comoros, and Madagascar. Phylogenetic reconstructions show that mainland *M. minor* are not closely related to the small insular *Miniopterus*. The latter cluster into two distinct, monophyletic clades. As they occur sympatrically both on the Comoros and on Madagascar, and are distinguished by a large genetic distance (mean K2P distance 9.9% for cytochrome *b*), these clades certainly represent two cryptic species. The common Clade 1 is widespread on the Comoros and Madagascar, while the rare Clade 2 is confined to Anjouan Island and northern Madagascar. No haplotypes are shared between any islands, suggesting the absence of contemporary geneflow. Demographic analyses of populations of the common Clade 1 show therefore a significant inter-island structure (Φ_{CT} = 0.237). These results and the current distribution of related lineages indicate a Malagasy origin for the two clades. Using a parsimony criterion we suggest that the Comoro Archipelago was colonized at least three times by independent Malagasy ancestors.

Detection of *Anenterotrema auritum* Stunkard, 1938 in a *Glossophaga commissarisi* from Costa Rica

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During a study on the feeding behavior of the nectar-feeding bat *Glossphaga commissarisi* in an Atlantic lowland rainforest of Costa Rica about 30 individuals of this species were caught and kept under experimental conditions for up to four weeks in a local research station. At the end of the experimental time period 22 animals were necropsied and examined microscopically for alterations in their intestinal morphology. Macroscopically, four individuals had multiple subserosal pinpoint-sized black spots in a linear pattern along the longitudinal axis outside of the small or large intestine. After isolation of these structures from one male bat they were examined by scanning electron microscopy and identified as small, flask-shaped trematodes. Further investigations by light microscopy revealed that the parasites belong to the genus *Anenterotrema*, species *Anenterotrema auritum* Stunkard, 1938. Other bat species reported to harbor this trematode are *Micronycteris megalotis mexicana* from Mexico, *Mormoops blainvillei* and *Eptesicus fuscus* from Cuba as well as *Glossophaga soricina* from Belize. This is the first report of *A. auritum* in a Commissaris's long-tongued bat. Interestingly, and in contrast to the previous publications where the parasite was intraluminal within the intestine, here these ovigerous specimens of *A. auritum* resided in the external

aspect of the gut. Whether this identifies *G. commissarisi* as a dead end host remains unclear until further individuals of this bat species carrying *A. auritum* are studied.

Bats and Natura 2000 in Brussels

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Despite its limited surface, high urbanization level, and population density, the Brussels Capital Region hosts a wide ecosystem and species diversity. To protect this diversity, Brussels designated 14% of its surface as Natura 2000 sites. "Fil rouge" in this designation has high bat diversity and the presence of relatively undisturbed forested habitats in periurban green spaces. In 2005–2008, the conservation status of all Natura 2000 sites was reassessed. A landscape scale approach based on bats was used to refine the conservation objectives for habitats. These objectives will form the core of the designation decrees. While most sites are well protected, edge habitats continue to experience huge urbanization pressure. The appropriate evaluation of plans and projects with potential impact is therefore crucial to prevent quality loss of edge habitats crucial to bats. A practical manual fixing evaluation quality standards, including bat survey guidelines, is in preparation. Finally, monitoring of Annex II and IV species is mandatory. A point-transect monitoring strategy covering Natura 2000 was put into place with the local bat groups in 2006. In 2008, a vehicle-based monitoring strategy was also started to monitor the whole of the region. The project involves the comparison between car- and bike-based transects.

Long-term Good Management Practices of Bat Hibernation Sites in Flanders, Belgium and Translation into Policy Measures: LIFE + Bat Action Project

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Long-term standardized hibernation counts in Flanders, Belgium, indicate that, as a result of good management practices of bat hibernation structures, overall numbers of hibernating bats almost tripled during the last two decades. Hibernating bats are found in 19th and early 20th century brick stone defensive strongholds, man-made caves as well as in smaller structures such as ice-cellars and bunkers. In a selection of six of the major defensive strongholds (Kessel, Borsbeek, Lier, Liezele, Oelegem, and Steendorp), overall hibernating numbers rose from 1000 to over 3000 between 1990–1991 and 2007–2008, with clear differences between structures that are subject to a management scheme (rise over 300%) and structures that still need a management plan for bats (almost status quo). All hibernating sites are part of the Habitat Directive Area "Historic belt of fortresses around the city of Antwerp" especially designated for bats. The major part of hibernating bats is obviously *Myotis mystacinus/brandtii* and *M. daubentonii*. In special cases, e.g., in the stronghold of Borsbeek, alongside an increase of all hibernating bat species, as a result of some straight-forward and cost-effective measures, hibernating numbers of *M. nattereri* rose from 10 to over 100 individuals since 1990–1991. The LIFE-project Bat Action, co-funded by EU DG Environment, combines the efforts of the Flemish Agency for Nature and Forest and the largest Flemish NGO for nature protection "Natuurpunt," and targets its activities on three of the less abundant and EU Habitat Directive Annex II species: *M. dasycneme*, *M. emarginatus*, and *M. bechsteinii*. All three species, at least in northwest Europe are dependant of man-made hibernation sites. Along with campaigns to raise public awareness of bats and involving stake-holders of all kinds in bat protection schemes, specific measures are taken in lime caves, fortifications, and smaller hibernation structures to guarantee non-disturbance during hibernation as well as to maintain favorable climatic conditions. The 2006–2010 LIFE-project includes monitoring of the effectiveness of the measures, during and after the end of the program. During the second half of the project, measures will be redirected towards improving summer colony conditions for bats in general, and the three target species in particular.

The ABC Project (Atlas of Bats of the Carpathians): New View

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The ABC project started 12 years ago. Its main goal was to gather all the available information about bats from the Carpathian parts in Poland, Czech Republic, Slovakia, Hungary, Ukraine, and Romania. The very first observations were about the lack of data for distribution of many bat species. Some species (e.g., *Miniopterus schreibersii, Eptesicus serotinus, Nyctalus lasiopterus*) decreased drastically in the number of individuals of their populations or even disappeared from their known shelters. Other bat species (e.g., *Rhinolophus hipposideros*) changed their range, being reported in higher altitudes, but also in latitude and longitude. In addition the methodology of work was improved, adopting GPS systems with precise geographic coordinates instead of UTM maps. Of the 45 European bat species, 32 are reported from the Carpathian Mountains. This means about 70% of all European bats are in the Carpathians. Considering only bats species, this area is an important eco-region, with shelters offering optimum conditions for hibernating, nursery colonies, and close by foraging habitats. These conditions give to the Carpathians a particular significance especially in the occurrence and range of bats species. However, the distribution of bats in the Carpathians differs from species to species. Some of them (e.g., *R. hipposideros, Myotis myotis, Pipistrellus pipistrellus)* have a large distribution all over the Carpathians, while others (e.g., *Barbastella barbastellus, E. nilssonii, N. leisleri*) were reported from few localities and several are present only accidentally—*Hypsugo savii*, recently reported but previously only known from the southeast part of Romania; *M. alcathoe*, in Hungary and the southern part of Poland; and *P. kuhlii*, identified since 2000, only at low altitudes (Cefa – Oradea and Iassy – Moldavia) as well as in Poland. Today, thanks to the co-operation of chiropterologists from all of the Carpathian countries it is possible to present the most accurate knowledge about the systematic, biology, ecology, and distribution of bat species all over the Carpathians. Reporting important changes in some bat distribution is also possible to understand the trends of evolution of their populations and to consider them as important bioindicators of environmental changes. Destruction of habitats (shelters for hibernating and nursery colonies as well as foraging habitats), increasing degree of pollution and use of pesticides and, not least, climate changes are reflected in the bat biology, their ecology, behavior, migration, and distribution. We consider the ABC as an important tool to update the information about bats and an important practical tool for bat protection measures in the Carpathian Mountains.

Hibernation and Swarming Activity in Front of Cave Entrances in Strandja Nature Park, Bulgaria

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During an ongoing monitoring project we started to investigate the populations of hibernating bats in caves of Strandja Nature Park. We focused our work on cave systems where information about hibernating bats was missing until now. In front of the most important hibernation sites identified during the winter of 2007/2008, we investigated the species composition during the swarming period of males at the end of April 2008 by mist netting. We caught 195 individuals of 10 species in 4 nights at 4 catching sites: *Rhinolophus euryale* (M: 109; F: 14), *R. blasii* (M: 25; F: 3), *R. ferrumequinum* (M: 17; F: 4), *R. hipposideros* (M: 7; F: 0), *R. mehelyi* (M: 6; F: 0), *Myotis bechsteinii* (M: 4; F: 0), *M. alcathoe* (M: 1; F: 1), *M. nattereri* (M: 1; F: 0), *M. daubentonii* (M: 2; F: 0), and *M. capaccinii* (M: 1, F: 0). The species composition shows that the Strandja Nature Park with its primary forest habitats and its caves is an important habitat for all five European rhinolophid bat species.

Winter Foraging Activity of Central European Bats

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The winter activity of bats was studied in Bavaria, southern Germany. We investigated the activity of bats in their foraging areas (in the surroundings of water bodies) and around their roosts between October 2007 and April 2008. Bats were observed in all months except January. While *Myotis* species were not present between mid-November and mid-April, *Barbastella barbastellus*, *Nyctalus noctula*, *Pipistrellus pipistrellus*, *P. nathusii*, and *Vespertilio murinus* displayed flight activity at the studied foraging sites. Terminal buzzes indicated attempts to

catch prey even in December and February, which supports the idea that the bats' intention was not only drinking. However, in warm periods during late December and the middle of February, bat activity was recorded only around roosts but not in the studied foraging sites, in spite of the fact that insects were present. Obviously, bouts of warm weather do not trigger the foraging activity of bats during midwinter.

Structure and Reproductive Behavior in a *Pipistrellus nathusii* Model Population

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A population of *Pipistrellus nathusii* was investigated in the Protected Landscape Area Trebonsko (South Bohemia). The object of the analysis was a group of 304 individuals, including 45 resident males, 98 adult females, and 161 juveniles, captured in 3 summer colonies during 2 consecutive seasons. Four microsatellite markers with a high level of alelic polymorphism were chosen for identification of individuals and family relationships. The paternity analyses revealed the multiple reproductive success of certain males and the increased proportion in reproduction of males from roosts in proximity to maternity colonies. Obvious differences in the detection of maternity and paternity genealogies, as well as differences in inter-seasonal recapture efficiency of females and males indicate dramatic inter-sexual differences in the level of roost fidelity. Moreover, inter-seasonal samples from particular colonies show different genetic profiles. In conclusion, colonies of *Pipistrellus nathusii* (at least in the surveyed model area lying on the boundary of the species' reproduction area) are very probably constructed each year de novo (it seems to be in reaction to the success of mating with local resident males), and their individual composition is restricted to that particular season. In this respect, the character of the formation of maternity colonies in this migrant species could be different from relationships in other species of European bats that have been studied until now, in which maternity colonies represent long-term, stable social units.

Population Status and Distribution of the Egyptian Fruit Bat (*Rousettus aegyptiacus*) in Iran

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This study was carried out on Egyptian fruit bats in Iran from 2004–2007. Site selection was based on old reports, climate (Ethiopian), cave (roosting area), and some plants such as *Phoenix dactylifora* and *Ziziphus spina-christi*. Twenty-one specimens were captured from three sites. The taxon was determined to be *Rousettus aegyptiacus*; none of the specimens from different localities belonged to *R. leschenaulti*. Statistical analysis using Principal Component Analysis (PCA) and Discriminate Component Analysis (DFA) showed that the population from Qeshm is more distant than the two populations from Jahrom and Baloochestan. Comparison of skull and external measurements of specimens in this study differed from those in several other studies as follows: head and body length and condylobasal length (Iran); weight, hind foot, and forearm length (Syria); weight, hind foot, and condylobasal length and zygomatic width (Turkey); forearm length, hind foot, condylobasal length, and brain case width (Israel and Lebanon); and ear length and C-M3 (Yemen and Oman). Seven to twelve fruit trees are available to Egyptian fruit bats throughout the year to provide the fruit bats with food supply. No signs of any insect parts were found in the fruit bat droppings. The findings showed that the distribution of fruit bats in Iran is mainly confined to the Saharo-sindian area. Indications of reproductive activities were noted by increase in male testis size, enlargement of female breast and teats, and the presence of newborn animals.

First Record of the Endangered Carriker's Round-eared Bat (*Lophostoma carrikeri*) in the Savannas of Central Brazil

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Carriker's round-eared bat, *Lophostoma carrikeri*, is an endemic species of South America that belongs to the diverse Neotropical family Phyllostomidae. Its known distribution was confined do the Amazon Basin of Colombia, Venezuela, Peru, Brazil, Bolivia, and Guianas. However, on 15 June 2007, during a bat survey an adult male was caught with mist nets near a riparian forest of Cerrado, in Central Brazil (municipality of São Domingo, State of Goiás—13º25'11.6"S 46º23'13.8"W, elevation 725 m). The Cerrado Domain is the second largest Brazilian phytogeographic province, occupying originally ca. 24% of the land area of Brazil. The typical vegetation of the Cerrado Biome consists of savannas of very variable structure, including open grasslands, scrublands, mesophytic

forests, and well-drained interfluves with gallery forests or other moist vegetation along the watercourses. The external and cranial measurements of our specimen agree with those described for the species. The specimen has an all-white belly, but lacks the white margin that is usually conspicuous in this species. Consequently, this characteristic should not be used as an identification character. Twenty-two other bat species were collected in the same area. Previous records of this species were in forested areas (semideciduous, lowland primary forest, logged forest, flooded forest) and also in mountain savanna forest. This is the first record of the species in the core area of the Brazilian Cerrado, enlarging significantly its geographic distribution. The taxonomic and conservation status of the species are discussed.

Low Frequency Calls of *Plecotus auritus*

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Plecotus auritus is one of five species of the genus *Plecotus* living in Europe. The vocalization of this bat species was studied at the locality Ledové sluje near Vranov nad Dyjí. Low-frequency calls of *P. auritus* are multiharmonic, frequency modulated with bandwidth between 25.1–12.7 kHz and average peak frequency 15.5 kHz. The pulse length was most commonly between 7–8 ms and maximally five harmonics have been recorded. Analyzed low-frequency calls of *P. auritus* had a simple structure similar to standard high-frequency echolocation calls with the highest intensity of signal moved from the second harmonic to the fundamental component. The activity of bats using low-frequency calls was recorded predominantly during the early spring period. At the time of full leaf bloom these signals were recorded rarely. Low-frequency calls were used by flying bats at various foraging sites, e.g., around coniferous trees and at the edge of woodland. As Lepidoptera forms the major part of *P. auritus*'s diet during the early spring, the frequency shift out of moths' hearing should represent predator advantage and this adaptation most probably could increase their foraging efficiency during the period with low food availability.

Bats of the Vrana Lake Nature Park

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Lake Vrana is the largest natural lake in Croatia, situated in central Dalmatia and protected with its surrounding area since 1999. Although the first data on bats in this area date from the end of 19th century, bat fauna had never been properly researched. During our research, which started in June 2007 and lasted until January 2008, we recorded bat species during summer, winter, and migration periods. We combined several methods: surveillance of all potential roosts including underground sites, mist netting near the lake or at the entrance of caves, and recording of bat echolocation calls using time-expansion bat detectors on various car-driven transects around Vrana Lake. Additional data were obtained from the findings of dead bats. In total, 12 bat species have been recorded: *Rhinolophus euryale, R. ferrumequinum, R. hipposideros, Myotis blythii, M. myotis, M. capaccinii, Miniopterus schreibersii, Pipistrellus nathusii, P. kuhlii, Hypsugo savii, Plecotus* sp., and *M. brandtii/mystacinus. H. savii, Plecotus* sp., and *M. brandtii/mystacinus* were recorded via bat echolocation analysis and these are the first data for these species or species groups for the Vrana Lake Nature Park. No maternity or hibernation roost was recorded. We found only 40 individuals in two caves during the summer (cave near Vrana and Banđenova jama). In the cave near Vrana, Đulić recorded a summer colony of *M. myotis, M. blythii, R. euryale, M. capaccinii,* and *Min. schreibersii* with around 1400 individuals in 1957. Unfortunately, the bats are not using this cave any more. This represents a significant loss and possible reasons may be vandalism and/or pesticide overuse. During the winter, we did not record any bats hibernating in caves since they are too warm to meet bat hibernation needs. Some caves surrounding Vrana Lake represent important migration sites. In October 2007, *R. euryale, R. ferrumequinum, R. hipposideros, Min. schreibersii, M. myotis, M. blythii*, and *M. capaccinii* formed colonies in two caves. We recommended the protection of these sites since all species except for *M. blythii* are listed in the Croatian Red Book of Mammals (2006).

Monitoring of Bats in the Veternica Cave

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Veternica Cave, situated in Nature Park Medvednica near Zagreb, was recognized as one of the key bat sites in the northwestern part of Croatia. The bat fauna of the cave has been researched continuously since the middle of 19th century. Recent studies showed that 8 out of 12 hibernating bat species use the cave continuously (*Myotis blythii, M. daubentonii, M. emarginatus, M. myotis, M. nattereri, Rhinolophus hipposideros, R. euryale*, and *R. ferrumequinum*) and 4 occasionally (*Barbastella barbastellus, Eptesicus serotinus, Plecotus macrobullaris*, and *M. bechsteinii*). During summer, *Miniopterus schreibersii* and *R. euryale* form colonies near the entrance in the warmest part of the cave. After completing bat ecology research conducted from 2003 until 2005, solid steel doors set at the entrance to the main channel were changed to grilles. Furthermore, a specially designed fence was placed around the main entrance to the cave to minimize bat disturbance. We started monitoring bats in January 2007. We found that *R. ferrumequinum* still forms colonies in hibernation. Although the number of individuals has decreased in the last 12 years it now appears to be stable at 100 individuals. On the other hand, the number of *R. hipposideros* has significantly increased and according to the published data, this is the largest colony found in a cave in Croatia. It may be a consequence of closing the cave for tourism in the winter period (1 November–1 April) since 2004. We did not record any other significant changes in numbers of other bat species. Since 2003 microclimate conditions (temperature and humidity) are being measured using data-loggers set at five stations in the cave. This will provide valuable microclimate data that can help us to determine if gating had any influence on the cave as bat habitat.

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IN MEMORIAM

Sheila Stebbings
2 July 1938 – 25 January 2010

A Tribute to Sheila Stebbings — Conservationist

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A few defining attributes underlined the life and career of Sheila Stebbings—loyalty, passion, modesty. She was motivational and in possession of a huge disarming smile. Although not originating as an academic, she quickly grasped research concepts and was meticulous in recording and note taking and often undertook most of the field work for various research projects.

In 1970 Sheila was one of the founding members of the Yorkshire Mammal Group, one of the first groups to establish in the UK and one that is still active today. Sheila's commitment to the group saw her plunge into long-term small mammal trapping and ecology and she soon became an expert in this field. In 1977 the Group, led by Dr. Michael Thompson, embarked upon groundbreaking research into the ecology of pipistrelle bats in the Vale of York. The detail and quality of this study was such that it still remains one of the most defining pieces of bat research

completed in over three decades. It showed individual colonies were discrete units whose cluster size was a function of the quality of foraging habitat and lack of roosts. Some colonies occupied over 20 different roosts annually, for the maternity cluster in summer. In an area of 500 km^2 there were 30 colonies with each being studied.

It was at this time that Sheila met Bob Stebbings. Bob had been liaising with the group, training them on ringing and handling bats, and was the perfect expert to assist with all stages of the project. Some eight years later and Sheila was still as active in the Mammal Group—and indeed in the bat world—as she was in 1970.

Soon after this Sheila joined Bob in Peterborough. With her rapidly gathering knowledge of bats in Britain as well as worldwide, and stimulated by the passing of legislation in 1981 giving protection to all species of bats in Britain, she started giving training courses. This enthusing of people to become interested in bat studies was pivotal, especially in educating the public about bats and the need for their protection. Many people had their lives changed when they became interested in working with bats.

This collaboration continued in the mid 1980s with the making of the 52-minute BBC Natural History Film "Bats Need Friends." The first national TV film, which has been shown many times in UK and abroad, aimed to raise the profile of bats with the general public. Sheila appeared a number of times on TV, both live in studios such as major programs for children and in short films made on location—all aimed at enthusing young people in particular.

Also at this time Sheila joined the UK Governments' Nature Conservancy Council in Peterborough as Species Officer with a responsibility for co-ordinating the newly established bat wardens and encouraging the developing network of bat groups. In addition, she provided advice, sometimes having to admonish companies responsible for remedial work in buildings and the use of chemicals that killed bats. She took great pride and gave unlimited time to the establishment of the bat network. Today there are over 100 bat groups that can trace their pedigree back to the help and training Sheila gave.

Her commitment to enlightening and encouraging bat workers went further with training events usually in conjunction with Bob Stebbings. The most legendary was their annual Field Study Course in Pembrokeshire, West Wales. The amount of knowledge passed on was only equalled by the enjoyment of the event. On each wonderful course, Sheila bought fruit and other products from around the world to show the contribution bats make to the economies of many countries, especially those in the Tropics. On one occasion she took advantage of the large classroom to let a captive born bat she had raised have a try at flying. The delight Sheila got from watching this bat flying for the first time was clearly evident, and the education the bat enthusiasts received from watching the bat fly was immeasurable. The last of the 13 species of bats in her collection of British bats, which she kept in permanent captivity for training purposes, died at the age of 24 years. Much advice on the husbandry and welfare of injured bats was dispensed with ongoing maintenance of interest in the 'patients'.

Others give testament to the commitment that found Sheila's home phone line being available seven days a week and at all hours. She was unstinting in her efforts and she supported all these new bat workers over and above the call of duty.

Sheila has had an enormous and lasting impression on us all—always ready to help and advise, to gently put us right if mistaken or in error, to frequently share our frustration with builders or vicars, and to wield a stinging pen if necessary when bats or their roosts

were being threatened. She was always supportive and persistent in trying to make sure things happened as they should under the legislation and occasionally providing solidarity and comfort to bat workers when an issue was outside our control and could not be put right except by her.

In the late 1990s, the Stebbings Consultancy was awarded the contract for providing bat advice on behalf of English Nature (the new name for the UK Governments' Conservation Agency). This initiative saw all the actions of the bat wardens from the East Midlands being co-ordinated and managed by Sheila and assistants in the company. The result was a new generation of bat ecologists trained and enthused by Sheila's team. Remarkably most of this new generation can trace their lineage back to the first recruits trained by Sheila in the 1980s. Without exception all of these wardens were proud to have been part of her team. Many of those also went on to train others in the national network now under the umbrella organization, the Bat Conservation Trust.

Sheila had the ability to motivate volunteers to go beyond the norm in the time and effort they put into bat work. She was an example of hard work and commitment, with her phone line open day and night and encouraging the new recruits to call if advice was needed when surveying in the field. Many calls were made from inside a house loft void or from a church tower with bats. Nobody had anything to fear from this lady—unless, of course, they were a timber treatment company or builder who was threatening any bat or bat roost! A few deserved individuals still carry the scars of Sheila's passion for conserving bats and their roosts.

The bat conservation world has sadly lost a great ambassador, educator, and contributor.

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. Corresponding author's e-mail address is provided where available.

ANATOMY

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ANNOUNCEMENTS

Retired Bat Biologist Donating Select Journals

Burr Betts has retired (congratulations, Burr!) and would like to give away his collection of scientific journals to anyone willing to pay the shipping costs. The journals are *Animal Behaviour* (1970–1999), *Bat Research News* (Winter 1995–2009), *Mammalian Species* (#1–714), *Northwest Science* (1981–2003), and *Journal of Mammalogy* (1971–2008). Please contact Burr directly at burrbetts@gmail.com if interested.

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*.

FUTURE MEETINGS and EVENTS

12–14 July 2010

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

30–31 July 2010

The 9th Annual Great Lakes Bat Festival will be held at the Cranbrook Institute of Science, Bloomfield Hills, Michigan. The Festival will begin on Friday evening, July 30th, with a special keynote speaker at 7 p.m. On Saturday, July 31st, there will be presentations by authors, bat experts, and field biologists; live animal programs; kids' activities; exhibits; an evening BBQ; and a bat research demonstration. The festival is for all ages and free of charge with museum admission. More information and directions are available at: http://www.batconservation.org

23–27 August 2010

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

27–30 October 2010

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

August 2011

XIIth European Bat Research Symposium will be held in Lithuania.

2011

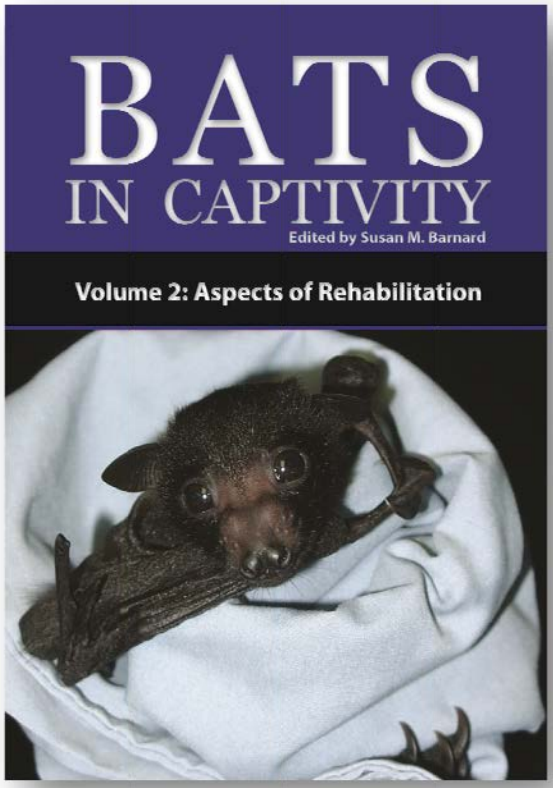
The 41st Annual NASBR will be held in Toronto, Ontario, Canada, dates to be announced. Please check the NASBR Web site at http://www.nasbr.org/ for upcoming information.

2012

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

BATS IN CAPTIVITY

Volume 2: Aspects of Rehabilitation



Susan M. Barnard, Editor
484 pages. First Edition, April 2010.
Hardcover: 978-1-934899-04-5 $89.95
Softcover: 978-1-934899-05-2 $67.95

Distributed by Ingram, Baker & Taylor and Lightningsource

About the Editor

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

A comprehensive book intended for anyone maintaining bats in captivity. *Bats in Captivity* is the only book of its kind, detailing the captive care of bats worldwide. This volume comprises 38 papers by 41 contributing authors. It contains a user-friendly guide to bat identification, subjects on reproductive patterns and parental care, social organization and communication, capturing and handling, releasing bats into the wild, marking bats for individual identification, torpor and hibernation, lactation and postnatal growth, simulating mother's milk and hand rearing pups of all bat groups, plus much more.

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Published by Logos Press · Washington, DC
info@logos-press.com · 202.487.0089 · www.Logos-Press.com

LOGOS PRESS

BAT RESEARCH NEWS

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BAT RESEARCH NEWS

VOLUME 51: NUMBER 2 **SUMMER 2010**

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Front Cover

Allen's big-eared bat, *Idionycteris phyllotis,* by Fiona A. Reid. These bats have flaps of skin on the forehead (lappets) from the base of each ear, and no lumps on the muzzle. 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

Volume 51: Number 2 Summer 2010

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;
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Bat Research News is published four times each year, consisting of one volume of four issues. *Bat Research News* publishes short feature articles and general interest notes that are reviewed by at least two scholars in that field. *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.)

The prices for one volume-year (4 issues within a single volume) are:

Institutional/Group subscriptions	US $50.00
Individual subscriptions:	
printed edition (U.S.A.)	US $25.00
printed edition (outside U.S.A)	US $35.00

Subscriptions may be paid by check or money order, payable to "***Bat Research News***." Please include both mailing (postal) and e-mail addresses with your payment, and send to Dr. Margaret Griffiths at the address listed above. To pay by credit card (Visa or MasterCard only) or for further information, please go to the *Bat Research News* website at http://www.batresearchnews.org/ and click on the "Subscription Information" link.

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Bat Research News is ISSN # 0005-6227.
Bat Research News is printed and mailed at Lycoming College, Williamsport, Pennsylvania 17701 U.S.A.

This issue printed June 28, 2010.

Letter 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.

Longevity Record for the Big Brown Bat (*Eptesicus fuscus*)

Susan M. Barnard

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During the 1st week of June 1986, owners of a home in Clayton Co., Georgia, ordered a pest control company to remove female big brown bats (*Eptesicus fuscus*) with pups from the attic of their house. The mothers and young were relocated to a bat box at Zoo Atlanta, Fulton Co., Georgia. The following day, 58 pups, ca. 1 week of age, were found abandoned inside the box. Most young bats survived subsequent hand rearing and had varying life spans. The last surviving individual was a male, and the age of this bat, while it was still alive, was reported in Rossinni and Barnard (2010) as 23 years and 7 months. This bat, however, died on 28 March 2010, at the approximate age of 23 years and 10 months.

Published longevity records for wild big brown bats were 19 and 20 years, from Ontario and Arizona, respectively (Davis, 1986; Paradiso and Greenhall, 1967). Although the bat from Georgia was a hand-reared captive, its lifestyle was as close to wild as possible. It was housed outdoors year-round from July 1986 to 29 June 2006 at my residence in Clayton Co., Georgia, in a thermostatically controlled bat box mounted inside a flight cage (Barnard, 1995). During winter, temperatures were set at 3–6 ºC, and during summer at 27–29 ºC. The bat was moved to Putnam Co., Florida, and housed indoors, from 29 June 2006 until its death, in a wooden cage that was 91-cm high, 43-cm wide, and 38-cm deep. Ambient temperature in the room ranged from 18–28 ºC, depending on season. The animal's diet throughout its captivity was fortified mealworms, similar to that described in Barnard et al. (in press).

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Abstracts of Bat-related Papers Presented at the

20th Colloquium on the Conservation of Mammals in the Southeastern United States

Asheville, North Carolina
19 February 2010

The following selected abstracts are from bat-related papers that were presented at the 20th Colloquium on the Conservation of Mammals in the Southeastern United States. The abstracts were compiled and submitted by Timothy Carter, and edited for publication by Margaret Griffiths. Any omissions or errors are inadvertent. Abstracts are listed alphabetically by first author.

The Indirect Effects of Prescribed Fire on Bats in the High Pine Ecosystem
D. W. Armitage and H. K. Ober, Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL

The historical exclusion of fire from the longleaf pine-wiregrass (high pine) ecosystem has resulted in a tremendous net loss of this important habitat. Prescribed fire has become the status quo for maintenance of these systems, and its restorative effects on tree, shrub, and ground-layer plant communities are well documented. Our goal was to elucidate which factor, the physical structure of the stand or its insect prey base, was the most influential predictor of bat activity (mean no. calls night^{-1}) and whether either of these factors was impacted by the periodicity of prescribed fire. We conducted a two-year echolocation-monitoring study of bats in xeric longleaf pine-wiregrass habitats representing three categories of fire periodicity: 0–1 years, 3–5 years, and > 8 years. We found significant differences in tree, shrub, and ground-layer characteristics among each of these categories. We did not detect fire-treatment effects for most orders of nocturnal insects. However, lepidopteran biomass was greatest at sites with the longest time between burns and was positively associated with fire-dependent deciduous tree and shrub densities. Overall bat activity above the canopy was equal among burn treatments and was not associated with any stand, insect, or landscape variables. Bat activity below the canopy was significantly lower in stands burned > 8 years ago than in either of the other treatments, and was positively associated with height of canopy closure (a fire-dependent variable). Species-specific activity patterns confirmed ecomorphological predictions, with small, clutter-adapted species replacing larger species below the canopy at sites with > 8-year burn frequencies. These results suggest that the prescribed fire regime is an important indirect determinant in structuring the communities of bats that forage in the understories of high pine ecosystems.

K-Nearest-Neighbor Classification to Identify Bat Calls: Performance with a Suite of Coastal Plain Forest Species and Comparison to Discriminant Function Analysis
Michael J. Bender[1], Steven B. Castleberry[1], Darren A. Miller[2], and T. Bently Wigley[3]; [1]Daniel B. Warnell School of Forestry and Natural Resources, University of Georgia; [2]Weyerhaeuser Company; and [3]National Council for Air and Stream Improvement, Inc.

The primary purpose of many acoustic surveys is to monitor and determine presence of free-flying bats. A critical step in this process is accurate identification of species based on echolocation calls. Many quantitative approaches to identification have been used, but

discriminant function analysis (DFA) is a relatively accurate and commonly used method. K-nearest-neighbor analysis (KNN) is an alternative classifier that is relatively simple, widely available, and free from restrictive assumptions. Our objectives were to test performance of KNN as a quantitative method to classify bat calls and compare accuracy rates to those produced by DFA. KNN achieved an 82.50 percent overall accuracy rate, which was 9.91 and 7.63 percentage points higher than linear and quadratic DFA rates, respectively. Our results indicate that KNN analysis should be given strong consideration when the primary objective is identification of unknown bat calls.

Do Edges Act as Conduits or Filters for Foraging Bats?

K. M. Briones[1], M. M. Marshall[1], D. A. Miller[2], J. A. Homyack[3], and M. C. Kalcounis-Ruppell[1]; [1]Biology, University of North Carolina at Greensboro, NC; [2]Weyerhaeuser Company, Columbus, MS; and [3]Weyerhaeuser Company, Vanceboro, NC

Research on managed forest landscapes in the southeastern United States has shown that six bat species (*Lasiurus borealis, L. cinereus, Eptesicus fuscus, Nycticeius humeralis, Tadarida brasiliensis*, and *Perimyotis subflavus*) have substantially higher activity along hard forest edges (older forested stands adjacent to young open-canopy stands) than in forest interiors, consistent with studies that show high bat species richness and abundance along hard forest edges. Hard edges may create a semi-permeable barrier to movements of bats into the forest, causing an accumulation of bat activity along edges (a filtering effect). Alternatively, forest edges may improve connectivity between foraging areas (a conduit effect), or serve as both a filter and a conduit. During summer 2009, we used a microphone array and thermal imagery along hard forest edges to examine how individual bats use edges, and to test the hypotheses that edges act as filters (fly perpendicular to edge) and/or conduits (fly parallel to edge). We used a 4-channel microphone array (Avisoft USG) to determine position of the incoming echolocation call, relative to the edge, based on time of arrival of the call at each microphone in the array. In addition, we used a thermal imaging camera (Photon 320; Flir/Core by Indigo) with the microphone array to visualize individual bat flight at the edge. We sampled 10 different edge sites, each for 3 continuous nights, within a managed forest landscape owned and managed by Weyerhaeuser Company in eastern North Carolina. To date, we have analyzed a subset of the data from five of the edges. More bats flew parallel to the edge than perpendicular or in an alternate direction, suggesting that the edge acts as a conduit for bats in this landscape. In the future we will analyze the thermal imagery data to confirm our microphone array results and identify echolocation calls to examine species-specific use of edges as conduits or filters.

Ecology of *Myotis lucifugus* in the Southeast: Comparisons with the Northeast

Eric R. Britzke, U.S. Army Engineer Research and Development Center, Vicksburg, MS

Like many other common bat species, the ecology of little brown myotis (*Myotis lucifugus*) is poorly understood. Existing data are largely from extensive banding efforts at caves prior to the 1970s. In the southeastern United States, little brown myotis occur over a wide area, but constitute a small percentage of the bats captured during summer or observed in hibernacula surveys. In summer, most roosts have been found in human structures (barns, old buildings, bridges, etc.), although some tree roosts have been located. Little browns typically forage over streams, particularly on stretches of calm water where they can forage on newly emerging

insects. In winter, little browns are often present in the same hibernacula as Indiana bats (*Myotis sodalis*), but are normally less abundant than Indiana bats. Information on little brown myotis in the Northeast will be provided for comparison. With white nose syndrome affecting little brown myotis, there is an imminent need to gather basic information on the ecology of little browns to inform future conservation efforts before these bats disappear from the landscape.

Roost Communication in the Indiana Bat, *Myotis sodalis*

Caroline M. Byrne[1], Dylan A. Horvath[1], and Joy M. O'Keefe[2]; [1]Binghamton University, NY; and [2]USDA Forest Service, Southern Research Station, Clemson, SC

In a pilot study, vocalizations of the Indiana bat, *Myotis sodalis*, were recorded at communal summer roosts. The goal was to capture social calls, differentiated from echolocation calls by their solely communicative function. Echolocation calls were eliminated with the use of known samples from *M. sodalis.* We used an Anabat bat detector and CF ZCAIM to record calls at known roosts from 15 minutes pre-emergence to 5 minutes post-emergence. Recorded calls were analyzed in AnalookW and compared to parameters given in Pfalzer and Kusch 2003, who described four general types of call based on corresponding behaviors. Calls were recorded at one roost in June-July 2008 and six roosts in June-July 2009. There were 45 call files, containing a total of 138 pulses. The preliminary results show calls recorded at the *M. sodalis* roosts fit the general parameters of the mother-to-juvenile isolation or directional call type (frequency modulated with a curved structure, single pulses with a duration of 5–58 ms or double pulses). If social calls of North American bats are found to exhibit species-specific characteristics similar to those found in Europe by Pfalzer and Kusch (2003), social calls could become a noninvasive research method, done along side existing research. If researchers are vectors in the spread of white nose syndrome, acoustic surveys could be a viable alternate to survey methods that require handling bats. Further research is needed to determine species-specific characteristics and the period in which the recordings are made should be extended to include pre-juvenile and mating periods.

Niche Breadth, Foraging Plasticity, and Conservation Risk of *Myotis leibii*, *M. lucifugus*, and *M. septentrionalis*

Aaron J. Corcoran and Joseph M. Szewczak, Wake Forest University, Winston Salem, NC; and Humboldt State University, Arcata, CA

An animal's behavioral plasticity is one of many factors that can determine its extinction risk in a changing environment. In bats, dietary breadth is indeed related to extinction risk. Microchiropteran bats use echolocation to detect and locate prey. The structure and variation of a bat species' echolocation repertoire can tell us much about its habitat selection and foraging flexibility. Echolocation structure also has been shown to reflect niche differentiation for bats in the genus *Myotis*. For the purposes of understanding the factors contributing to the conservation status of three bat species (*Myotis leibii, M. lucifugus*, and *M. septentrionalis*), I report on what is known of the dietary variation and echolocation repertoires of these species. All three species are known to use multiple foraging strategies, including aerial hawking and gleaning off of substrates. They all also forage widely on over eight orders of insects and spiders, and are typically considered generalist foragers. These myotines frequently eat soft-bodied insects, including lepidoptera. This is particularly true for *M. septentrionalis* and *M. leibii*. *M. lucifugus*

has the broadest repertoire of echolocation call structure, including calls suited for foraging in open and forest interior. *M. septentrionalis* and *M. leibii* calls show less variation and reflect foraging only in forest interior. Of the three species, *M. septentrionalis* appears the best suited for gleaning and foraging in cluttered environments given its echolocation structure. In summary, the three species are all generalist foragers that eat many soft-bodied insects. Echolocation structure reflects a greater degree of niche partitioning than does diet of these bats, with *M. lucifugus* employing the greatest breadth of echolocation call structure. Concordantly, *M. septentrionalis* and *M. leibii* may be at greater conservation risk due to their specialized foraging within the forest interior.

Neither Rain nor Sleet nor Gloom of Night: Stubborn Bridge Roosting Habits of Big Brown Bats (*Eptesicus fuscus*)

M. E. Frazer and M. R. Miller, NC Department of Transportation, Raleigh, NC

Although big brown bats (*Eptesicus fuscus*) probably favor large hollow trees and rock crevices as day roosts, they are commonly observed roosting in a variety of man-made structures, such as concrete bridges. Bats roosting in large bridges may enjoy thermal benefits from sunlight-warmed concrete and reduced exposure to predators, but bridge-roosting bats still have to contend with weather. We monitored big brown bats roosting in three bridges in western and central North Carolina to determine roosting habits. Bats day-roosted in guardrail crevices and in bridge deck expansion joints despite the lack of overheard cover and their proximity to traffic noise and exhaust, while night roosting occurred underneath bridge decks. During rain events, instead of moving to a well-used night roost below the bridge, a maternity colony of 50–100 individuals remained in a bridge deck expansion joint despite exposure to the elements. Other observations include winter roosting by big browns under bridge decks and opportunistic use of bat boxes mounted on a bridge that had been intended for eastern small-footed bats (*Myotis leibii*). Since they could not fit into the narrow slots of the bat boxes, big browns simply wedged themselves between the bat box and the side of the bridge. These observations demonstrate big brown bats' versatility in adapting to a variety of roost types and weather conditions. The ability to use a wide range of roosts in summer should benefit resource managers seeking to create or improve big brown bat summer roosting habitat, although care must be taken not to do this at the expense of less common species. This adaptability may also help big brown bats when contending with white nose syndrome (*Geomyces destructans*) in winter.

Temporal Roosting Patterns and Population Dynamics of Two Bridge Populations of Eastern Small-footed Bats (*Myotis leibii*)

M. E. Frazer and J. M. O'Keefe, NC Department of Transportation, Raleigh, NC; and USDA Forest Service, Southern Research Station, Clemson, SC

Bats often use bridges as day or night roosts to supplement or replace natural roost sites. The eastern small-footed bat (*Myotis leibii*) is a tiny (4–6 g) bat that typically roosts in natural rock crevices, but they have also been found roosting in the crevice-like expansion joints of concrete bridges. The objectives of our study were to identify temporal roosting patterns and to measure population dynamics in two bridge populations of eastern small-footed bats in western North Carolina, where this species is considered vulnerable. At the Fontana bridge (elevation ~500 m), bats were first banded in 2000 and were monitored in the bridge ≥ 3 times per year from March–

November 2004–2009. At the Stratton Meadows bridge (elevation ~1400 m), bats were first banded in 2004 and were monitored in the bridge ≥ 1 times per year from May–June 2007–2009. The warmer Fontana bridge is primarily used by adult females (n ≥ 22), but male and juvenile small-footed bats and male little brown myotis (*M. lucifugus*) are sometimes observed. The Stratton Meadows bridge is used by ≥ 36 bachelor male and ≥ 7 female small-footed bats, as well as the occasional male little brown myotis. Although numbers of bats using the bridges varies by day, eastern small-footed bats show fidelity to both bridges; one female has used Fontana bridge for ≥ 7 years and several males have used Stratton Meadows bridge for ≥ 5 years. Relatively large populations and long-term fidelity indicate that both bridges provide important roosting habitat for eastern small-footed bats.

The SBDN/NEBWG Bat Capture Database: Current Status and Future Uses

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Regular monitoring of bat populations is needed to assess the impacts of threats to bats such as climate change, wind turbines, and white nose syndrome. Researchers have been collecting bat capture data for many years, and combining those data into an organized database is important in monitoring bats populations. The Southeastern Bat Diversity Network and the Northeast Bat Working Group (SBDN/NEBWG) Bat Capture Database is just such an example. The database is similar to databases currently used by some State agencies and houses bat data from researchers throughout the eastern United States. Currently the database ranges from 1999 to the present and covers data from Arkansas, Georgia, Illinois, Indiana, Kentucky, Maine, Missouri, North Carolina, New York, Ohio, South Carolina, Tennessee, and Virginia. The database can be used to document band recoveries. Further, relationships are established to facilitate efficient management of information in order to ascertain any patterns in variables such as species, location, and habitat. These patterns can then be compared to known threats to bat populations to establish possible cause and effect, such as species distribution and capture frequency from 1999–2009. Extensive range maps as well as ones specific to certain species of bats can also be produced given the significant amount of data from a wide range of sources. Tables and reports can be generated to summarize the number of bats captured in each county each year. While the database will be maintained by members of the SBDN/NEBWG Database committee, it will be possible for contributors who have research and management needs to request specific queries. One of the biggest advantages of having such a database is the accessibility of data to researchers. Sharing knowledge leads to cohesive studies and ultimately improves overall research and management.

Bat Community Structure within Riparian Areas of Northwestern Georgia

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Although it is well known that bats commonly forage in riparian areas, which provide water resources and insect concentrations, the role that the physical structure of riparian areas plays in influencing local bat communities is less certain. In 2000–2002, we used acoustic monitoring to

determine bat species at 338 riparian sites in northwestern Georgia. We used a 2-dimensional nonmetric multidimensional scaling (NMDS) ordination to assess how separations among species were partially associated with riparian conditions. Our NMDS analysis found some degree of habitat partitioning among bat species occurring in northwestern Georgia and was dictated in part by riparian condition. *Myotis grisescens* and *M. septentrionalis* were associated with low-elevation lotic waterways, whereas *M. lucifugus*, *Lasiurus borealis*, and *Eptesicus fuscus* were associated with high-elevation lentic waterways with sparse canopy cover. However, riparian conditions had weak relations with NMDS axes, possibly resulting in coincidental associations in some cases. Regression tree analysis indicated that higher bat species richness was associated with apparently uncommon small, high-elevation waterways with sparse canopy cover as well as larger streams and rivers that had wetlands adjacent to them. Including high-elevation waterways with existing management recommendations for foraging areas (large, low-elevation streams and rivers) of the endangered gray myotis will be the most effective conservation strategy to benefit the most bat species in northwestern Georgia and probably elsewhere in the southern Appalachians.

Comparison of Indiana Bat (*Myotis sodalis*) Maternity Colony Home Ranges among Three Sites

Melanie L. Michaels and Timothy C. Carter, Ball State University, Muncie, Indiana

The Indiana bat (*Myotis sodalis*) is currently listed as an endangered species by U.S. Fish and Wildlife Service and have populations that only recently began to rebound. The objective of this study was to examine the foraging home range for female Indiana bats living in both southern Illinois and east-central Indiana. Two-station telemetry was used to triangulate the signal from bats fitted with radio transmitters to determine home range. Foraging points were determined using Locate III and overlaid onto habitat maps using ArcMap® GIS. Both minimum convex polygon and adaptive kernel methods were used to determine home range size. This multi-site analysis of female Indiana bat foraging home ranges will give wildlife managers a better understanding of how much foraging area female Indiana bats require to be successful.

Review of the Ecology of Eastern Small-footed Bats (*Myotis leibii*) in the Southeastern United States

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The eastern small-footed bat (*Myotis leibii*) is one of the least studied species of bats in the southeastern United States. Distribution during the non-hibernation period likely is restricted to areas with exposed rock outcrops, including cliff faces and talus slopes, although colonies have been reported in expansion joints of bridges in the Southeast and in talus-like rip rap of dams in the Northeast. Limited data suggest maternity sites may be associated with south-facing slopes. Males have been documented in a greater variety of roosting habitats, including shaded outcrops and buildings. During summer, most *M. leibii* have been captured < 600 m from roosts, and radiotelemetry suggests they forage within a 2.5-km radius of their roosts, making captures unlikely unless suitable habitats are intentionally targeted. Most encounters with *M. leibii* have been during winter surveys, typically in the coldest parts of hibernacula, including under rocks,

in crevices, and on walls near entrances. Duration of hibernation appears shorter than that of most co-occurring species of bats in eastern North America, suggesting *M. leibii* may have greater cold tolerance. White nose syndrome (WNS) is causing ongoing declines in *M. leibii* populations in the Northeast. Whether the unique winter ecology of *M. leibii* will affect mortality rates from WNS in the Southeast remains unknown. However, ecology of *M. leibii* makes it difficult to monitor populations with traditional hibernacula surveys. Efforts are needed to identify summer roost sites to provide alternative means to detect population declines and to improve knowledge of their ecology.

Towards a Better Understanding of the Ecology of *Myotis leibii, M. lucifugus,* and *M. septentrionalis*

Joy M. O'Keefe and Matina C. Kalcounis-Rueppell, USDA Forest Service, Southern Research Station, Clemson, SC; and University of North Carolina at Greensboro, Greensboro, NC

Hundreds of thousands of *Myotis* in the northeastern United States have died from white nose syndrome (WNS), and biologists have predicted that some species of *Myotis* may be extirpated in the Northeast. WNS also threatens populations of bats in the Southeast, including five species of cave-wintering *Myotis*. Historically, more attention and funding have gone towards the study of the endangered *M. grisescens* and *M. sodalis*, but few data are available to guide conservation and recovery of the three more common cave-wintering species, *M. leibii, M. lucifugus*, and *M. septentrionalis*. Until recently, *M. leibii* was considered vulnerable across its range, but *M. lucifugus* and *M. septentrionalis* were considered secure. However, WNS has potentially dire consequences for populations of these three species. Summarizing data on summer roosting and foraging habitat requirements as well as winter roosting ecology for *M. leibii, M. lucifugus,* and *M. septentrionalis* are necessary to make policy and management decisions, and also will give us a better understanding of the potential impacts that WNS may have on theses species. Further, some data are in the gray literature and it is important that these data be combined with published findings. Finally, we hope that summarizing what is known about *M. leibii, M. lucifugus,* and *M. septentrionalis* in the Southeast will allow us to identify critical gaps in our knowledge.

Snag Population Dynamics Relative to Indiana Bat Roost Habitat Selection in the Southern Appalachian Mountains

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Little information exists about the roost ecology of Indiana bats *(Myotis sodalis*) at the southern extent of their range. From 1999–2009, biologists have gathered data on roosts in the southern Appalachians, where Indiana bats primarily use beetle-killed yellow pines but occasionally roost in white pine or hemlock snags. Multiple studies in the region have shown that Indiana bats selectively roost under sloughing bark in tall, low decay conifers that receive greater solar exposure than random trees. In fall 2009, we measured snag characteristics in the Cherokee and Nantahala National Forests and the Great Smoky Mountains National Park in North Carolina and Tennessee. We located mature stands with a conifer component, searched stands for dense snag patches, and measured ≥ 40 snags in variable size plots on lower, middle, and upper slopes. For snags ≥ 18.4 cm dbh, we recorded species or genus, height, dbh, and overall decay status (1–4). To evaluate decay, we recorded branch state (e.g., size and number),

bark tightness, percent remaining bark, and surface wood hardness. We measured 1,063 snags in 23 plots: 75.3% were yellow pine, 12.2% were white pine, 6.4% were hemlock, and 6.1% were hardwoods. Hemlock snags were taller and less decayed than known roosts (mainly yellow pines), while yellow and white pine snags were shorter and more decayed than known roosts ($p < 0.0001$). Known roosts and yellow pines had 25–28% bark remaining, while white pines and hemlocks had significantly more bark remaining (58–96%). Although yellow pine snags are abundant in pine-hardwood forests, most will soon be too decayed to be suitable for roosting and recruitment of yellow pine snags is very low. In the near future, white pines with ≥ 30% bark and hemlocks recently killed by adelgids may be significant roost structures for Indiana bats in the southern Appalachians.

Ecology of *Myotis septentrionalis* in the Southeastern United States

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The northern long-eared bat (*Myotis septentrionalis*) is primarily distributed east of the Rocky Mountains in the northern United States and Canada. Often considered rare in the southeastern United States, it may be locally common, particularly where upland forested conditions occur. Caves and mines are often used as winter hibernacula, where males and females roost alone or in small mixed groups (generally < 30 individuals). Within these hibernacula, cooler locations are often selected where one or more individuals may occupy cracks or crevices. Temperature, air flow, humidity, and disturbance periodicity affect use of hibernacula. However, studies on winter selection of hibernacula and microclimate associations are often conflicting and additional research is warranted. The rarity of mines and caves in areas where these bats are common implies other features may be used as hibernacula, but common use of other types of hibernacula is currently unknown. Recent studies have contributed a wealth of information on summer roosting. During summer, both sexes roost beneath loose bark or in cavities of live trees or snags; males and non-reproductive females roost alone, whereas reproducing females often roost in small colonies (10–70 individuals). Reproductive females tend to select mature trees (> 20 cm diameter) that are tall and in relatively open forests with reduced canopy coverage and less structural clutter. Males often roost in small (< 10 cm) understory trees and in shady, relatively dense forests. In general, long-eared bats are flexible in selection of tree species during summer and appear to have regional preferences based on availability of tree species and historical disturbance in an area. Long-eared bats often return to the same hibernacula each year during fall and to the same forest areas to roost and forage during summer. Nevertheless, spatial relationships between hibernacula and summer use areas are unknown. This bat's habit of roosting in small numbers, in inaccessible portions of caves and mines, and foraging beneath the canopy in relative dense forests may all contribute to underestimated abundance in portions of its range.

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. Corresponding author's e-mail address is provided where available.

Please note this issue provides only an abbreviated section of the recent literature. A comprehensive section will be provided in the next issue (vol. 51: no. 3).

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BOOK REVIEW

Bats in Captivity: Volume 2: Aspects of Rehabilitation. Edited by Susan M. Barnard. Logos Press, Washington, DC. 468 pp., 2010. Hardcover ISBN: 978-1-934899-04-5 ($89.95 United States). Softcover: ISBN: 978-1-934899-05-2 ($67.95 United States)

The second volume of *Bats in Captivity* includes 13 sections written by 41 authors and is packed with information apparently aimed at all levels of reader. It gives some basic bat biology and natural history as well as detailed accounts for individual species. However, the structure of the book takes some time to evaluate because clearly, there is a collection of contributions from some of the world's most respected research scientists and other sections written by enthusiasts who have knowledge about a limited sphere of bat care.

To some extent the book covers topics that would not be expected for a rehabilitator's handbook. For instance, the second chapter "Identifying Bats" starts by saying "this chapter may not enable identification of a bat to species" but it is important to correctly identify a bat in captivity if there is an intent to keep it alive and especially for eventual release. Even closely related species can have different diets and behaviors, so knowledge of which species is in captivity is generally vital for a rehabilitator. In contrast, there is a comprehensive review of marking bats by Tom Kunz that is useful not just for bats in captivity, where it is usually important to know individuals, but for field studies as well.

Many rehabilitators soon come across the problem of having to feed young bats that are dependent on a milk diet. Artificial feeding of these animals has often resulted in failure. The book contains extensive appendices (about 40 pages) with information on the composition of milk for many species of bat, often in various stages of lactation, along with suggestions for artificial replacements created from commercially available products, such as those based on cow or goat milk.

In conclusion, this volume, with its authors of widely differing knowledge, provides accounts that vary from the general 'what is a bat and its natural history' to detailed descriptions of the maintenance of individual species, and therefore, the second volume of *Bats in Captivity* will appeal to research workers as well as rehabilitators. It will be extremely helpful for wishing to maintain healthy bats in captive conditions in research laboratories as well as zoos. Despite the title, much of this book does concern the maintenance of bats in captivity, and only three sections (of 13) actually deal with rehabilitation of bats back to the wild. Nevertheless, there is much valuable information gathered between the covers that anyone will wish to have if they keep bats in captivity, for whatever purpose.

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ANNOUNCEMENTS

Midwest Bat Working Group

The Midwest Bat Working Group (MWBWG) provides a structure for coordination, collaboration, and communication among concerned citizens and professional biologists in state, federal, academic, and private organizations. The MWBWG is dedicated to the conservation of bats and their habitats, particularly in the midwestern United States, and works to address bat-related issues with a regional approach. Although most participants are from Arkansas, Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin, membership is open to anyone who seeks to collaborate on research and management of bats or to promote conservation by enhancing public understanding of bats. The second annual meeting of MWBWG was held on 6–7 May 2010 in Terre Haute, Indiana, and was sponsored by the Indiana State University Center for North American Bat Research and Conservation. During the meeting, organizational procedures were discussed by approximately 75 attendees and the first board of directors was elected. Much of the meeting centered on the dual problems of wind power and white nose syndrome and how the various states, agencies, organizations, and individuals can cooperate to meet these threats. The next meeting of MWBWG will be held in conjunction with the annual meetings of the Northeast Bat Working Group and the Southeast Bat Diversity Network, in Louisville, Kentucky, on 23–25 February 2011. Further information about MWBWG, including how to participate, upcoming meetings, and research projects, can be found at the group's Web site (http://mwbwg.org/).

Request for Manuscripts — *Bat Research News*

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

Change of Address Requested

Will you be moving in the near future? If so, please **send** your **new postal and e-mail addresses** to Margaret Griffiths (griffm@lycoming.edu), and include the date on which the change will become effective. Thank you in advance for helping us out!

FUTURE MEETINGS and EVENTS

12–14 July 2010

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

30–31 July 2010

The 9th Annual Great Lakes Bat Festival will be held at the Cranbrook Institute of Science, Bloomfield Hills, Michigan. The Festival will begin on Friday evening, July 30th, with a special keynote speaker at 7 p.m. On Saturday, July 31st, there will be presentations by authors, bat experts, and field biologists; live animal programs; kids' activities; exhibits; an evening BBQ; and a bat research demonstration. The festival is for all ages and free of charge with museum admission. More information and directions are available at: http://www.batconservation.org

23–27 August 2010

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

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

23–25 February 2011
The joint meeting of the Southeast Bat Diversity Network, the Northeast Bat Working Group, and the Midwest Bat Working Group will be held in conjunction with the 21st Colloquium on Conservation of Mammals in the Southeastern United States, in Louisville, Kentucky, on 23–25 February 2011. Information is available at http://www.sbdn.org/meetings.html.

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

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

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

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The logo for the 14th Australasian Bat Society Conference features a northern Australian endemic, the Arnhem sheath-tailed bat (*Taphozous kapalgensis*). It was specially drawn for the conference by biologist Dr. Gerhard Koertner (University of New England, Armidale, Australia). The ABS Conference was held 12–14 July 2010 in Darwin, Australia, and the meeting abstracts are published in this issue of *Bat Research News*. Conference logo used with permission of the Australasian Bat Society and Gerhard Koertner.

BAT RESEARCH NEWS

Volume 51: Number 3 Fall 2010

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Bat Research News is published four times each year, consisting of one volume of four issues. *Bat Research News* publishes short feature articles and general interest notes that are reviewed by at least two scholars in that field. *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.)

The prices for one volume-year (4 issues within a single volume) are:

Institutional/Group subscriptions	US $50.00
Individual subscriptions:	
printed edition (U.S.A.)	US $25.00
printed edition (outside U.S.A.)	US $35.00

Subscriptions may be paid by check or money order, payable to "***Bat Research News***." Please include both mailing (postal) and e-mail addresses with your payment, and send to Dr. Margaret Griffiths at the address listed above. To pay by credit card (Visa or MasterCard only) or for further information, please go to the *Bat Research News* website at http://www.batresearchnews.org/ and click on the "Subscription Information" link.

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Bat Research News is ISSN # 0005-6227.
Bat Research News is printed and mailed at Lycoming College, Williamsport, Pennsylvania 17701 U.S.A.

This issue printed September 21, 2010.

Letter 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.

Herniated Urinary Bladder in a Male Little Brown Myotis, *Myotis lucifugus*

John O. Whitaker, Jr., and Angela K. Chamberlain

Indiana State University Center for North American Bat Research and Conservation, Indiana State University, Terre Haute, Indiana 47809
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On 19 October 2009, a male little brown myotis (*Myotis lucifugus*) was captured in a harp trap at Copperhead Cave, an abandoned mine west of the Wabash River, across from Montezuma, Vermillion County, Indiana. The bat possessed some type of growth on the ventral side of the posterior abdomen. The growth was covered with skin and fur and looked very much like the larva of a botfly (Diptera: Cuterebridae) embedded in a white-footed mouse, *Peromyscus leucopus*. Nevertheless, a search of the area revealed no opening for the breathing tube of a botfly.

A pair of scissors was used to cut the length of the body and partly expose the growth. Under the skin, but outside the body wall, in the left inguinal region, there was a fluid-filled spherical vesicle. It was yellow in color, vascularized, and distended, with a length of about 15 mm and width of 9 mm. Both the testis and penis appeared normal. At that point, we stopped further dissection because we wanted an anatomist (W. M. Chamberlain) to examine the specimen.

Careful dissection later identified the urethra through the pelvic canal to the penis and established the connections to the urethra of the vas deferens from each testis and the ureter from each kidney. The boundaries of the urinary bladder were traced, and it became evident that the prominent externalized vesicle was the result of a herniated bladder, rather than an inguinal hernia of the colon. The bladder appeared fully functional, and the presence of substantial accumulations of fat beneath the skin and around the kidneys suggested the bat was healthy, despite the anatomical abnormality. We thank W. M. Chamberlain for dissection and interpretation of the results.

Abstracts of Papers Presented at the

14th Australasian Bat Society Conference

Darwin, NT, Australia
12–14 July 2010

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 listed in the abstracts.

Many thanks to the Australasian Bat Society (ABS) and the conference organizers, Chris Pavey, Damian Milne, Toni Mitchell, and Gavin 'Lunar' Eclipse, for allowing *Bat Research News* to publish the meeting abstracts. The abstracts and list of participants were compiled and submitted by Chris Pavey. 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.

Population Genetics of the Grey-headed Flying Fox (*Pteropus poliocephalus*)

Heather Baldwin, Peggy Eby, Jackie Chan, and Adam Stow, Macquarie University

The grey-headed flying fox (*Pteropus poliocephalus*) is a threatened species whose population has experienced a rapid decline of approximately 30–35% in the last 20 years. This study investigates population structuring among permanent grey-headed flying fox colonies. The limited genetic analyses conducted to date suggest that the grey-headed flying fox breeds as a single panmictic population, but the strength of this conclusion is limited by the kinds of analyses used (allozymes and mitochondrial DNA), which are capable of showing only broad scale patterns and limited in their resolution. Here I use microsatellite data to address several key questions: 1) Is there evidence of population structuring and what does this tell us about breeding dispersal and natal philopatry? 2) Is dispersal sex-biased? Samples obtained from five permanent colonies, ranging from Melbourne to Brisbane, were analyzed using six microsatellite markers. Preliminary results show a pattern of high levels of dispersal and the occurrence of some natal philopatry in permanent colonies. This research is important given the current context of grey-headed flying fox management, which includes culling, forced dispersals of colonies, and inconsistent conservation statuses between the states. If my final results show panmixia, the species should be managed as a single connected population, as actions affecting one colony are more likely to affect the species as a whole. Recommendations based on these results may include: 1) amendment of the Queensland conservation status from common to vulnerable to conform with New South Wales and Victoria; 2) all permanent colonies be managed as equally important; and 3) reduction or elimination of culling. Alternatively, if some level of population differentiation is detected, then this may allow the identification of colonies of high conservation priority. The findings may also aid in decisions such as areas of habitat to protect and restore, and colonies on which to spend limited funds on measures for mitigating heat-stress mortality.

Group Size of Bats Using Artificial Roost Boxes

Robert Bender, Friends of Organ Pipes National Park, Victoria, Australia

A bat roost box project has been undertaken at Organ Pipes National Park on the northwest fringe of Melbourne since late 1994. Over 14,000 bat capture records have been obtained from 168 monthly and recently bi-monthly checks of the 37 boxes. There are now over 1,500 records of bats found in individual boxes, an average overall of 9.5 bats per box. But the size of bat groups found varies from a very common solitary bat, to a maximum of 86 bats in one box. This paper explores the variation in group size by year, by season and month, by box, and by box type. Experimenting with different box designs has resulted in six different types of boxes, classified by internal volume, size of entrance slit, and thickness of timber used. Box design has a major influence on the distribution of group sizes found using the box, so the pattern of group size attracted to use roost boxes can be influenced by manipulating the design.

The Function of Curvature in Vespertilionid Echolocation

Arjan Boonman, Queen Mary University London, Bogor, Indonesia

Many vespertilionid bats use an echolocation system composed of frequency modulated pulses ending in a QCF component. Generally, the FM component is believed to carry distance information whilst the QCF component is thought to be used for detection purposes. The precise curvature of the pulses has also been interpreted as optimizing the acuity in receiving single echoes, even if high flight speeds are used. Here I present an alternative explanation for the curvature changes typically observed in vespertilionid bats. I hypothesize that the main task of the bat is to separate overlapping echoes. To maintain an identical echo-separation performance across frequency, cochlear filters require higher sweep rates at high versus low frequencies. This requirement is reflected in the pulse design used as observed in a range of vespertilionid species occurring all over the world. The pulse design is a trade off between receiving a maximum amount of acoustic energy while maintaining the highest possible performance in separating returning echoes.

Preliminary Results of Bat-detector Surveys in Indonesia

Arjan Boonman, Queen Mary University London, Bogor, Indonesia

I have started doing bat-detector work in Indonesia since March 2009 working together with LIPI and Queen Mary University London. The first aim was to gather a database of bat calls from large parts of Indonesia, focusing on the little explored eastern regions (Sulawesi, Flores, Papua) and Java. I used a batcorder and a D240X detector and worked all year round, weather permitting. I will present some preliminary results in my presentation. In many places in Indonesia, *Scotophilus kuhlii*, *Pipistrellus javanicus*, *Saccolaimus saccolaimus* and *Myotis muricola* are the most common species. Using a bat-detector, *Kerivoula/Murina* is only very rarely recorded. I will present a description of several species I have recorded so far. Identification of the species could not always be verified and I hope the audience will interact and add all they know to my overview.

Colony Size Reduction Coincides with Roost Loss due to Clear-fell Harvest of Plantation Forest

Kerry Borkin and Stuart Parsons, School of Biological Sciences, University of Auckland, Auckland, New Zealand

The impact of clear-fell harvest on bats is of concern to many biologists because of the loss of roosts and changes to foraging opportunities, both of which have possible effects on populations. Long-tailed bats (*Chalinolobus tuberculatus*) are present throughout New Zealand in plantation forests managed with clear-fell harvest, but the impacts of such management have not yet been investigated. We determined colony size, roost loss, roosting range size (minimum convex polygons), and the use of roosts over three summers in a *Pinus radiata*-dominated plantation to test our predictions that all these measures would decrease in the presence of harvest operations. Over three summers, colony size declined from a median 8.0 to 2.0 bats, and roosting ranges shrank from 11.6 to 1.0 x 10^{-4} ha. Bats also used fewer roosts post-harvest operations. The rates of roost loss reported here are among the highest reported worldwide. Although there is no direct causal evidence that reductions are due to clear-fell harvest, we suspect this is the case. Such levels of roost loss may cause locally ephemeral populations of long-tailed bats that are vulnerable to predation and that use roosts until they are lost due to forestry operations or natural causes.

Bat Home Ranges in Plantation Forest Change After Clear-fell Harvest Operations

Kerry Borkin and Stuart Parsons, School of Biological Sciences, University of Auckland, Auckland, New Zealand

The impact of clear-fell harvest on home ranges of bats is poorly understood, but home ranges may alter as both roosting and foraging opportunities change. New Zealand's long-tailed bat (*Chalinolobus tuberculatus*) is resident in exotic plantation forest, but no investigation of their home range has taken place there. To test our hypothesis that home ranges would be smaller post-harvest due to reductions in older stands, bats were captured and radio-tracked over three summers in an intensively managed plantation forest, and their home ranges determined. Home ranges were traditional, overlapping between years, and when bats were in different reproductive conditions. Home range sizes and range spans of bats were smaller post-harvest than pre-harvest. Post-harvest home ranges of repeatedly radio-tracked female bats overlapped with their pre-harvest home ranges but changed slightly, suggesting that clear-fell harvest operations result in bats either moving slowly into less familiar areas or contracting their home ranges. A mosaic approach to clear-fell harvest will be most sympathetic to bats' needs to balance roosting and foraging opportunities.

Roosting and Foraging Behavior of *Taphozous australis* in the Central Queensland Coast Bioregion

Maree Cali, Tina Ball, and Eddie Adams, Qld. Department of Environment and Resource Management, QLD, Australia

We investigated the foraging behavior of the coastal sheath-tailed bat (*Taphozous australis*) from three locations in the Central Queensland Coast (CQC) bioregion, central eastern Queensland. A total of 15 roost sites were located and 43 bats were caught. Of the *T. australis*

captured, radio transmitters were attached to one female and six male bats. Roost and foraging locations were combined (795 fixes) to establish habitat mapping for the species in the CQC bioregion. *T. australis* tended to utilize airy boulder sea caves with multiple entries located on the rocky foreshore of peninsulas and were not located in caves further than 50 m from highest astronomical tide. Even though one bat was recorded traveling a distance of ~15 km from its roost site, all foraging was within 3 km of the coast, confirming previous speculations that this species is confined to the coast. Our results reveal that *T. australis* foraged in mangroves, mangrove ecotones, forest, and rainforest of the coastal lowlands and hillslopes. This information should be used to guide habitat protection for this species in the CQC bioregion, and perhaps throughout its geographic range. *T. australis* was also observed, on several occasions, taking advantage of insect aggregations attracted by artificial lights located in urban areas adjacent to remnant vegetation. As a result of this study, ~84,797 ha of known essential habitat and ~102,287 ha of potential essential habitat have been identified.

How Much Effort Is Enough? Survey Protocols for Detecting Bat Faunas in Urban Environments

Fiona Caryl[1], Rodney van der Ree[1], Caroline Wilson[1], Lindy Lumsden[2], and Brendan Wintle[3]; [1]Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne, Melbourne, VIC, Australia; [2]Arthur Rylah Institute of Environmental Research, VIC Department of Sustainability and Environment, Heidelberg, VIC, Australia; [3]Applied Environmental Decision Analysis Research Facility, School of Botany, University of Melbourne, Melbourne, VIC, Australia

The Australasian Bat Society makes recommendations regarding the survey effort, methods, and reporting of bat surveys conducted with acoustic detectors. Typical inventory surveys should involve detector deployment for at least three complete nights in each major habitat in the survey area, ideally in conjunction with capture methods. Although this is generally entirely feasible in forested environments, conducting bat surveys within urban areas is more problematic because of physical and social constraints. As part of a larger project investigating the impacts of urbanization on microbat faunas within Melbourne, we conducted a pilot study to develop a survey protocol specifically for surveying within urban environments. We determined bat species occupancy probabilities at 14 urban “green spaces” using two methods: 1) an acoustic detector left in situ for three entire nights and 2) an observer performed a 30-minute survey within 3 h of sunset on three separate occasions. We present results of species detectability rates between the two methods, which can be used to determine the minimum survey requirements required for impact assessments and species monitoring within urban environments.

Whose Calling? Developing a Tasmanian State-wide Bat Call Identification Key

Lisa Cawthen, Sarah Munks and Bradley Law, University of Tasmania, Australia; Forest Science Centre, Industry and Investment NSW, Australia

The incorporation of acoustical surveys into monitoring and research of Tasmanian bats has been largely hampered by the absence of a published state-wide bat call identification key. Bat calls were recorded from hand-released and free-flying bats using Anabat bat detectors. This poster presents my preliminary results into the inter- and intra-specific differences in the characteristics of the calls of Tasmania’s eight species of bats: Gould’s wattled bat

(*Chalinolobus gouldii*), chocolate wattled bat (*Chalinolobus morio*), eastern falsistrelle (*Falsistrellus tasmaniensis*), large forest bat (*Vespadelus darlingtoni*), southern forest bat (*Vespadelus regulus*), little forest bat (*Vespadelus vulturnus*), lesser long-eared bat (*Nyctophilus geoffroyi*), and the endemic Tasmanian long-eared bat (*Nyctophilus sherrini*). This key will be used in Anascheme to identify the calls collected as part of a larger study investigating how forest availability affects insectivorous bat habitat use, species composition, and demographics.

Echolocation Calls and Harmonics in Australian Horseshoe Bats

Roger Coles, School of Biomedical Sciences, University of Queensland, Brisbane, Queensland, Australia

The two forms of *Rhinolophus philippinensis* in Australia are size morphs and may represent separate species but all three versions of the genus, which includes *R. megaphyllus*, are very close genetically so the situation remains unclear. Interestingly, this group of bats is clearly separated phonically, particularly by the CF component of the echolocation call. Individuals of *R. megaphyllus* have CF ranges from 67–74 kHz forming a clinal variation with latitude along the east coast of Australia. With a much more restricted distribution in north Queensland and Cape York, variation in CF for both morphs of *R. philippinensis* is 27–35 kHz (larger) and 40–42 kHz (smaller) although observations are limited. To investigate the acoustical properties of these echolocation calls in detail, full bandwidth recordings (high speed digital sampling) have been made in the field, to study geographical variation and the harmonic structure. Typically, horseshoe bats emit a dominant CF component and heavily suppress the other harmonics making it impossible or very difficult to unequivocally determine the harmonic series. Limitations are imposed by the choice of bat detector, signal recording (distortions), and analysis methods, all of which can produce spurious harmonics. Therefore the echolocation calls of *R. megaphyllus* and both morphs of *R. philippinensis* have been recorded both in air and in a light gas mixture (heliox) under field conditions. This technique 'unmasks' the first harmonic and allows the harmonic structure of individuals' calls to be determined, and then the acoustical relationship between species can be determined definitively. The results show that each version of *Rhinolophus* relies on the second harmonic for normal echolocation call emission, despite the very low CF used by the large morph of *R. philippinensis*. Furthermore the first harmonics are not related in the Australian species or between the morphs. This finding contradicts the conclusion drawn for the echolocation calls of three size morphs of *R. philippinensis* found in Indonesia. It is claimed that 'harmonic hopping' between morphs is based on the same fundamental frequency, and may be leading to speciation. A re-examination of these published data from the Indonesian morphs suggests that the first harmonic frequencies are not in fact related as previously assumed.

Acoustic Identification of *Saccolaimus*

Chris Corben

With increased interest in surveying for the little known species *Saccolaimus saccolaimus* in northern Australia, a critical question is whether or not this species can be acoustically recognized from other species in the region. I compared the calls of *S. saccolaimus* recorded in Borneo with those of *S. flaviventris* recorded near Brisbane and found them to be surprisingly different and easily distinguished. With the caveat that things might be different in northern

Australia, I suggest that observers could easily be trained to quickly scan passive bat detector recordings and identify a substantial subset of *Saccolaimus* calls for survey purposes. Results from the work of other researchers in Cape York show that *S. mixtus* calls are much closer to *S. saccolaimus* than to *S. flaviventris*, complicating the identification of *Saccolaimus* in northeastern Australia.

A Successful Bleeding Technique Used on Australian Microchiroptera

Carol de Jong and Craig Smith, Biosecurity Queensland, Coopers Plains, QLD, Australia

Sampling blood from bats (Chiroptera) can be valuable for a range of studies including antibody detection for disease surveillance, analysis of blood biochemistry, and populations genetics. However, collecting sufficient volumes of blood, plasma, or serum from smaller microbats can be challenging. We describe a technique for sampling small quantities of blood from microbats and report the volumes taken from 1,129 bats. A sterile needle was used to puncture either the brachial or the propatagial vein. Blood was collected using a micropipette and sterile tip and immediately diluted 1:10 in phosphate buffered saline, eliminating the need for anticoagulants. On average we collected 4 µl of blood/g of the bats' mass (SD = 1.6; min = 0.1; max = 12.0) and partial clotting was observed in approximately 2% of samples. Extraneous bleeding was also observed so we recommend collecting less than 6 µl of blood/g of the bats' mass. No deaths were recorded whilst bats were in our care and we observed the short-term (3 months) survival of bats that we had sampled.

Hendra Virus: Ecology and Epidemiology

Hume Field, Biosecurity Queensland and the Australian Biosecurity Cooperative Research Centre for Emerging Infectious Diseases

Five of the thirteen recognized Hendra virus incidents in horses have involved transmission to humans, most recently in July 2009 when a veterinarian was fatally infected. Low infectivity but high case fatality rates are features of infection in both horses and humans. Infection appears not to transmit readily from bats to horses, from horse to horse, or from horses to humans. However, once infected, horses have a 75% probability, and humans a 50% probability, of a fatal outcome. Fruit bats are the natural reservoir of the virus. All human cases are attributed to exposure to infected horses; there is no evidence of bat-to-human transmission. Hendra virus can cause a range of clinical signs in horses, a legacy of its affinity for endothelial cells. The predominant clinical presentation may depend on which organ system sustains the most severe endothelial damage, and be influenced by route of infection and viral dose. Animal health authorities in Australia foster increased awareness, alertness, and preparedness in the horse-owning and veterinary communities, and encourage husbandry practices that minimize risk of exposure. Veterinarians should routinely consider Hendra virus as a differential diagnosis when presented with a febrile horse, should use a risk-based approach to personal protective equipment, and should maintain good infection control practices at all times. Minimization of the future occurrence and impact of Hendra virus requires an understanding of the factors that promote spillover from bats, an informed risk-based approach by owners and veterinary practitioners, and early involvement of animal health authorities. Research into effective vaccines and effective human therapeutics continues.

Landscape Genetics of Gould's Long-eared Bat (*Nyctophilus gouldi*) and the Lesser Long-eared Bat (*N. geoffroyi*) in Fragmented Populations of Southeastern Australia

Nicholas Fuller, Susan Carthew, and Steve Cooper, University of Adelaide

Bat fauna represents a significant proportion of global mammalian diversity (approximately 20%) yet we know little about how this mega-diverse order responds to major threatening processes such as habitat fragmentation. This project aims to address this issue by assessing and comparing population genetic structure and gene-flow across fragmented and continuous habitat in two species of long-eared bat (*Nyctophilus*), one of the most abundant and species rich Australian genera of bats. We have selected species with near-identical morphology but contrasting ecology and behavior in an attempt to assess variability in chiropteran sensitivity to this landscape threat. Gould's long-eared bat (*N. gouldi*) is a habitat specialist with a distribution limited to tall mature forests and has been listed as endangered in South Australia. In contrast, the lesser long-eared bat (*N. geoffroyi*) is a habitat generalist that displays a ubiquitous distribution across Australia and is commonly recorded within modified landscapes. We have collected 1200 samples throughout western Victoria and southeastern South Australia from 14 sites including 5 control sites within extensive continuous forest and 9 sites representing forest fragments of varying size and degrees of isolation. In addition to our primary objective we also plan to utilize our dataset to assess the genetic diversity and connectivity of the endangered and fragmented South Australian populations of *N. gouldi*, and to investigate dispersal strategies for each species to determine whether there is a sex bias in dispersal. We are currently developing 15–20 microsatellite markers for each species to facilitate our genetic analyses. Preliminary results will be discussed.

Torpor in Australian Bats: Implications for Energy Conservation, Predator Avoidance, and Minimizing Extinctions

Fritz Geiser and Clare Stawski, Centre for Behavioral and Physiological Ecology, Zoology, University of New England, Armidale, NSW, Australia

Torpor, which is characterized by substantial reductions in body temperature (T_b) and metabolic rate (MR), is the most effective means for energy conservation available to mammals and is widely employed by bats. Six of the seven Australian bat families from all climate zones, including the tropics, contain heterothermic species that are capable of using torpor. These are the Pteropodidae (blossom bats), Emballonuridae (sheath-tailed bats), Rhinolophidae (horseshoe bats), Hipposideridae (leaf-nosed bats), Vespertilionidae (e.g., long-eared bats), and Molossidae (free-tailed bats). The T_b in some hibernating Australian vespertilionids can fall to minima of 2–5 ºC, and the MR during torpor can be as low as 0.5% of that of active individuals. Further, recent evidence suggests that torpor may not only be important for energy conservation, but also for predator avoidance, because it is frequently employed by subtropical bats in summer when food is abundant, and especially when they are fat. The ability to reduce energy and thus foraging requirements in heterothermic mammals in general appears to be the main reason why only 6% of the confirmed extinct mammals over the last 500 years likely were heterothermic, whereas the vast majority of extinct mammals were homeothermic and unable to employ torpor. In mainland Australia, despite some range reductions, not a single bat species has become extinct, whereas many homeothermic rodents and marsupials have. This suggests that torpor use

permits mammals not only to survive adverse conditions, but also helps them in dealing with habitat degradation and introduced competitors/predators.

Microchiropteran Bat Activity in Coastal Salt Marsh on the New South Wales Central Coast, an Endangered Ecological Community

Leroy Gonsalves[1], Bradley Law[2], and Vaughan Monamy[1]; [1]School of Arts and Sciences, Australian Catholic University, North Sydney, NSW, Australia; [2]Industry and Investment NSW, West Pennant Hills, NSW, Australia

Coastal salt marsh is an endangered ecological community in New South Wales as a result of widespread mangrove transgression and urban encroachment. It provides suitable habitat for a large suite of arthropods, marine life, and migratory shorebirds. Recent surveys have revealed coastal salt marsh also to be an important secondary habitat for microchiropteran bats. We report the results of a detailed investigation of microchiropteran bat activity in three spatial zones within coastal salt marsh undertaken on the New South Wales Central Coast using ultrasonic bat detectors. Echolocation calls were collected concurrently along two salt marsh edges: landward (a salt marsh-casuarina ecotone) and seaward (a mangrove-mangrove ecotone), and within the interior. Anabat SD1 detectors recorded echolocation calls in each zone for four consecutive nights in March 2010. Calls were identified using automated call identification software in association with a suitable species key for the study area. A total of 1,232 bat calls were recorded. In all, 12 species and 1 species group were detected flying in salt marsh. Within each zone, 8 species and 1 species group were detected. Additionally, feeding activity was determined by identifying feeding buzzes. Feeding buzzes were recorded from two species (*Chalinolobus gouldii*, *Mormopterus ridei*) and one species group (*Vespadelus* spp.). A comparison of both total bat activity and feeding activity within each zone was made. The findings of this study will be of importance to land managers and wildlife biologists as both landward edges and salt marsh interior continue to decline as a result of the urbanization of fringing landward habitats and on-going mangrove transgression.

Are Salt Marsh Mosquitoes (*Aedes vigilax*) Important Prey Items of Little Forest Bats (*Vespadelus vulturnus*) Near Salt Marsh on the Central Coast of New South Wales?

Leroy Gonsalves[1], Bradley Law[2], Cameron Webb[3], and Vaughan Monamy[1]; [1]School of Arts and Sciences, Australian Catholic University, North Sydney, NSW, Australia; [2]Industry and Investment NSW, West Pennant Hills, NSW, Australia; [3]Department of Medical Entomology, University of Sydney and Westmead Hospital, NSW, Australia

An investigation of the importance of the salt marsh mosquito, *Aedes vigilax*, to the diet of the little forest bat, *Vespadelus vulturnus*, was undertaken on the Central Coast of New South Wales using a relatively new technique: fecal DNA identification. The impacts of broad scale mosquito control on bat diet are yet to be established. Investigating whether bats consistently select for mosquitoes at times of high and low mosquito abundance may allow for inferences to be made regarding the impacts of mosquito control on bat diet. Little forest bats were harp-trapped fortnightly over summer 2009/2010, in accordance with predicted fluctuations in the abundance of salt marsh mosquito populations associated with the tidal cycle. Trapped individuals were held in calico bags and guano produced in these bags was collected, stored dry, and frozen. Prey availability data were obtained for each trapping night using CO_2-baited

encephalitis virus surveillance (EVS) traps and standard light traps. DNA was extracted from pooled guano samples and a section of the 16S mtDNA was amplified using standard polymerase chain reaction (PCR) techniques. Amplified DNA was cloned and sequenced to provide DNA sequences of prey items to provide species-level identification. A comparison of bat diet was made between two tidal treatments (spring and neap) to distinguish whether mosquitoes are a consistent part of the diet of *V. vulturnus* or whether they are actively selected for during peaks in mosquito abundances. Additionally, inferences relating to the impacts of mosquito control on bat diet will be presented.

The Use of Bats for Environmental Education

Chris Grant, Department of Environment and Heritage, Berri, SA, Australia

The communication of environmental messages forms a significant component of the work of many bat workers. The authors are no exception, and have spent considerable time and energy developing ways to engage with people of all age groups. This presentation explores some of the ways to make environmental education effective using bats and bat themes. Harnessing the fun elements that can be associated with bats appears to be a powerful tool for dispelling other contrary and negative perceptions. This talk discusses some of the techniques we have found effective, including the secrets to the amazing Bat Cave©.

The Implications of the Black Saturday Bushfires on *Miniopterus schreibersii oceanensis* and *Myotis macropus* at Kinglake National Park

Rob Gration, SMEC Australia

On 7 February 2009, Victoria experienced its worst ever bushfires. The bushfires claimed 173 lives, 414 people were injured, and 2,029 homes were destroyed and displaced an estimated 7,500 people. One of the most severely impacted regions was Kinglake. Kinglake is located approximately 35 km north of Melbourne. The nearby Kinglake National Park, encompassing the Wallaby Creek Catchment area, covers an area of 22,340 Ha, approximately 98% of which was burnt during the bushfires. The resulting impact on flora and fauna is currently being assessed. I was commissioned by Parks Victoria to undertake post fire surveys for *Miniopterus schreibersii oceanensis* and *Myotis macropus*. Both species have been previously recorded at the base of the Wallaby Creek Catchment Area in the Toorourrong Reservoir. The objectives of the study were to compare the current survey results with historical data, to assess the impacts of the bushfires on *Miniopterus schreibersii oceanensis* and *Myotis macropus*, and to provide recommendations for their management. Two stationary Anabat® detectors were operated across seven sites for between one and seven nights at each site. The detectors were strategically placed to record bat activity levels, habitat utilization by bats in general but with an emphasis on *Miniopterus schreibersii oceanensis* and *Myotis macropus*, and to record bat calls that could be potentially attributed to the targeted species. The subsequent trapping program concentrated on areas where the calls of the targeted species were potentially recorded based on historical records. The survey results indicated a marked decrease in capture rates and roosting and foraging activity compared to the historical records. It is therefore implied that the 'Black Saturday Bushfires' had a significant impact on both *Miniopterus schreibersii oceanensis* and *Myotis macropus*.

What Factors Influence the Use of Roost Boxes for Insectivorous Bats under Bridges? A Case Study from Northern New South Wales

David Hannah[1], Ross Goldingay[2], and Mitchell Cambridge[1]; [1]Tweed Shire Council; [2]Southern Cross University

The Tweed Shire local government area is situated on the far north coast of New South Wales, Australia. Within the Tweed, some timber bridges are known to provide roosting habitat for insectivorous bat species including one threatened species, *Myotis macropus*. Many of these timber bridges, however, are being replaced with concrete bridges because they are reaching the end of their structural design life. To help mitigate the loss of roosting habitats, artificial roost structures in the form of timber boxes are being deployed under the new concrete bridges where bats have been known to roost. A number of box designs have been employed to date with variable success. Consequently, a program of monitoring a range of roost types for *M. macropus* in the shire has been initiated through a joint partnership with Tweed Shire Council and Southern Cross University. Ultimately, research aims to better understand the roosting requirements of insectivorous bats utilizing bridge structures with a view to optimizing the design of artificial roost habitat and minimizing long-term impacts to threatened insectivorous bats as a result of bridge upgrades in the shire.

Identification of Successful and Unsuccessful Treatments for Wing Injuries in Australian Flying Foxes

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The efficacy and efficiency of treatments for healing injuries on the wings of grey-headed flying foxes, *Pteropus poliocephalus*, have been tested. Effects of gender, open or closed wound, and wound severity on success of healing were not significantly different ($p < 0.05$), whereas the effect of injury site (e.g., over arm or membrane) was significantly different ($p < 0.1$). Treatment (listed below) was highly significant in its impact on the chance of healing success. Responses to treatment were quantified as duration for both the inflammatory and granulation phases of healing. The rate of wound healing was compared after moist and dry dressings, aqueous and oil-based topical treatments, and no intervention (controls). Over 300 injuries were allocated to seven treatment groups: 1) honey, 2) hydrocolloidal dressings, 3) spray bandage, 4) topical arnica, 5) aloe, 6) macadamia oil, and 7) oticleans. Unacceptable failure rates occurred with five treatment types: aloe (43%), arnica (29%), spray bandage (43%), oticleans (20%), and untreated (44%). If healing occurred, time for the inflammatory phase was unaffected by any variable. Predicted time is 10.60 days ± 0.98. Time for the granulation phase was impacted by injury category, site, severity, and treatment, e.g., 2.9 days (minor injury) to 32 days (severe injury). Differences between treatments were explored by testing bacterial growth. Honey inhibited bacterial growth but the effect of the hydrocolloidal and macadamia oil was minimal. The antimicrobial effect of honey is not likely to have contributed to its efficacy because wounds on flying foxes rarely develop infection. In contrast prevention of desiccation by oil or moist dressings may well have contributed to their efficacy.

Unexpected Patterns of Microbat Diversity among Habitats in the Urban Landscape

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Urban landscapes are mosaics of different habitat types, consisting of large areas of residential housing, roads and paved surfaces, interspersed with parks, vegetation remnants, industrial, commercial, and even agricultural land. Species composition can vary significantly between such habitats, even when species richness is similar. Although bats are an important component of vertebrate diversity, studies of bat assemblages in urban landscapes have mainly focused on species richness and bat activity, and have been largely confined to temperate regions of the Northern Hemisphere. We investigated the diversity of the bat fauna occurring within a large mosaic urban landscape in subtropical Australia. We assessed whether species richness, species composition, and bat activity varied between four broad habitat types: high-density residential, low-density residential, parkland, and native bushland remnants. Each of ten sites within each habitat (total 40 sites) was surveyed for bats on six non-consecutive nights using ultrasonic bat detectors. Fourteen species were identified from a total of 14,930 call sequences. The species richness of low-density residential areas was significantly higher than large parklands but statistically similar to that of remnant bushland. Bat assemblages in low-density residential and parkland habitats differed from those in remnant bushland and high-density residential habitats; however there was little difference between either low-density residential and parkland or high-density residential and remnant bushland. This was due to a number of species that were less common in both remnant bushland and high-density residential areas. In addition, levels of bat activity were highest in the low-density residential habitat. These results contradict previous studies of bat assemblages in urban landscapes, which report the highest levels of species richness, bat abundance, and activity in woodland habitats. Possible reasons for these unusual patterns of microbat diversity will be discussed.

Salt Marsh and Estuarine Habitat Use by Insectivorous Bats, Central Coast, New South Wales, as Revealed by Acoustic Bat Detection and Radiotelemetry

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Acoustic bat detection was used to compare habitat use by insectivorous bats over-flying salt marsh, coastal forest, and urban macrohabitats in summer 2008/09 on the Central Coast, New South Wales (NSW). In all, 15 species were detected and data were compared using one-way ANOVA and ordination plots. Greatest species richness and activity occurred in forest macrohabitat, followed by urban and salt marsh macrohabitats, which did not differ significantly from one another. In addition to acoustic bat detection, radio-tracking of one of the most commonly recorded species in salt marsh, *Chalinolobus gouldii* (n = 7), was used to explore detailed habitat preferences. The study area was divided into four focal macrohabitats, including estuarine, forest, urban, and water macrohabitats. Radio-tracking showed similar habitat use to that revealed by acoustic monitoring, with the majority of activity being recorded in forest macrohabitat. Sufficient data were obtained for six *C. gouldii* individuals to enable Kernel Density Estimates (KDE) and Minimum Convex Polygons (MCP) foraging ranges to be

constructed. Habitat compositional analysis showed that macrohabitats were mostly used in proportion to their availability within the foraging range areas. Salt marsh offered some species of insectivorous bats a suitable foraging resource, but when combined into the estuarine macrohabitat complex, this relatively small area was not used preferentially by *C. gouldii*.

Eucalypt Plantations: Do They Benefit Bats?

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Extensive areas of eucalypts are being planted for land rehabilitation and timber on previously cleared farmland. Environmental benefits are a major selling point for this land use change, but data concerning the response of biodiversity are scarce. We compared insectivorous bat activity within 4–6 year old eucalypt plantations with paddocks and remnant woodland in a heavily cleared agricultural landscape on the Liverpool Plains of northwest New South Wales. The ultrasonic survey of bats found that the plantings were typically used by 7–8 species and activity averaged 87 passes per night. However, the activity within plantings was similar to tree-less paddocks and it was about six times less than in small remnants. The very high activity levels and feeding buzzes in small remnants could be related to the widespread rich, basalt soils on the Liverpool Plains. Neither planting area nor shape influenced bat activity, but rather total activity and species richness was correlated positively with the number of remnant trees on the site. State forests supported the only records of two threatened species. Radio-tracking four different bat species supported the findings from the ultrasonic survey, in that plantings were not preferentially used by individual bats. The percentage nocturnal use of plantings was relatively small, although similar to the extent of plantation in the landscape immediately surrounding our tracking area. In contrast to providing foraging habitat, plantings did not provide roosting habitat. Most bat roosts were in tree hollows, which were absent in the plantings. Although decorticating bark was abundant in eucalypt plantings, only *Nyctophilus geoffroyi* was observed beneath bark and only in remnant trees. Overall, our results emphasize the importance of retaining remnant trees in the landscape and within plantings.

Bats in the Backyard: Developing Recommendations for Monitoring Threatened Long-tailed Bats (*Chalinolobus tuberculatus*) in an Urban Ecosystem

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Monitoring animal populations is crucial to formulating conservation and management strategies. This is especially important, yet challenging, for cryptic threatened species. We developed a non-invasive stratified monitoring design to identify the spatial and temporal changes in foraging activity. We aimed to use this information to establish optimal detection strategies for future research. Automated bat monitoring detectors were arranged in two tiers (between 15–30 m and 4–7 m). Bat activity was then measured across different nights, seasons, microhabitats (considering both vertical and horizontal dimensions), and environmental conditions (e.g., temperature). To maximize bat detections we recommend passively monitoring long-tailed bat activity using detectors placed at lower heights (4–7 m) in microhabitats with open spaces and internal water bodies (e.g., ponds and channels). Monitoring bat activity during the first 4 hours after official sunset over warmer spring and summer months is also likely to

yield the greatest number of detections. Our results should guide future monitoring, management and conservation efforts for this species with wider implications for monitoring bats in urban ecosystems.

A Successful Translocation Method for New Zealand's Short-tailed Bats (*Mystacina tuberculata*) Using Soft-release of Captive-bred Juveniles

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Since humans arrived in New Zealand less than one thousand years ago, one of New Zealand's three native bat species has gone extinct and the range and abundance of the other two species have declined dramatically under the impact of habitat destruction and predation by introduced mammals. In recent years, habitat destruction has slowed, but declines in bats continue as a result of predation by feral cats, rats, and mustelids. Similar impacts have been observed for most other components of the New Zealand's fauna. Consequently, mammalian predator control and translocation to predator-free areas are the principal method for conservation of many of New Zealand's threatened animal species. However, these methods have proved problematic for bats. Both species are wide-ranging tree-roosting species, which makes in situ conservation by predator control challenging. There have been no successful translocations of bats for conservation purposes, presumably because of bats' homing abilities. An initial attempt at translocating short-tailed bats to a predator free island in 1994 failed when the transferred bats disappeared shortly after release. In 2004 and 2005 the Department of Conservation attempted translocation of short-tailed bats from the Tararua Range in the North Island to Kapiti Island, a predator free island 5 km from the mainland. To avoid bats returning to their natal area, captive-born juvenile bats were transferred. Forty-two late-stage pregnant female bats were taken into captivity. Thirty-eight pups were born in captivity. After the pups were weaned the females were released at their capture site, and the 23 healthy remaining pups were transferred to an enclosure on Kapiti Island and held for an acclimatization period before being released. At least ten of the released bats remained free-living on the island, but occasionally feeding and roosting in the enclosure. The translocation method proved successful at overcoming the bats homing instinct, as bats remained on the island. However, the translocation failed, as eight months after release, the first cohort of bats were discovered to be suffering severe lesions to the pinnae, which were lethal without veterinary intervention. Subsequent observations showed the infection was probably a herpes virus contracted on Kapiti Island. Two-and-a-half years after the first transfer, twelve remaining bats were transferred to Auckland Zoo.

The Probable Extinction of the Christmas Island Pipistrelle: Causal Factors and Rescue Attempts

Lindy Lumsden, Arthur Rylah Institute, Department of Sustainability and Environment, Heidelberg, Victoria, Australia

The Christmas Island pipistrelle *Pipistrellus murrayi* was endemic to Christmas Island and was the only species of microbat on the island. The species was common and widespread in the 1980s. The first evidence of decline was in 1994. This decline continued rapidly, with the species progressively contracting westwards until by the mid-2000s it occurred only in the far west of the island. Decline trajectories suggested there was a high risk that that the species would go

extinct by 2008/09. As the cause of the decline was unknown, it was considered that the best chance of saving the species from extinction was to establish a captive breeding colony. Despite advocating for several years, stressing the urgent need to commence this program, the decision was delayed. By the time the Australasian Bat Society was given permission to undertake a rescue mission to capture the remaining few individuals in August 2009, it was too late. Only one individual could be located and despite innovative techniques being developed, it evaded capture and then also disappeared. It was last heard on 26 August 2009 and no further calls have been recorded. Reluctantly it was assumed that the species went extinct on that date. This presentation will discuss what went wrong and what lessons have been learnt that we can use to try and ensure other species do not suffer the same fate.

Landscape Patterns of Bat Activity Revealed by Simultaneous Anabat Call Detection and Spotlight Observation during Vehicle Transects in Forests in the Bega District, Southeast New South Wales

Dan Lunney[1], Harry Parnaby[1], and Chris Corben, [1]Department of Environment, Climate Change, and Water, Hurstville, NSW, Australia

We explored patterns of bat activity by vegetation type, elevation, and land tenure during vehicle transects across forests and farmland. We ranked 18 vegetation alliances into 5 categories based on broad patterns of soil fertility and moisture regimes, as a proxy for habitat productivity. Among the findings were that the proportion of bat calls recorded in each vegetation type departed significantly from time spent for most of the 21 species and phonic groups. Activity of most species was highest in the most productive vegetation types. Species with similar calls could be recognized by combining spotlight observation of flying bats with the call display of Anabat, thereby enabling a higher level of species recognition than from calls alone. Our results demonstrate that this approach has great potential to reveal differential habitat use by bats, a neglected area of research in Australia, and suggests that management prescriptions for bats need to pay greater attention to retaining the most productive vegetation.

Paleoecology of the Mount Etna Bat Fauna, Central-eastern Queensland

Sandrine Martinez, Unidel Group Pty. Ltd., Brisbane, QLD, Australia

In this study twelve microchiropteran fossil assemblages from Mount Etna, central-eastern Queensland, ranging in age from more than 500,000 years to the present day, were investigated. The principal aim was to assess the responses of insectivorous bats to Quaternary climate change in Australia. In particular, this investigation focused on the effects of increasing late Pleistocene aridity and the subsequent retraction of rainforest habitat on bat species and bat communities. Fifteen fossil bat taxa were identified; ten taxa were identified to the species level (*Macroderma gigas, Hipposideros semoni, Rhinolophus megaphyllus, Miniopterus schreibersii, Miniopterus australis, Scoteanax rueppellii, Chalinolobus gouldii, C. dwyeri, C. nigrogriseus,* and *Vespadelus troughtoni*) and five taxa were identified to the generic level (*Mormopterus, Taphozous, Nyctophilus, Scotorepens,* and *Vespadelus*). Paleoecological analysis of the fossil taxa revealed that bats have remained essentially stable in terms of species diversity and community membership between the mid-Pleistocene rainforest habitat and the mesic habitat that occurs today in the region. The single major exception is *H. semoni*, which went locally extinct at Mount Etna. The overall resilience through time of the bat species discussed herein is

perhaps due to their unique ecological, behavioral, and physiological characteristics as well as their ability to fly, which have allowed them to successfully adapt to their changing environment. This study highlights the importance of paleoecological analyses as a tool to gain an understanding of how bats have responded to environmental change in the past and provides valuable information for the conservation of threatened modern species, such as *H. semoni*.

Morphometric Variation through Time in the Australian Ghost Bat (*Macroderma gigas*) At Mount Etna, Eastern Queensland

Sandrine Martinez, Unidel Group Pty. Ltd., Brisbane, QLD

Middle and late Pleistocene faunal assemblages located at Mount Etna, central-eastern Queensland, document morphological change over the last 500,000 years in the carnivorous Australian ghost bat, *Macroderma gigas*. Fossil *M. gigas* specimens from Mount Etna differ from Holocene ghost bats from the same locality in being significantly smaller in craniodental features. The Pleistocene ghost bat populations from Mount Etna are more similar to modern populations from the Kimberley region, northwestern Western Australia, than colonies from elsewhere in Australia including Mount Etna Whether Mount Etna's Holocene ghost bat population is part of a continuous lineage evolving in situ since the late Pleistocene or represents recolonization by more northern populations of ghost bats remains unclear. Regardless, the morphological changes are likely to be an adaptive response to changes in prey availability as a result of increased aridity in central-eastern Queensland since the late Pleistocene.

Habitat Use by the East Coast Free-tailed Bat (*Mormopterus norfolkensis*) in the Hunter Region

Anna McConville, Bradley Law, and Michael Mahony, University of Newcastle; Forest Science Centre, Industry and Investment NSW

Few systematic, quantitative studies on microbats have investigated species-specific landscape-scale habitat use and most habitat models are based on presence-only records that span many years. This is particularly the case for rarely captured species such as *Mormopterus norfolkensis* (listed as Vulnerable under the New South Wales *Threatened Conservation Act 1995*). The aim of the study is to determine what factors influence landscape-scale habitat use by *M. norfolkensis* and to determine what particular elements within each landscape are important. A grid of 5 km x 5 km was placed over the Hunter region and each grid cell was classified into different landscape types according to the amount of vegetation cover and amount of urban land use; a total of 30 landscapes were randomly selected. From these, bat detectors were placed at each of four landscape elements within each landscape—cleared, paddock tree, riparian, and forest patch—with a total of 100 sites sampled. Activity levels of *M. norfolkensis* were compared across both landscape class and landscape element scale. A total of 231 *M. norfolkensis* passes were recorded during the study at 39% of sites sampled. Overall, cleared and semi-cleared landscapes were found to have higher activity levels than urban or forested landscapes. Of the landscape elements, riparian sites were found to have greater activity levels across all landscape types. Habitat models are being developed for the study area and will be discussed during the presentation.

Conserving Flying Foxes in Ipswich, Queensland, Australia

Debbie Melville, Noah's Ark Wildlife Coalition, Ipswich, QLD, Australia

The Woodend Flying Fox Colony in Ipswich is an important and permanent roost site for black (*Pteropus alecto*), grey-headed (*P. poliocephalus*), and little red flying foxes (*P. scapulatus*). Camp numbers fluctuate greatly but typically swell around September in time for the *P. alecto* and *P. poliocephalus* birthing season and again during summer when *P. scapulatus* arrive in large numbers. It is believed that the first flying foxes began using the site during the mid 1980s following the clearing of a nearby roost site. The last three decades have heavily involved a lot of human-flying fox conflict typical of roost sites around the country. To ensure flying foxes always have a roost in Ipswich, Noah's Ark Wildlife Coalition purchased a 7.5-ha property in 2004 (about 40% of the current roost site) and established the Noah's Ark Ipswich Bat Sanctuary. The main aim of this not-for-profit organization is to revegetate the heavily weed-infested property in order to save existing roost trees and plant native trees for the future and thereby encourage the flying foxes to move away from neighboring houses and utilize Sanctuary trees. Although the main aim is focused on providing suitable roost habitat, the group is also in the process of transforming the Sanctuary house into an Education, Rehabilitation, and Research Centre. The Centre has held rehabilitation workshops for local wildlife care groups, conducted community talks, and had local school students participate in education days where they were able to 'get up-close and personal' with some education flying foxes. The next goal is to complete an on-site release cage for orphaned and rehabilitated flying foxes.

Artificial Insemination of Captive *Pteropus* Species

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Threatening processes are decimating pteropid (flying fox) populations, with many species teetering on extinction. The survival of some species may depend upon the establishment of captive breeding programs. Artificial insemination (AI) can aid in the management of these captive populations, providing accurate knowledge of paternity. Global semen transport also eliminates transportation of live flying foxes and would facilitate the use of semen collected from free-ranging animals. To maximize fertilization the correct timing of AI is vital and requires the ability to detect estrus, which is difficult to do as pteropids have no overt behavioral estrus; therefore pharmacological induction of ovulation may be required. The small body size of pteropids (< 1 kg) also makes insemination beyond the vagina problematic. A preliminary AI trial combining estrus induction together with vaginal insemination was conducted using 20 female black flying foxes (*Pteropus alecto*) divided into three subgroups: AI, control, and ovariohysterectomized. Twelve were given 25 I.U. of pregnant mare serum gonadotrophin (PMSG) and inseminated with fresh diluted semen from one of eight *P. alecto* males. The four control females were given 25 I.U. PMSG and housed for one week with males and with the four ovariohysterectomized females, which received no PMSG. Weekly, then fortnightly, blood samples were collected from all females until the estimated parturition date. Progesterone levels were analyzed for evidence of ovulation and pregnancy. Assays revealed that no plasma concentrations were elevated above background levels. Additionally, palpation mid-way through the estimated gestation failed to confirm pregnancy and no female underwent parturition.

Monitoring Cave Bats Using Thermal Imaging and 'Poor Mans' Missile Tracking Software

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We have been trialing an automated counting system to measure populations of the vulnerable eastern bent-winged bat (*Miniopterus schreibersii oceanensis*) at two of the three known large maternity colonies in New South Wales, Church Cave at Wee Jasper and Drum Cave in Bungonia State Conservation Area. The Thermal Target Tracker (T3) system, developed by Bruce Sabol and Eddie Melton of the U.S. Army Engineer Research and Development Center, is based on a thermal infrared video camera that captures video footage of moving objects (such as missiles). We have used the T3 system to track bats as they exit or enter a roost; the thermal camera captures the heat that is radiated by the bat, enabling it to be distinguished against the static background. The video footage is digitally processed, allowing flying bats to automatically be tracked and counted. To assess the accuracy of the T3 system, manual counts were conducted using the infrared thermal video footage. From comparisons of manual counts versus the T3 counts the results are extremely promising, with the majority of the fly-out counting errors within 1.5% of the manual counts. We estimate the adult population at Church Cave was 17,797 bats in 2008/09, and 16,425 bats in 2009/10 (7.7% lower). The combined adult and juvenile population was estimated to be 26,150 in 2008/09 (breeding/weaning success rate of 46.9%) and 30,173 in 2009/10 (breeding/weaning success rate of 83.7%). The adult population estimate for Drum Cave was 19,287 bats in 2009/10, with a combined adult and juvenile population of 35,361 (breeding/weaning success rate of 83.3%).

Morphometrically Defined Stages of Fetal Development in Flying Foxes

Gemma O'Brien, Renee Gear, and Judith Hopper, Human Biology & Physiology, University of New England, NSW, Australia

Identification of environmental hazards that may reduce the reproductive success of flying fox populations, and assessment of prematurity in affected individuals, depends on understanding normal fetal development in these species. The present study derived a developmental timeline from morphometric analysis of external anatomical structures. Specimens of 43 fetal and newborn *Pteropus poliocephalus* were available, either fixed or frozen. Structures were measured in situ (in mm), and body mass (BM) was measured to the nearest gram. Structures measured included head length (HL), ear length, crown-rump length (CRL); elements of the forelimb: forearm length (FAL), distance from shoulder to elbow, length of the whole thumb, the proximal phalanx of the thumb (digit 1), outstretched 2^{nd}, 3^{rd}, 4^{th}, and 5^{th} digits, length of the 1^{st}, 2^{nd}, and 3^{rd} phalanges of the third digit, and the claw and joint on the thumb and 2^{nd} foredigit; and hindlimb: foot length, and all hind digit claws. Measurements were graphed against FAL to determine the pattern of growth for each structure. Growth of HL, ear pinna, thumb claw, 2^{nd} claw, mean toe claw length, and foot length occurred at two different rates—initial rapid growth was followed by slower growth. Switching from fast to slow indicates a gene switching time point. These time points identify boundaries between discrete developmental stages that end when FAL is approximately 40 mm, 57 mm, 68 mm, and 88 mm. Features that were not useful included BM and CRL, which are not linear, and the remaining features that grow at a constant rate during the fetal period.

The Problem with Linkage: Do Bats Really Save Energy by Linking Flight with Call Production?

Stuart Parsons, School of Biological Sciences, University of Auckland, Auckland, New Zealand

Most aerial hawking bats typically produce a single echolocation call per wingbeat cycle, with calls produced either late in the upstroke or early in the downstroke. The timing of call production correlates with the action of wing adductor muscles in the thorax. The contraction of adductor muscles is thought to increase abdomino-thoracic pressure, which should increase subglottal pressure for the production of high intensity echolocation calls. This is the theoretical mechanism by which the action of the wing muscles allows the bats to produce echolocation calls without any additional energetic input—bats are already compressing the thorax, so shouting at the right time costs almost nothing. However, closer inspection of the literature highlights three major problems with the current linkage hypothesis, several of which have been evident since the earliest studies. First, bats inspire on the downstroke. Can echolocation calls be produced when bats are breathing in? Second, at least half the bat species studied to date do not produce echolocation calls at the predicted phase of the wingbeat cycle. Although these species do produce calls during expiration, production coincides with the contraction of muscles incapable of increasing subglottal pressure. Third, bats that are agile on the ground, such as the common vampire bat and the New Zealand lesser short-tailed bat, echolocate while on the ground at rates and intensities equivalent to those produced in flight. Is the cost of terrestrial locomotion so much lower than that of flight that bats can afford both without linkage, or could some other as yet undescribed mechanism be at work? In this talk I will review the anatomical, physiological, and biomechanical evidence for linkage of echolocation call production with flight, and highlight where current theory falls short in providing an adequate explanation for observed phenomena. I will then propose new theories and new research that may help better explain the exceptions to the linkage rule. Finally, I will speculate about how terrestrially agile bats might afford biomechanically independent echolocation and locomotion.

Mass Abandonment of Grey-headed Flying Fox Pups at Canungra in 2008

Trish Paterson-Wimberley, Australian Bat Clinic, Advancetown, QLD, Australia, and Wildcare Australia, Gold Coast, QLD, Australia

During November 2008, following a major storm event, grey-headed flying fox (*Pteropus poliocephalus*) pups were found abandoned at the Canungra flying fox camp on Queensland, Australia's Gold Coast. Wildcare Australia wildlife rehabilitators were first on the scene and joined forces with the Environmental Protection Agency, other wildlife care groups, and veterinarian staff, from the Sunshine Coast south to the Queensland border. Dead and dying pups on the ground or still hanging in trees or shrubs were stabilized on-site before being transported to the Australian Bat Clinic for veterinary assessment and hospitalization. Over 340 live pups were rescued over a 3-day period with many suffering from pneumonia, severe dehydration, exposure, fractures, and wing membrane damage, which resulted in the subsequent death of approximately 10% of these pups. Vaccinated volunteers worked 24 h around the clock for the next 3–4 months at the Australian Bat Clinic feeding the orphans, while unvaccinated volunteers provided a constant supply of sterilized bottles, milk formula, and clean wraps for use by the vaccinated volunteers (and kept the latter well fed as well). After an initial 4-wk stabilization period, approximately 80 pups were transferred to other local bat organizations, leaving over 200

pups at the Australian Bat Clinic. As the pups thrived and moved onto solids the primary (and mammoth) task was preparing cut fruit, which took ~6 h/d. Thanks to the overwhelming support during this event, the large influx of orphans was relatively easily managed, and all Canungra pups were successfully released by the Australian Bat Clinic.

The Steady Movement and Integration of the Black Flying Fox, *Pteropus alecto*, into the Camp at the Current Southern Limit of its Range — The Royal Botanic Gardens, Sydney

Tim Pearson, Ku-ring-gai Bat Conservation Society

The range of the black flying fox, *Pteropus alecto*, has been expanding steadily southwards over recent years. From being found no further south than the New South Wales-Queensland border in the late 1980s, the current southern limit of their range is the Royal Botanic Gardens, Sydney, where the species has been present since 2005. Since March 2006 the numbers and behavior of *P. alecto* in the Royal Botanic Gardens have been closely monitored. This paper reviews how the numbers of *P. alecto* have fluctuated over the period, both in themselves and in relation to the substantially larger population of the grey-headed flying fox (*P. poliocephalus*) in the camp. It also looks at how over time the population of *P. alecto* has utilized different roost locations within the camp, the composition and behavior of the group, and their interaction with *P. poliocephalus*.

An Investigation of Weather Protection Devices on Anabat Detectors and their Impacts on Detector Performance

Michael Pennay, NSW Department of Environment, Climate Change and Water, Queanbeyan, NSW, Australia

Anabat bat detectors, commonly used for passive monitoring of bats, can easily be damaged by rain and require some form of weather protection. Common devices to protect the microphone from damage include sound reflection devices, tubing over the microphone, or weather proof membranes. Despite the widespread use of weather protection devices, there is little quantifiable analysis of the impact these devices have on the capacity of the detector to record bat species. The impact of a range of weather protection devices were measured in two experiments: 1) a controlled threshold experiment measuring the maximum distance two sample tones could be detected from a static detector, and 2) a field experiment aimed at quantifying the impact of weather protection devices on the actual detectability and identification of real bats in a natural situation. The field experiment revealed no significant difference between detectors or nights, but there was a significant difference between weather protection treatments. The threshold experiment revealed that all weather protection devices reduced the range of the detector down the central axis, however one weather protection device had a greater overall range than the control. The results demonstrate that weather protection devices can have a significant impact on the performance of the detector including its range, the number of identifiable calls, and number of species recorded. Only one weather protection device tested in this study did not result in the significant loss of data or range. The potential impact of weather protection devices should be seriously considered by those designing studies or experiments where they are to be used.

A Simple Technique Using Geographic Information Systems (GIS) to Measure Bat Airframe Morphology

Michael Pennay, NSW Department of Environment, Climate Change and Water, Queanbeyan, NSW, Australia

Traditionally measurements of bat morphology for the study of flight mechanics or airframe design has involved tracing the outline of bats, or complex calculations of surface area based on a series of linear measurements of body parts. This poster describes a simple and accurate technique to measure bat wings and flight membranes (or any other object) for morphological studies using a Geographical Information System (GIS) package (ArcGIS). As the name suggests, GIS programs are traditionally used for mapping and measuring geography and land systems at large scales, but using standard tools and techniques GIS can be a powerful tool for measuring objects in the macroscopic (or even microscopic) scale.

The Bat Fauna of Yanga National Park and the Lowbidgee Region of New South Wales

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Yanga National Park is a large floodplain conservation reserve on the Murrumbidgee River downstream of the Lachlan junction. Due to drought and over extraction of water for irrigation, large parts of the floodplain are highly stressed. Some parts of the reserve have received environmental water allocations to support ecological assets. A bat survey of Yanga by the Australasian Bat Society in March 2009 found 12 microbat species occur within the reserve. The survey revealed extensions in the known range of three species, including the first records of *Myotis macropus*, *Vespadelus darlingtoni*, and *Nyctophilus gouldi* on the lower Murrumbidgee River. Prior to the surveys the bat fauna of the reserve was unknown. Some bat species captured were exceptionally small, the mean weight for individuals from three species was > 30% less than the average weight in for the species in New South Wales. The bats with the greatest deviation in body mass were generally those at the edge of their range. The observations generally supported Bergmann's rule, which states that body mass decreases with increased aridity. The environmental watering appeared to have a positive affect on bat activity with high capture rates in these areas. Greater levels of activity were recorded on bat detectors in watered areas than those in unwatered areas. A small number of white-striped mastiff bats were also radio-tracked to roosts, all of which were very large river red gums fringing Mercedes Swamp, an irrigated wetland. This suggests that microchiropteran bats are also beneficiaries of the environmental water allocations.

Effect of the Lunar Cycle on Body Temperature and Activity Patterns of the Eastern Tube-nosed Bat (*Nyctimene robinsoni*) in the Australian Tropics

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Pteropodid bats, such as *Nyctimene robinsoni* (body mass ~ 50 g) forage at night and rely on vision to find their food sources and thus are likely affected by changing predation pressure during nocturnal illumination, such as during different phases of the moon cycle. Therefore the

aim of our study was to investigate how the lunar cycle influences daily body temperature and hence the energy balance in a small free-ranging bat in a tropical environment. Daily body temperature (T_b) fluctuations in five free-ranging bats were measured via radio-telemetry using implanted temperature-sensitive radio transmitters. Average daily core T_b ranged from 34.7 ± 0.6 to 37.3 ± 0.8 °C (mean ± SD) over an average daily T_a range of 17.1 ± 1.1 to 23.5 ± 1.8 °C. On days at moon illumination of 51–100 % ("Full moon period") T_b on night hours of 22:30–04:30 was significantly lower ($P < 0.001$) than during the "New moon period" (illumination of 0–50%) with no differences among individuals ($F_{1, 523} = 0.76$, $P = 0.385$). These T_b differences during the lunar cycle reflect changes in intensity of activity, which are likely due to increased predation pressure during moon-lit nights. Our study provides the first evidence in a mammal that moon illumination results in a substantial reduction in T_b, which has implications on foraging and energy expenditure.

Rapid Bat Biodiversity Surveys in Developing Countries: Guesswork Meets Knowledge in Unexplored Ecosystems

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In developed countries such as Australia there is a great deal of background information upon which more than adequate bat fauna assessments can be based. Such is not the case in the Third World where very little previous work has been conducted, especially the documentation of microbat echolocations calls, which avail the use of Anabat systems. Considering that major agencies such as the World Bank now require high standard EIS's for key developments, this paper discusses the trials and tribulations of studying in remote Southeast Asian locations, and outlines methods that can be used for generating biodiversity assessments in previously unexplored ecosystems. The primary survey method using call detection is refined by using mnemonics generated from the basic characteristics of unidentified calls. Bats are initially identified by a "code," which allows later identifications as live bats are captured and reference calls are obtained. Through this method, even though at the end of a survey some species may still be unidentified, they remain as conservation units and allow refined conservation planning to be carried out.

Bat Occurrences within Cape Range Peninsula, Western Australia

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To date 14 species of bats have been recorded within Cape Range Peninsula and include 1 megachiropteran and 13 microchiropteran species. The records were determined from a variety of detection methods with varying levels of certainty. Since 2005, there have been three studies, primarily focusing on cave-dwelling bats, aimed at elucidating which bat species occur within Cape Range. Detection methods included echolocation call analysis for all three studies while two studies also trapped individuals for identification purposes. Previous records are derived from anecdotal observations from Cape Range National Park staff or from specimens from either the Western Australian Museum or from the personal collection held by Norm McKenzie. Nine species are recorded from either specimens or capture detection: *Pteropus alecto, Taphozous georgianus, Chalinolobus gouldii, Nyctophilus arnhemensis, N. geoffroyi, Vespadelus finlaysoni, Chaerephon jobensis, Mormopterus loriae,* and *Austronomus australis*. *Mormopterus beccarii* was detected with high certainty using bat ultrasound detectors while *Saccolaimus flaviventris*

and *Scotorepens greyii* were detected with only moderate certainty. Two species ranked as vulnerable, from a conservation perspective, also potentially occur within Cape Range: *Rhinonicteris aurantia* and *Macroderma gigas*. The Western Australia Museum has a record of a preserved specimen of *R. aurantia* from the Cape Range Peninsula and there have been unconfirmed sightings of *M. gigas* within the region. Because of the at-risk nature of these species, range expansions would have conservation implications. Further studies within the Cape Range Peninsula are necessary to conclusively determine if *M. gigas* and *R. aurantia* inhabit the peninsula.

The Effect of an Invasive Vine (*Merremia peltata*) on Productivity in the Common Rainforest Tree *Dillenia biflora* and Access for Its Bat Pollinators in Fiji

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Merremia peltata is an invasive vine that smothers rainforest and garden areas in Fiji. The vine blankets tree canopies, but how the species affects forest processes is unknown. We followed flower and fruit production in the common rainforest tree *Dillenia biflora*, a bat-pollinated species, in covered and uncovered treatments. We selected 10 study trees covered in *M. peltata*, and then removed the vine from half. The number of buds, flowers, and fruits was then noted each month from August 2009 to May 2010. Evidence of bat visits to flowers was recorded via bite marks. Preliminary results show trees that had *M. peltata* removed produced significantly more buds and flowers than did covered trees, although the flower abortion rate was also higher. The proportion of flowers visited by bats was not different between treatments; however, uncovered trees produced far more fruits than did blanketed trees. The study shows that *M. peltata* decreases forest productivity, including resources for bats. We emphasize the need for *M. peltata* control in protected rainforest reserves.

Colony Structure and Historic Patterns of Gene Flow in *Chalinolobus morio* from Southeast Queensland as Revealed through MtDNA Investigation

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The genetic structure of three maternity colonies of the chocolate wattled bat in southeast Queensland was investigated through analysis of sequence divergence in two hypervariable domains in the mitochondrial (mtDNA) D-loop region. Maternity colonies were located at the Bunya Mountains, Mt. Glorious, and Squirrel Creek. Overall, mtDNA diversity in each colony was found to be remarkably similar (FST indices 0.14557–0.14760) and within each colony, males and females were found to be more closely related to one another than they were to either sex from other colonies. A network analysis of the data clearly indicated two ancient populations that were genetically isolated for a period of time and have now recombined. These clades are separated by 14–15 mutations (4.9% divergence) and are now represented in each of the maternity colonies sampled, although their representation is asymmetric. Similar levels of mtDNA divergence (4–7%) have been used to infer restrictions to gene flow during the Pleistocene ice ages in Europe (*Myotis myotis*). It is possible that in eastern Australia, the onset of an exceptionally dry period from 170,000 to 205,000 years bp, precipitated range retractions and restricted gene flow between refugia. This pattern also is suggested by recent paleoecological investigations of Chiroptera in this region. A mismatch distribution of the data

and associated indices strongly suggests population expansions after this time and the star-shaped network analysis pattern of each clade also is suggestive of recent population expansion.

Roosting Ecology of Three Microbat Species with Differing Success in an Urban Landscape, Sydney, New South Wales, Australia

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Maintaining biodiversity in urbanizing landscapes has become a pressing issue around the world. However, the causative mechanisms for success or failure of wildlife to establish in the urban setting remain largely unresolved. A lack of suitable refuge in urban areas is a common explanation, which for microbats means a lack of roosting opportunities. However, roosting requirements for many species are poorly known. This study examines species-specific differences in roosting behavior between three species in urban remnant bushland at Cumberland State Forest, Sydney, New South Wales, Australia. Over two tracking periods (March 2009 and November–December 2009) we radio-tracked 27 individuals from three species including Gould's long-eared bat, *Nyctophilus gouldi*; Gould's wattled bat, *Chalinolobus gouldii*; and the eastern broad-nosed bat, *Scotorepens orion*. Individuals were located during the day on foot and were triangulated at night for every night the transmitters remained attached. Random trees available to bats (defined as containing at least one hollow, or had shedding bark able to house a bat) but not occupied by bats were also measured at a local and forest scale. Tree measurements included a hollow density index, tree diameter, tree height, and senescence. Roost trees will be compared to those randomly available in the landscape at both the roost tree and forest level. Differences between species preferences such as characteristics of roost trees, roost locations, cavities selected, roosting group size, and roost switching behavior will be discussed. Both dead and live trees were used as roost sites and species differed in their use of roost trees within and outside of the remnant. Data will be used to gain an understanding of how roosting strategies differ between these species and why some species may benefit over others in urban environments.

Urbanization and Its Effects on the Distribution and Activity of Insectivorous Bats in Sydney, Australia

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Urbanization affects indigenous fauna in many ways; some species persist and even increase in urban areas, whereas others are lost. This study examines the impacts of urbanization and habitat loss on insectivorous bats across the urban landscape of Sydney, New South Wales, Australia. We present data on species richness and activity (bat passes per night) collected systematically using ultrasonic bat detectors from 30 randomly selected landscapes (each 25 km^2). To compare the relative effects of habitat cover and level of urbanization, landscapes were categorized using a Geographical Information System (GIS) into classes including: urban (> 5 dwellings/ha and < 10% vegetation cover); suburban (10–40% vegetation cover); and vegetated (< 5 dwelling/ha and > 40% vegetation cover). Within the 'suburban' landscape category, we

also investigated a landscape productivity hypothesis and compared the relative effects of contrasting geology (shale, sandstone, and shale/sandstone transition) on species richness and activity. Four landscape elements were sampled within each landscape, including remnant bushland (> 2 ha), riparian areas, open space/parkland and residential/built space (n = 6 replicates of each landscape, 120 survey sites total). Nightly activity and species richness were compared across all landscape categories and elements. Both nightly activity and species richness were significantly higher in intermediate areas along the urban gradient, in suburban landscapes. Average nightly activity was significantly higher in bushland sites compared to open space sites, across all landscape categories. There was no clear effect of habitat element sampled on species richness, and there was no landscape by element interaction. Variation in underlying geology underpinned variation in activity and richness between landscapes. We suggest that productivity in shale areas is higher thus affecting insect density and bat response.

Radio-tracking Study of *Tadarida australis*

Margaret Turton, Australia

The white-striped free-tailed bat (*Tadarida australis*) is a large insectivorous molossid that occurs across southern Australia. Monitoring of a maternity colony of this species has been carried out over a period of several years. In April, the population of the maternity colony decreases as the juveniles become independent, and adults also leave for other areas. At present there is no information as to where the juveniles or adult bats disperse when they leave the roost at the end of the maternity season. This study was aimed at gaining a better understanding of the movements of adult and juvenile *T. australis* when they leave the main maternity roost at the end of the breeding season. Five *T. australis* were radio-collared and radio-tracked to both day roosts and foraging areas. Extensive movement between roosts by the bats was noted, with bats moving between the main roost (in a building) and tree spout roosts in scribbly gums (*Eucalyptus haemastoma*) located in adjoining woodland. Results from this study will be presented and findings discussed.

Population Dynamics and Camp Health of a Recently Relocated Colony of Grey-headed Flying Foxes

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In 2003 a colony of grey-headed flying foxes (GHFF) was relocated from the Royal Botanic Gardens Melbourne (RBGM) to Yarra Bend Park in Kew. Since early 2004, an extensive research and monitoring program on the colony and camp at Yarra Bend has been undertaken to provide basic ecological information on the species and inform management actions. This research includes regular estimates of population size (monthly fly-out counts and fortnightly static counts), reproductive output, sex-ratios, and mortality rates within the camp. We also conducted a 2-year study to assess the reliability of static counts using a double-blind approach. Regular counts at the other Victorian camps (e.g., East Gippsland and Geelong) have also been undertaken. The health of the vegetation has included repeated assessments of the extent of defoliation using fixed-point camera surveys and subjective assessments categorizing trees on a

range of "health" criteria. The colony of GHFF at Yarra Bend has continued to fluctuate seasonally as it did at the RBGM, with winter lows between 5,000 and 10,000 individuals, and summer peaks typically reaching ~25,000–30,000 bats. Approximately 80% of females appear to raise young each year, with very low rates of mortality within the camp, except after extreme high temperatures (> 39–40ºC) when hundreds to thousands of bats have been collected. The trees that GHFF occupy year-round have also been impacted, with higher rates of defoliation recorded. The colony of GHFF at Yarra Bend remains an important camp for the species and on-going management must continue to focus on making the roosting vegetation sustainable in the long term.

The Effects of Urbanization on the Diversity and Abundance of Nocturnal Insects: Implications for Microbat Conservation

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The few studies focusing on microbats in cities indicate that urbanization has a negative effect on species richness and diversity, probably due to a reduction in the availability of prey and roost sites. However, quantitative data on the effect of urbanization on resource availability and how this influences microbat populations are currently lacking. Therefore we aim to quantify the relationship between the diversity and foraging activity of microbats in urban areas and the diversity and abundance of their invertebrate prey. We also aim to investigate the habitat and landscape variables that influence insect distribution. This study was carried out between January and March 2010 in the city of Melbourne, southeast Australia. Nocturnal aerial insects and microbats were sampled at 60 study sites distributed along an urban-rural gradient. Ten sites each were located within six land-use categories (industrial areas, residential areas, golf courses, recreational parks, remnant bush reserves, and riparian vegetation), representing varying levels of human modification. Light traps were used to survey insects at each of the study sites, and Anabat detectors were set up simultaneously to record microbat activity. Results will be presented on the effects of urbanization on microbat prey availability. This study will help us manage urban areas more effectively to conserve both microbats and their prey, and help determine why microbats respond negatively to urbanization. Practical implications for management will be discussed. As part of this research project, we will also examine microbat roosting behavior and seasonal roost tree characteristics in an urban environment over the next few years.

The Establishment of the Australian Bat Clinic and Wildlife Trauma Centre

Terry Wimberley and Trish Paterson-Wimberley, Australian Bat Clinic, Advancetown, Queensland, Australia

Seeing the need to develop a specialist bat facility on Queensland's Gold Coast, we began development of the Australian Bat Clinic in 2000. We traveled to learn from bat specialists in the United States, South Africa, Mexico, the Amazon, and Madagascar. Plans were drawn up for the

construction of specialty treatment and food preparation rooms at our home and construction was completed in October 2007. A large purpose-built flying fox flight aviary was completed in time for the release of flying fox orphans from the 2008/09 season. The fully incorporated, not-for-profit Australian Bat Clinic and Wildlife Trauma Centre officially came into being in February 2009. The clinic is a specialist center for both mega- and microchiropterans and thus far we have treated 6 megabat and 19 microbat species. Wounds in other wild animals species—marsupials, birds, reptiles, and platypus—also are managed. The clinic liaises heavily with several veterinarians including those from the Australian Wildlife Hospital Beerwah, Currumbin Wildlife Hospital, and Dreamworld. Numerous volunteers regularly donate their time to ensure all wildlife receive the best care. Bat education and trauma workshops are conducted at the center and have been attended by wildlife rehabilitators, veterinarian staff, researchers, and university and TAFE students from across Australia, and also by international bat groups. Plans are in place to establish an official on-site education center where the general public can learn about the ecological importance of bats.

Taxonomy, Population Genetics, and Conservation of the Critically Endangered Southern Bent-winged Bat (*Miniopterus schreibersii bassanii*)

Rebecca Wood and Belinda Appleton, Genetics Department, University of Melbourne

It is integral to the effective long-term management and conservation of populations that taxonomic relationships are understood and resolved. This research aims to clarify the taxonomy of the Australian complex of the large bent-winged bat (*Miniopterus schreibersii*) with a particular focus on the critically endangered southern bent-winged bat (*M. s. bassanii*). Using mitochondrial, microsatellite, and nuclear genetic markers, investigation into historical and contemporary population structure has provided insight into the interactions and evolutionary relationships within and between populations of the two southern forms, *M. s. bassanii* and *M. s. oceanensis*. Despite the overlapping ranges of these two taxa, the genetic, morphological, and ecological differences observed indicate that they may in fact be reproductively isolated, thereby warranting recognition as distinct species. A major concern for *M. s. bassanii* is not only their declining populations but also the low genetic variation observed. As this is likely to have a long-lasting impact on their viability in the long-term, efforts should focus on promoting habitat quality and demographic stability, at least in the short-term. The importance of this research in establishing the taxonomic status and population structure of *M. s. bassanii* is emphasized by the continued decline of populations and the imminent need for their effective management and conservation.

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ANNOUNCEMENTS

2011 Student Research Scholarship Program—Bat Conservation International

Bat Conservation International is now accepting applications for its 2011 Student Research Scholarships. BCI will award 15–20 scholarships of up to $5,000 each for the 2011–12 academic year. Grants will be awarded for research 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. About 10 of these scholarships are supported by the U.S. Forest Service International Programs specifically for research conducted in developing countries. Students enrolled in any college or university worldwide are eligible to apply for BCI scholarships. Applications are competitive and will be reviewed by bat scientists outside BCI. The **application deadline** for 2011 scholarships is **15 December 2010**. Information and the on-line application form are available at http://www.batcon.org/scholarships.

Bat Conservation International Needs Kids to Vote!!

Bat Conservation International's "Philippines Bats: Extinction and Discovery!" project was one of five conservation efforts selected by The Walt Disney Company for funding through Disney's Friends for Change: Project Green. By voting, kids will decide how $250,000 will be distributed among the five different programs. The amount each project receives depends on the percentage of votes received, with the first place receiving $100,000! Ask kids ages 5–18 to help BCI win $100,000 to save bats by voting at http://disney.go.com/projectgreen/explorevote.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*.

Change of Address Requested

Will you be moving in the near future? If so, please **send** your **new postal and e-mail addresses** to Margaret Griffiths (griffm@lycoming.edu), and include the date on which the change will become effective. Thank you in advance for helping us out!

FUTURE MEETINGS and EVENTS

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

23–25 February 2011
The joint meeting of the Southeast Bat Diversity Network, the Northeast Bat Working Group, and the Midwest Bat Working Group will be held in conjunction with the 21st Colloquium on Conservation of Mammals in the Southeastern United States, in Louisville, Kentucky, on 23–25 February 2011. Information is available at http://www.sbdn.org/meetings.html.

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

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

2012
The 15th Australasian Bat Society Conference will be held in Melbourne, Australia, dates TBA.

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

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Front Cover

The logo on the front cover was drawn by Emily Snode (University of Northern Colorado, Greeley, Colorado) for the 40th Annual North American Symposium on Bat Research. The meeting was held in Denver, Colorado, October 27–30, 2010, and was hosted by Rick Adams (University of Northern Colorado, Greeley, Colorado). Many thanks to Emily and Rick for sharing the logo with us.

BAT RESEARCH NEWS

Volume 51: Number 4 Winter 2010

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

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Institutional/Group subscriptions	US $50.00
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Bat Research News is ISSN # 0005-6227.
Bat Research News is printed and mailed at Lycoming College, Williamsport, Pennsylvania 17701 U.S.A.

This issue printed December 20, 2010.

Abstracts of Papers Presented at the

40th Annual North American Symposium for Bat Research
Denver, Colorado
27–30 October 2010

The following abstracts are from papers presented at the 40th Annual North American Symposium on Bat Research (NASBR). They were compiled and submitted by Gary Kwiecinski, 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 40th Annual NASBR follows the abstracts.

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

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

The Evolution of Flight in Bats: Ontogeny and TAIL Locomotion Reveal New Insights
Rick A. Adams, University of Northern Colorado, Greeley, CO

Current scenarios outlining the evolution of flight in bats have little-to-no empirical support. Using ontogeny of flight as a surrogate for evolutionary patterns, I employed high-speed videography to investigate functional dynamics of flight development to parse out potential transitional stages from a nonvolant to volant mammal. The recent discovery of extensive and complex use of the uropatagium during flight (Tail-Assisted-Inertial-Lift, or TAIL) in vespertilionid bats and its relationship to body mass (R^2 = 0.33, R = 0.58, P < 0.05), along with morphological adaptations indicating an ancient evolution of this flight mode, compel a new consideration of flight ancestry for bats. Integrating data on ontogeny, morphology, and performance with mechanics and kinematics of TAIL locomotion and associated adaptations, I put forth a new interpretation and a unique hypothesis concerning the origin of flight in mammals.

"Being a Bat's Friend" and Walt Disney: Love at First Ultrasound
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The goals of the project initiated in 2006 by the Natural History Museum of Florence, "*BAT BOX – Un pipistrello per amico*" (Being a Bat's Friend), are to raise the appreciation of bats in Italy and to encourage everybody to provide roosting habitat through the use of bat boxes. Thanks to Coop, a large Italian retail outlet, it has been possible to create a good model for a bat box and to distribute it throughout Italy. In the past four years, about 25,000 artificial wooden roosts for bats have been released and sold at cost both to private citizens and public entities. In 2010, Disney Italy joined the project; they changed the layout in order to give children and adults a greater opportunity to learn more about bats. Disney has created the comic "Paperino e il pipistrello Kiro" (Donald Duck and Kiro the bat) to enhance a positive image of bats, such as agents of biological control through mosquito predation. Many people were (and are) happy to cooperate. The monitoring data have confirmed a growing success of colonization depending on the length of time since bat box installation: the bat boxes placed in 2007 are occupied

18.7% in the first year, 31.9% in the second, and up to 40.0% at the end of the third year (2009). A similar trend is recorded for the artificial roosts positioned in 2008. The permanence time is therefore one of the main elements influencing the colonization. The height above the ground and the hours of sun that the artificial roost receives during the day are positively correlated to bat box occupancy. The lack of homogeneity of the collected data has unfortunately limited the potential practical usefulness of the connected analysis. In 2011 a new and better model of wooden bat boxes and another experimental model made with inert material and recycled plastic are planned as well, in addition to new comics about the adventures of Kiro.

Summer Thermal Regulation of Desert Kuhl's Bat, *Pipistrellus kuhlii*
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Most studies of thermal regulation have examined bats' responses to summer heat in regions where temperatures rarely exceed 40º C, but not to extreme heat as in deserts. As seasonal climate fluctuation poses a challenge to bats in central Saudi Arabia, Kuhl's bat (*Pipistrellus kuhlii*) was studied for daytime body temperature fluctuations including the phenomenon of torpor. Temperature-sensitive transmitters were attached to nine bats over a 7-day period in late July. At dawn, Kuhl's bats entered a state of torpor in a manner similar to temperate bats as body temperature decreased from a normothermic level (~37°C) to a resting temperature of 26–31°C (air temp. 28°C, roost temp. 24°C). However, increases in air temperatures as morning progressed led to increases in roost temperature, thus body temperatures of bats rose reaching 32–35°C by noon. At 15:00, body temperatures of bats reached the normothermic level and surpassed it to a range from 35–42°C (air temp. 43.5°C, roost temp. 37°C), thus forcing them to emerge from roosts before dusk while it was still daylight and immediately seek water.

Acoustic Sampling: A Comparison of Detectors and Automated Software
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Acoustic detectors have been used for monitoring flight activity of bats since Griffin discovered echolocation in 1940. Recently, significant progress has been made in the areas of portability, weather resistance, and the collection and storage of large data sets over extended periods of time. This progress includes the continued development of new and potentially more accurate means of collecting the information contained within each call sequence, as well as more accurate and repeatable ways to identify the species making these calls. The two main categories of detectors used to collect these data are zero-crossing analysis and full spectrum detectors. This study included three commonly used detectors: Anabat (Titley Electronics, Inc.), AR-125 (Binary Acoustic Technology), and SM2 (Wildlife Acoustics). Side-by-side comparisons were conducted for 43 nights during 2010 throughout Missouri. Data collected were used to compare average memory consumption, total files collected, total bat passes, quality of the call sequences, and reported call parameters. In addition, two automated call identification software packages were used for comparison: BCID (Bat Call Identification, Inc.) and Sonobat 3 NE (Sonobat). Call files recorded at the same time and location were initially identified by three experienced investigators and then run through the automated software systems. Furthermore, full spectrum calls from the SM2 recorder were converted into zero-crossing call files allowing the systems to analyze the same files. Accuracy rates, species composition, and processing times were measured for each block of files. The results of this study are of growing importance with the recent explosion in bat research due to large-scale wind farms and white-nose syndrome.

Paraphyly and Speciation within Bulldog Bats (Chiroptera: Noctilionidae)
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Assessing species' boundaries or phylogroups using multifaceted approaches from independent genetic markers would be an appropriate method to identify independent evolutionary units. Under this framework, intrageneric relationship and species limits within bulldog bats, genus *Noctilio* with an emphasis on *Noctilio albiventris*, were explored using four data sets: cytochrome-*b* (cyt-*b*), cytochrome *c* oxidase-I (COI), amplified fragment length polymorphisms (AFLPs), and morphology. We genetically analyzed 51 samples of *Noctilio* from two currently recognized species: *N. albiventris* and *N. leporinus*. In cyt-*b* and COI gene phylogenetic analyses, *N. albiventris* form a paraphyletic clade, containing the gigantic species *N. leporinus*. Moreover, five monophyletic clades were documented, four associated with *N. albiventris* with > 5% genetic distance and a single clade for *N. leporinus*. Clades within *N. albiventris* are morphologically indistinguishable but they mostly have different geographic distributions, matching with all the recognized subspecies in *N. albiventris*: *N. a. minor*, *N. a. affinis*, *N. a.*

albiventris, and *N. a. cabrerai*. Although we recovered all the clades from mitochondrial DNA in AFLP analysis (nuclear DNA), there are two individuals from different clades that were positioned differently. These individuals are from Guyana. These localities lie in the periphery of the geographic range of subspecies suggesting that these sites may represent a contact zone with gene flow between different maternal lineages. Genetic divergences in the mitochondrial genes (> 5%) that are congruent with geographic distribution, and the paraphyly of *N. albiventris* (sensu lato) suggest that currently recognized subspecies within *N. albiventris* should be recognized at the specific level.

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

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Large numbers of bats are being killed at utility-scale wind energy facilities, especially along forested ridge tops in the eastern United States, that raise important concerns about cumulative impacts of proposed wind energy development on bat populations. We implemented the first U.S.-based experiment on the effectiveness of changing turbine cut-in speed on reducing bat fatality at wind turbines at the Casselman Wind Project in Somerset County, Pennsylvania. Our objectives were to determine differences in bat fatalities at turbines with different cut-in-speeds relative to fully operational turbines, and economic costs of curtailment. We employed three treatments at each turbine with four replicates (n = 12 turbines) on each night of the experiment: 1) fully operational; 2) cut-in speed at 5.0 m/s; and 3) cut-in speed at 6.5 m/s. We randomly assigned treatments to turbines each night of the experiment, with the night when treatments were applied being the experimental unit. We conducted daily searches at turbines from late July to mid-October in 2008 and 2009. We found no difference between the number of fatalities for 5.0 and 6.5 m/s treatments during both years. Total fatalities at fully operational turbines were estimated to be 5.4 times greater on average than at curtailed turbines (5.0 and 6.5 m/s combined; 95% CI: 2.08–14.11) in 2008 and 3.6 times greater on average than at curtailed turbines (95% CI: 1.79–7.26) in 2009. In other words, 82% (95% CI: 52–93%) of all fatalities at curtailment turbines likely occurred when turbines were fully operational in 2008 and 72% (95% CI: 44–86%) in 2009. The lost power output was only 0.3–1% of total annual output. Our findings indicate that changing cut-in speeds to the levels we tested offers an effective mitigation strategy for reducing bat fatalities at wind facilities.

A Digestive Perspective on Nectar-feeding Specialization in Phyllostomid Bats

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Floral nectar is one of the simplest foods in nature. It varies widely in sugar concentration, affecting the physiology and behavior of nectar-feeding animals. When nectar sugar concentration decreases, animals increase their food intake. In this behavior, named intake response, animals tend to achieve compensatory feeding. However, this behavior could be limited by physiological constraints. We hypothesized that the digestive capacities of bats affect their ability to acquire and store energy, and could modify the way they use the floral resources present in their environment. To test this idea we measured the intake responses and changes in body mass of the members of a community of nectar-feeding bats: *Choeronycteris mexicana*, *Leptonycteris curasoae*, and *Glossophaga soricina*. We expected differences in the intake responses of the three species, with changes in body mass being independent of sugar concentration in bats achieving compensatory feeding, but positively correlated to sugar concentration in bats exhibiting physiological constraints. The three bat species presented different intake responses. Only *C. mexicana* was able to achieve compensatory feeding. *G. soricina and L. curasoae* increased their sugar intake with sugar concentration. *C. mexicana* increased body mass independently of sugar concentration, while *G. soricina* presented a positive correlation between these two variables. Based on our results we generated a model relating digestive capacities and use of food resources in the field. In this model the physiologically-specialized bats (those able to perform compensatory feeding) should act as ecologically generalists capable of feeding on a wide range of nectar concentrations, while less-physiological specialized bats should act as ecologically specialists that use only concentrated nectars. Interestingly, bats that achieve compensatory feeding seem to be able to use a larger diversity of plants as food sources, supporting the idea that digestive traits affect the way these animals use food resources in the field.

Observations on the Reproductive Ecology and Postnatal Growth of the Silver-haired Bat (*Lasionycteris noctivagans*)

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Silver-haired bats (*Lasionycteris noctivagans*), hoary bats (*Lasiurus cinereus*), and eastern red bats (*L. borealis*) all roost in trees and are assumed to be long-distance migrants, thus they are frequently lumped together into a migratory tree-bat group. However, silver-haired bats differ from the other members of this group in roosting ecology, phylogeny, and likely in their migratory or seasonal behavior. *Lasionycteris noctivagans* are not solitary foliage-roosters, but generally form small maternity colonies in tree-cavities or hollows. Whereas *L. cinereus* and *L. borealis* belong to the tribe Lasiurini, *L. noctivagans* belongs to the tribe Nycticeiini, and is therefore more closely related to big brown bats (*Eptesicus fuscus*) than to *L. cinereus*, for example. Therefore, we were interested in the relative influences of phylogeny, roosting ecology, and migratory or seasonal behavior on the reproductive ecology and postnatal growth of silver-haired bats. We maintained three pregnant female *L. noctivagans* and the ensuing four offspring in captivity. We determined postnatal growth rates by measuring forearm length and body weight of known-age juveniles. We also characterized patterns of fur growth and isolation calls of the pups. We then compared litter size, growth rate and fur-growth patterns to that of *L. cinereus*, *E. fuscus*, and *Myotis lucifugus*. One of the three females aborted underdeveloped triplets, while the other two females successfully birthed twins. One of those two females also bore a stillborn triplet. Preliminary data suggest that *L. noctivagans* twins have larger forearms and greater mass (in proportion to average adult size) than *L. cinereus* twins, but are smaller than *E. fuscus* twins and *M. lucifugus* singletons.

Comparing the Anatomy and Kinematics of Bat Handwings

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Bat wings are derived from the mammalian forelimb and retain most of the bones and joints of basal mammals. Bat wings have at least 22 joints with at least 16 in the dactylopatagium. Many joints confer the ability to manipulate wing shape to an extraordinary degree and consequently modulate the aerodynamic performance of the wings. All known vertebrate synovial joints have, at minimum, an antagonistic pair of muscles crossing the joint to control motion, and we expect bat wings to retain this condition to realize the full potential for controlling 3D morphology. To test this prediction, we compared muscle attachments for all muscles crossing joints in the dactylopatagium for 12 species of bats from 5 families, representing both Yinpterochiroptera and Yangochiroptera. Data for eight species were taken from published literature and four additional species from dissection. Additionally, we analyzed kinematics of handwing joints based on high-speed video (1000 fps) for four of the species, and compared motion of specific joints with predictions based upon muscle anatomy. Our results show that every species examined had at least one joint that lacked muscles on the flexor and/or extensor side. All pteropodids had two interphalangeal joints without muscles on at least one side of the joint, and Yangochiropterans had an average of 4.9 joints without a muscle on at least one side. These joints were interphalangeal joints. Kinematic analysis showed that despite the lack of muscular actuators, these joints still flex and extend with each wingbeat in a manner similar to joints that retain muscles. We propose that the distinctive mechanics of bat wing membrane skin plays a critical role in transferring force between digits and has facilitated the evolutionary loss of heavy musculature. This pattern of controlled joint motion in the absence of muscle is a unique chiropteran adaptation for flight.

Speciation Dynamics in Bats

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Studying speciation is a difficult endeavor, because a vast number of variables can contribute to genetic isolation and protection of the integrity of the gene pools of the two speciating populations. Proposed mechanisms or models of speciation (i.e., allopatric, centrifugal, ecological, parapatric, peripatric, reticulated, sympatric, etc.) frequently overlap and are intriguing and complicated. Furthermore, application of these models to empirical data is frequently messy. To emphasize this observation, we provide an example of the complexity of the speciation process within a single group of non-model organisms, fruit-eating bats of the genus *Artibeus* (Chiroptera: Phyllostomidae). Our data indicate that at least three speciation processes (allopatric, ecological, and hybrid speciation) have contributed to species-level diversity currently recognized within the genus. Each of these processes has resulted in distinct signatures (or wing prints) that could only have been discovered through detailed genetic and morphometric

analyses. What types of data are needed to elucidate these wing prints? Examples include: diversification time estimates, sister taxon status, sympatry, evidence of reciprocal monophyly in genomic, nuclear or mitochondrial genes, genetic distance values, presence/absence of hybridization, karyotypic uniqueness, presence/absence of morphological distinctness (size vs. shape or unique characters or presence of unique diagnostic characters), ecological tolerance, phylogroups, and behavioral observations. We hypothesize that detailed genetic studies of other recently evolved Chiropteran genera will document a similarly complex pattern of speciation to that observed in *Artibeus*. A common theme will be recognition of a greater number of species rather than a reduction of currently recognized species into a single species level taxon.

Variation in Offspring Sex Ratio of Big Brown Bats (*Eptesicus fuscus*)
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Life history theory predicts that offspring sex ratio should be 1:1, unless there are different costs or benefits of producing one sex over the other. For example, sexual dimorphism that develops during dependence on the mother may favor production of the less costly sex. Most studies of bats have found an equal sex ratio at birth and few have related sex ratio variation to seasonality, age of the mother, or other factors that may favor a skewed sex ratio. My students and I gathered data on juvenile big brown bats at three nursery colonies in Medicine Hat, Alberta over nine years. In this population, most females produce litters of one. I used site-specific growth curves of known-aged young to estimate the birth date of 899 juveniles, and examined sex-ratio variation relative to age of the mother (estimated by tooth wear), and birth date. Overall, the sex ratio was 1. The mother's age did not influence pup sex ratio. The timing of births varied considerably from year to year depending on spring weather, with the median birth date ranging from 21 June to 14 July. In early years, there was a significantly female-biased sex ratio early in the year, and a male-biased ratio later. In late years, there was no such seasonal variation, indicating that sex ratio varied with absolute date, not simply the stage of the reproductive period. Overall, the sex ratio of young born before 22 June was female biased (61.3%, n = 150), while the ratio of those born after was male biased (53.8%, n = 749). Some first-year females reproduce, and one explanation for the sex-ratio variation is that selection favors production of female young early in the year when they have the opportunity to enter hibernation with sufficient fat reserves to emerge in spring in good enough condition to reproduce.

Distribution, Abundance, and Habitat Use of Bats in North Dakota
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In North Dakota, no baseline survey of bats has ever been conducted across the state, hence state and federal wildlife agencies have no information about this large group of mammals. As North Dakota bat populations inevitably decline due to human development, extensive construction of wind energy facilities, and the pending spread of white-nose syndrome to the state, it is imperative to document key characteristics of bat populations so that an appropriate state conservation plan can be developed. Our research focuses on an extensive baseline survey of bats in North Dakota using acoustic monitoring and direct capture via mist nets. Specifically, we are assessing the current distribution of the nine bat species reported from North Dakota, and determining the locations and types of key habitats used by each species. We are primarily focusing on "hotspots" around the state that include high quality bat habitat. Data were collected in the summers of 2009 and 2010. We will discuss our findings to date and how this information will be used to develop a state conservation plan for bats, as well as lay the ground work for future studies on the bats of North Dakota.

Relationships among Bonneted Bats (Genus *Eumops*): A Molecular Test of Morphological Hypotheses
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The genus *Eumops* (bonneted bats) consists of 15 species and is more variable (both morphologically and karyotypically) than other genera in the family Molossidae. *Eumops* species range in forearm size from 37–83 mm and the monophyly of the genus is supported by morphological data. The objective of our study was to use molecular data to test the relationships among *Eumops* species that have been proposed by cladistic analysis of morphological data. We included 12 species of *Eumops* and 4 outgroup genera (*Tadarida, Nyctinomops, Molossus*, and *Promops*) in our analysis. We analyzed DNA from the mitochondrial genome. A total of approximately 1674 base pairs from the ND1 gene (33 taxa studied) and cytochrome *b* gene (27 taxa studied) was collected. Bayesian analyses partitioned by codon position were performed on both individual and combined data sets. Divergences (GTR + I + G) ranged from 1.4–39% among the species of *Eumops*. Based on BEAST analysis of cytochrome *b*

data, the genus originated around 15 MYA, divergence events between species ranged from 14.9 MYA (14.22–15.69) to 0.7 MYA (0.39–1.23), with most events occurring within the last 10 million years. Significant phylogenetic groupings were evaluated by Bayesian posterior probabilities for each gene. Significant disagreement between the two data sets was observed only in the position of *E. hansae*. Generally, the relationships supported by molecular data were not consistent with morphological hypotheses although some sister-groupings did agree with those previously proposed by morphological data. Our analyses provided additional resolution to the phylogeny of bonneted bats.

Impacts of Wind Energy Facilities on North Dakota Bats: Biological and Social Implications
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Wind energy is quickly becoming a critical technology for providing Americans with renewable energy and reducing fossil fuel dependence. The consideration of both biological and social issues related to wind energy development will provide a framework for effectively meeting human energetic needs while conserving species biodiversity. Biological implications of wind farm impacts on bats in North Dakota are especially dire, as the high wind energy potential in the state has led to rapid construction of many wind facilities, yet very little is known about local bat populations and how they may be affected by major landscape modifications. Pre-construction acoustic monitoring was conducted with Anabat detectors during the 2009 fall migration period at a proposed wind energy facility in south-central North Dakota. We identified a high number of calls from eastern red bats, *Lasiurus borealis*, one of three bat species that have especially high mortality rates at wind facilities. Post-construction acoustical monitoring and mortality surveys were conducted at an established turbine facility in the same county during the 2010 fall migration period. The information acquired from this research will be used to identify potential needs for mitigation measures to reduce bat habitat loss and mortality. We are also currently conducting a public opinion telephone survey to assess public attitudes toward wind energy and wildlife issues at two turbine facilities located over seven additional counties in North Dakota. The survey is composed of several measurement scales and is being used to measure public awareness of wind energy issues, including general attitudes toward bats and wildlife, and public concern for, and understanding of, the importance of biodiversity conservation.

Comparison of Three Acoustic Surveying Techniques for Detection of Adirondack Bat Species Richness and Foraging Activity
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I present results of acoustic bat surveys conducted at Huntington Wildlife Forest, in the central Adirondacks, New York. Determining bat species composition is common in acoustical surveys, but no comparison between acoustical surveying methods has ensured these techniques are equivalent. Transects have been developed throughout the Adirondack Park to monitor for the effects of white-nose syndrome on *Myotis* populations through mobile surveying. This investigation uses four Anabat II detectors to compare the efficiency of mobile surveys to traditional active and passive techniques. I identified 9 species acoustically over 43 nights at 12 stations along 4 routes, on the basis of call signatures using Analook and Bat Call Identification (BCID) software. Only calls recorded within three hours after sunset were analyzed, and calls were averaged each night as number detected per hour, for each technique. Significant differences between techniques were found using an ANOVA test in minitab ($P < 0.001$ for both Technique and Species, and interaction of species richness x method, $P = 0.002$). Mobile recording detected five species, (55% of the species detected by either passive or active), but did detect a greater number of big brown (*Eptesicus fuscus)* and hoary bat *(Lasiurus cinereus*) calls. Passive and active detected significantly more little brown bat (*Myotis lucifugus*) and Indiana bat (*M. sodalis*) calls. Passive detectors recorded the greatest activity but significantly more unknown calls and noise files. Results indicate active detectors record proportionately more identifiable calls due to longer call sequences and higher-quality recordings, but fewer total calls. Results suggest that difference in methodology may yield different species richness, call quality, and activity data. Standardized survey methods for obtaining reliable information on bat populations are particularly crucial as the federally endangered Indiana bat is an Adirondack resident.

Bats, Mines, and Citizen Science in the Colorado Rockies
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Several educational theorists have argued that informal education and citizen science are important aspects of conservation and ecological education. In 1991, an innovative program called the Bats/Inactive Mines Project (BIMP) was initiated in Colorado to involve volunteers in conducting bat surveys at abandoned mines. Thirteen of

Colorado's nineteen bat species have been documented using abandoned mines as roosting habitat. However, the approximately 23,000 abandoned mines in the state represent significant safety hazards to humans. The involvement of volunteers helped the state's wildlife management agency conserve habitat for bats in abandoned mines throughout the Colorado Rockies, while closing unsafe mine sites to human access. We considered the value of BIMP including informal education and citizen scientists in its conservation project and believe that the program is a successful model of citizen science. BIMP volunteers developed conservation biology knowledge and skills such as bat natural history, field orientation, and safe survey techniques. Experienced volunteers also demonstrated knowledge and skills in bat species identification, understanding bat diversity and distribution patterns, and many eventually lead volunteer survey crews. Participants in BIMP informally achieved many of the learning targets biological educators seek in ecological and conservation curricula, and developed habits of mind necessary for effective conservation projects. Several volunteers went on to become BIMP employees and attend graduate school studying bat biology. Since BIMP's inception, biologists trained 1421 citizen scientists, generated over 57,000 volunteer-hours, conducted approximately 3000 volunteer bat surveys, and saved the state of Colorado over $580,000 in human resource costs. Conservation biologists and educators who provide informal education and citizen science opportunities will be doing a service to their communities by improving the biological knowledge, skills, and experience of their citizenry. Citizen scientists can help organizations leverage limited financial resources and achieve conservation goals not otherwise attainable without supportive volunteers.

Applying Non-invasive Genetic Monitoring to Bat Populations

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In response to the ever increasing threats to natural ecosystems internationally, the Convention on Biological Diversity (http://www.cbd.int) has established guidelines to monitor biological diversity towards the goal of conservation and sustainable use of biological resources. Monitoring biodiversity at the ecosystem and species level already exist, but little has been done at the level of genetic biodiversity. Most studies do not take full advantage of the potential afforded by molecular genetic markers to systematically monitor changes in genetic composition and diversity through time. Here we discuss the development of a genetic monitoring scheme applying microsatellite DNA fingerprinting through non-invasive genetic mark-recapture techniques to monitor two of Ireland's most elusive bat species, the whiskered bat (*Myotis mystacinus*) and Natterer's bat (*M. nattereri*). In Ireland these species are found in low abundance in the environment, are acoustically cryptic, and with no known hibernacula, traditional bat monitoring methods are made extremely difficult. We present the comparative results of fecal vs. tissue sampling, examine the utility of census population numbers from mark/recapture analyses, compared to effective population estimates as monitoring indices, as well as discussing the reliability of recording temporal patterns of genetic composition from fecal matter. These species will be used as a model to develop this methodology, which could then be applied worldwide as a monitoring strategy for rare, endangered, or indicator bat populations.

Summer Bat Community Structure across Vegetation Types and Burn Units within the Ozark National Scenic Riverways

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A three-year project, beginning summer 2009, is underway within Ozark National Scenic Riverways (ONSR) to evaluate potential park habitat to determine the scope and dimensions of summer/fall Indiana bat (*Myotis sodalis*) use. One aspect of this is characterizing bat community structure across different vegetation types within the park. In addition, prescribed burns are performed each winter over 2500–3000 acres of woodland forest and glade communities. Recent information on fire effects on vegetation changes, however, indicate that summer burns would be more effective in restoring open woodland habitat communities, which are important to foraging bats, including listed species. Determining summer habitat use and activity patterns is necessary to reduce potential negative impacts caused by moving prescribed burns to summer months. How community structure changes over time across different vegetation types, including within burn and non-burn units, will be compared. Mist-net surveys, along with acoustic detection, take place between April and October with sampling periods beginning at sunset and lasting a minimum of five hours. Nets are placed in potential fight corridors, in proximity to proposed burn areas as well as in proximity to known hibernacula, with at least four days between sampling at each site. In 2009, 17 sampling sites were established, which yielded a total of 94 net nights and 89 detector nights. There were 1100 total captures,

representing 10 species, within 19 of the 49 classified vegetation types within the park boundaries. Species diversity, sex ratios, and 2010 sampling data will be included in future analysis. These data will be used in the revision of the park's fire management plan and other park actions relevant to bats, especially listed species. Understanding which vegetation types are important to bat species will help determine future management practices.

Nightly Emergence and Seasonal Activity Patterns of a Mixed-species Bat Colony in Relation to the Pecan Nut Casebearer Moth, *Acrobasis nuxvorella*

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Insectivorous bats have been postulated to play vital roles in ecosystem function by suppressing herbivorous arthropods. Installation of bat houses has been a commonly used strategy to increase these services on agricultural lands. However, seasonal variation in bat abundance, foraging activity and behavior around bat houses can influence the degree to which bats suppress insect pests. Pecan orchards, which span 14 U.S. states, are economically important for both local farmers and national exports. The pecan nut casebearer moth (PNC), *Acrobasis nuxvorella*, is considered the most devastating insect pest of pecans. Anecdotal observations suggest that bats inhabit bat houses in pecan orchards in response to seasonal emergences of PNC. This study investigated this relationship using a mixed-species bat house in an organic pecan orchard in San Saba, Texas. We hypothesized that 1) colony size and nightly activity around the bat house is influenced by emergence patterns of PNC and selected environmental factors, and 2) foraging activity increases with proximity to the bat house. Throughout the summers of 2008–2010, colony censuses were conducted weekly at the bat house using a thermal infrared camera and hourly 15-second thermal-imaging recordings were taken on eight nights. AnabatII/Zcaim detectors were used to compare bat passes and feeding buzzes at different distances from the bat house. Colony size was not significantly related to PNC abundance; however, it was consistently highest in May during the largest and most damaging PNC emergence. Activity around the bat house was negatively correlated with temperature, suggesting that bats stay closer to their roost in low temperatures, and was lowest during peak hours of PNC activity. Bat passes and feeding buzzes increased with proximity to the bat house. These results suggest that roosting patterns of bats do not correspond to PNC abundance, but do show temporal overlap with PNC in the orchards.

Response of Tree-roosting Bat Species to Riparian Habitat Development along the Lower Colorado River in Arizona and California

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Acoustic monitoring of riparian habitat being developed as part of the Lower Colorado River Multi-species Conservation Plan (LCR MSCP) has shown that bat activity for two species of tree-roosting bats, the western red bat (*Lasiurus blossevillii)* and western yellow bat (*L. xanthinus*), has increased substantially since planting began. Specifically these two bat species are being managed, along with 24 other threatened or endangered species or species at risk of becoming endangered. Planting cottonwood, willow, and mesquite in five restoration sites along the LCR began in 2006 and is ongoing, with the ultimate goal of creating 7260 acres of riparian habitat. These sites are growing rapidly, creating diverse, multi-species stands with complex canopy structures. At Palo Verde Ecological Reserve near Blythe, California, the number of bat minutes (a measure of bat activity) has increased from 3 in 2008 to 11 in 2009, then to 163 minutes in 2010, while bat activity in the adjacent agriculture and saltcedar habitats ranges from 0–8 minutes during the same time periods. Western yellow bat activity increased from 0 in 2008 and 2009 to 88 minutes in 2010. At Cibola Valley Conservation Area downstream 20 miles in Arizona, red bat minutes increased from 0 in 2008 to 91 in 2009 in cottonwood-willow habitats. Acoustic monitoring was conducted at all restoration sites during October, February, April, and July, 2008–2010, following a 1-year pilot program. From 9–15 Anabat bat detectors were deployed in each restoration site with 3 detectors per habitat (sapling cottonwood, intermediate cottonwood, mesquite, agriculture, saltcedar) depending on which habitats are present. Analyses of recently collected acoustic monitoring data and the relationships between bat activity and various habitat variables for all bat species are ongoing. Acoustic monitoring results are used in adaptively managing the habitats.

Inferences on the Diet of *Myotis* Bats as Revealed by Stable Isotope Analysis

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Although multiple researchers have spent many years studying and writing hundreds of papers on the diet of insectivorous bats, there is still much on the topic that is a mystery. The difficulty in accurately characterizing foraging dynamics is likely due to a number of factors including: 1) tremendous variation in population sizes of

nocturnal insects across spatial and temporal scales and among weather regimes, 2) possible differences in "preference" or "selection" of prey types between genders and among individuals or species, and 3) impacts of inter- or intra-specific competition for prey. Regardless, most studies find that species include a large variety of prey types in their diet, suggesting most bats are dietary generalists. Stable isotopes are a relatively new area of research that permits researchers to make characterizations of diet based upon the relative abundance of element isotopes in the tissues of predators. Previously, in samples collected from southern New Brunswick, Canada we had identified the possibility of a methane-derived source of carbon in little brown bats and shown that northern long-eared bats are diet specialists. The objective of this study was to expand the spatial scale of sampling in the same species to determine how generalizable these inferences are by further quantifying stable isotope ratios of carbon and nitrogen in little brown and northern long-eared bat tissues. For northern long-eared bats our results support the previous contention that they are specialists. However, there was significant spatial variation in the profile of little brown bats that highlight the unique nature of the presumed methane-derived-carbon that was found in southern New Brunswick. Further, we detected a marine influence in their diet on Brier Island and agriculturally derived nitrogen enrichment on Prince Edward Island. Finally, because of the spatial variation in isotope patterns of little brown bats it may be possible, with more sampling, to use stable isotopes to assign some migrating, swarming, or wintering bats to summering areas.

Change in Summer Bat Activity in Southern New England Following White-nose Syndrome Outbreak
Robert Brooks, U.S. Forest Service Northern Research Station, Amherst, MA

White-nose syndrome (WNS) was first reported from a bat hibernaculum in central New York State in February 2006. Serendipitously, I completed a three-year acoustic survey of bat activity in a working-forest landscape of central Massachusetts in 2006. The survey of three replicate sites of the ten most common habitats showed that the Quabbin Reservoir watershed supported a rich and abundant summer bat community. *Myotis* species were the more commonly recorded (three-year average, all habitats, 6.0 call sequences/hr [CSs/hr]) than large-bodied species (1.34 CSs/hr). Both types of bats were recorded more frequently in open and aquatic habitats. The diverse landscape of aquatic, open, and forest habitats provided abundant foraging and roosting habitat for bats. By 2010, WNS had spread across the northeastern United States and adjacent Canada and is associated with the death of untold numbers of cave-hibernating bats. To assess the impact of this catastrophe on the summer community of bats on the Quabbin, I repeated the passive acoustic bat component of the earlier surveys in 2010, using the same locations I had surveyed between 2004 and 2006. In 2010, *Myotis* activity had declined dramatically from the pre-WNS surveys to an average 1.67 CSs/hr across all habitats. Large-bodied bat activity increased slightly in 2010 from the earlier surveys, to an average 1.98 CSs/hr. From these preliminary data, it appears that WNS-caused mortality at winter hibernacula has resulted in a major decline in summer activity of cave-hibernating *Myotis*, resulting in a substantial change in the relative composition of the bat community. The results of the resurvey provide additional documentation of the devastation of North American bats being caused by WNS.

Bats and Mine Closure: A Double-edged Sword
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Much of the western United States was settled as a result of mining. When the mines were abandoned, bats colonized these new "caves." Cities grew up around some mining districts. Even in remote areas, mines are visited by people exploring on off-highway vehicles. Abandoned mines can be hazardous, and accidents result. The recent influx of funds in the United States for mine closure has stimulated a rush to remediate mine hazards on federal lands. To attain the goal of the Economic Stimulus Package of putting more people to work, some people are involved who do not have experience in bat biology or bat-compatible closures. If done properly, bats in mines could be protected through the installation of bat gates and cupolas. However, if bat habitat is not identified, mines could be closed through foam and backfill that would deprive bats of roosting habitat and potentially kill them, especially if exclusions are not done properly at the appropriate time of year. Most bat species use a variety of roosts throughout the annual cycle as dictated by physiological and behavioral needs. The timing of surveys will influence the ability to detect bat use of a mine feature, which can affect the treatment that a mine may receive (hard or bat-compatible closure). There is no substitute for site-specific bat surveys using established protocols to detect bat use, nor is there a universal style of mine closure. Some bat colonies do not accept culverts or even gates. To understand the importance of a single mine feature, most of the mines in a geographic unit may need to be evaluated in order to determine those with the most significant bat use at different times of the year. The scope of the "landscape" will depend on the species of bat and their dispersal ability. The goal is to identify and protect the most important bat mines, and to avoid killing bats if a non-wildlife compatible method is selected.

Molecular Analysis of Guano from Bats in Bat Houses on Organic Pecan Orchards
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Bats are generalist predators of night flying insects, including many crop pests. Pecan nut casebearer (*Acrobasis nuxvorella),* hickory shuckworm (*Cydia caryana*), and several stink bug species are some of the most damaging crop pests in pecan orchards. Attracting bats to agricultural areas using bats houses may reduce the numbers of these pests and, consequently, their economic impact. This study uses quantitative polymerase chain reaction (QPCR) of mitochondrial DNA found in the guano of bats living in bat houses on organic pecan orchards to document the consumption of pecan nut casebearer, hickory shuckworm, and corn earworm (*Helicoverpa zea*), which is one of the most destructive pests of many crops throughout the world. This study also uses direct sequencing of insect remains in bat fecal pellets to identify species of stink bugs consumed by bats in bat houses. Evidence that bats prey upon crop pests supports the hypothesis that bats are both economically and ecologically beneficial to pecan farmers and provides incentives for bat conservation.

Behavior of Bats with White-nose Syndrome
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In 2006 a fungus was found growing on the muzzles and forearms of hibernating bats in New York. This fungus was later found to be connected to the death of a million or more bats in the northeastern United States. The relationship between the fungus, *Geomyces destructans,* and the disease, known as White-nose Syndrome (WNS), is now at the forefront of bat research. Unfortunately, our knowledge of bat behavior during hibernation is sparse. Previous work has shown that WNS-affected bats arouse to euthermic temperatures during hibernation more frequently than unaffected bats. However, what they are doing during these arousals is unclear, and has been identified as a topic of high priority. To monitor hibernating bat behavior, infrared motion-sensitive cameras were deployed in WNS-affected and unaffected hibernacula, and in captivity. The duration and frequency of behaviors was measured. Behaviors included general arousal behaviors, grooming, and locomotion. The duration of arousal bouts (time spent euthermic) was significantly shorter in WNS-affected bats, which spent significantly more time grooming (and less time engaged in all other behaviors) than unaffected bats. Future studies include monitoring the behavior of more affected and unaffected bats and experimentally testing the hypothesis that affected bats are disoriented, have lower flight maneuverability, and have altered echolocation calls compared to unaffected bats.

Shifts in Bat Activity in Response to Wildfire in the Southern Sierra Nevada
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Little is known about the effects of forest fires on bat communities. Disturbance events such as fires can shift the composition of ecological communities. The frequency of wildfires is predicted to increase due to climate change, demonstrating the importance of understanding the impacts of fire on forest bat communities. Here, we assess changes in bat activity in response to a forest fire in the southern Sierra Nevada. We measured echolocation activity of bats across 14 sample locations to compare bat use of burned and unburned habitats associated with McNally forest fire in Sequoia National Forest, California during July and August 2003, one year post-burn. We used broadband ultrasonic detectors (Anabat II) paired with storage devices (Anabat ZCaims) to record all night activity for a minimum of five nights at each site in riparian and upland habitats. Call data were assigned to species or acoustic groups based on terminal frequency to avoid species misidentification. Categories included *Antrozous pallidus*, *Myotis thysanodes*, *M. evotis*, 50 kHz *Myotis*, 40 kHz *Myotis*, and 25 kHz. A zero-inflated Poisson generalized linear model was implemented in R to assess the influences of fire and habitat type on bat activity. Differences in bat activity by habitat type were consistent with known foraging ecology of the species. All *Myotis* species showed increased echolocation activity within burned habitats ($P < 0.02$). In contrast, species within the 25-kHz group (including, *Eptesicus fuscus*, *Lasiurus cinereus*, and *Tadarida brasiliensis*) had higher levels of activity in unburned habitats ($P < 0.001$). There was no difference in use of burned and unburned areas by *A. pallidus* ($P = 0.90$). Our study demonstrates that bat species may respond differently to the structural changes in habitat due to forest fire and that severe forest fires have the potential to shift the composition of forest bat communities.

Home Range and Habitat Associations of a Maternity Colony of *Myotis mystacinus* (Whiskered Bat) in a Heavily Altered Landscape in Ireland
Daniel Buckley, Mathieu Lundy, Emma Boston, David Scott, W. Ian Montgomery, Paulo Prodöhl, Ferdia Marnell, and Emma C. Teeling; University College Dublin, Dublin, Ireland; Queens University Belfast, United Kingdom; National Parks and Wildlife Service, Dublin, Ireland

Since the expansion of agriculture in Europe, forest habitats have been significantly reduced and altered leading to the marginalization of woodland specialist plants and animals. Nowhere is this more evident than in Ireland, where native woodland cover now stands at less than one percent. Forest animals, such as bats, have been driven to utilize woodland ecotone habitats. The whiskered bat *Myotis mystacinus* is a woodland specialist species found throughout Europe. In Ireland it is widespread but localized and in low densities. To elucidate what habitats this species used in a heavily altered lowland agricultural environment, a maternity colony of *M. mystacinus* in County Cork, southern Ireland was chosen for a radiotelemetry study. Eighteen bats were tagged and followed for a five-night period from May to July in 2009. Location points were estimated by triangulation. Bats were found to forage within a very small home range (70–180 hectares) but used a network of roosts, both man-made and artificial. Riparian habitats were found to be heavily utilized. The implications for agricultural landscape design and management through the identification of key habitat components that could be a conservation priority for this species is discussed.

Fruit Bats Are the Major Pollinators of the Economic Food Plants, Durian and *Parkia*, in Southern Thailand
Sara Bumrungsri, Prince of Songkla, Hat Yai, Songkhla, Thailand

Although the floral traits of durian and *Parkia* conform to the bat-pollination syndrome, many visitors other than bats have been observed at their flowers and some chiropterophilous plants are also pollinated by other animals. The present study aimed to determine the breeding system of the economically important trees, durian and two species of *Parkia*, and to identify their pollinators. The floral biology and pollination ecology of durian, *Durio zibethinus*, were determined in 8 semi-wild trees, while 28 trees of *P. speciosa* and 4 *P. timoriana* were examined. They are mostly or completely self incompatible. Flowers open fully during late afternoon or evening, and anthers dehisce around 2000 h when the stigmata are already receptive (*Durio*) or receptive at same time (*Parkia*). In a series of pollination experiments, the highest pollination success occurred either after hand-crossed (*Durio*) or open pollination (*Parkia*). Insect pollination resulted in fruit set in only 12% of *P. speciosa* inflorescences. Fruit bats, mainly *Eonycteris spelaea*, visit flowering plants continuously from dusk till after midnight. Nocturnal and diurnal insects (moths and giant honey bees, stingless bees) also frequently visit flowers. Bats visited durian flowers at the rate of 26.1 (SD = 20.7) visits per inflorescence per night. The pollination services of fruit bats to these plants were estimated to be 137 million U.S. dollars in southern Thailand. Although these economically important plants depend on fruit bats as their pollinators, *E. spelaea* appears to be declining throughout its distribution, often as a result of persecution by farmers who believe the bats damage flowers. Therefore protection of fruit bat populations and their roosts is vital for the continued production of these fruit crops.

@BatRoost: A Prototype Device to Monitor Bat Activity through Twitter
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Non-invasive monitoring of bat populations is often expensive and time-consuming, but it has obvious potential benefits for our understanding of bat populations and behavior. New developments in web-based applications and microprocessors have made it possible to develop monitoring devices that can provide new capabilities with minimal expense or difficulty. With a minimum of hardware and software experience, it is possible to assemble custom-built devices that can be used to monitor bat activity while simultaneously measuring a number of environmental variables. The data recorded by such devices can be stored for retrieval at a later time, sent directly to a computer or other recording device, or sent through the Internet using services such as Twitter. I will provide details on the assembly of a prototype system, with a discussion of cost, flexibility, and potential uses of this device for bat population studies, including benefits and limitations to using such a system. While this type of device will not replace systems that are more expensive and precise, these devices can be included in the set of overall techniques used by bat researchers, allowing the collection of data from a wider variety of sources.

Citizen-based Acoustic Monitoring as Part of an Undergraduate Science Curriculum
Deanna Byrnes, Carthage College, Kenosha, WI

Research experiences at primarily undergraduate institutions (PUI) are valuable for providing students with practice in all aspects of the scientific process, and in their ability to generate excitement and a feeling of responsibility that cannot be matched by classroom experiences alone. Faculty at PUI's are challenged to develop excellent teaching practices that reach all students, maintain an active program of scholarship, and contribute to their communities in meaningful ways. As white-nose syndrome spreads westward, agencies face difficulties in developing management and conservation plans given the paucity of population-level information for most of our bats. In an effort to learn more about Wisconsin's bat populations, our state's Department of Natural Resources has organized an extensive network of volunteers as part of the Wisconsin Bat Monitoring Program (http://wiatri.net/inventory/bats/) to gather occurrence and relative activity data from across the state. Here I describe how this citizen-based monitoring program has provided myself and undergraduate students at Carthage College a unique and rewarding research experience, and how incorporating research service-learning (RSL) into the undergraduate curriculum can develop ecological understanding in a broad range of students and help procure valuable information when help is most needed.

Reciprocal Food Sharing in Vampire Bats Revisited
Gerald G. Carter, Adi Shaked, and Gerald S. Wilkinson, University of Maryland, College Park, MD

Why do some animals spend time and energy helping others? To evolve, any form of helping that is energetically costly must provide lifetime inclusive fitness benefits that outweigh the temporary costs. This occurs when helping is directed at kin (kin selection), stops harassment or punishment, prevents partner switching, signals quality to other potential partners, or promotes reciprocal help in the current partner (reciprocity). Although reciprocity, or reciprocal altruism, is very popular among theorists as an evolutionary explanation for cooperation, its overall importance in nonhuman animal societies is highly controversial. Critics have posed alternative explanations for all cases of putative reciprocity, including the classic study of regurgitated food sharing in vampire bats (*Desmodus rotundus*; Wilkinson 1984). Using captive groups of common vampires caught in Trinidad, our aim was to replicate this original captive food sharing experiment. Each night, we isolated and fasted single subjects, returned them to the group, and observed social interactions. In addition to testing for reciprocity between familiar roostmates, we investigated the emergence of social grooming between previously unfamiliar bats. Much to our surprise, we found no evidence so far of regurgitated food sharing among bats caught at the same site (n = 2 groups) or in the same roost tree (n = 1 group). However, we did observe "begging" behavior (i.e., licking of face and mouth) by hungry subjects, and the emergence of social grooming between previously unfamiliar bats. We also found that our *D. rotundus* in Trinidad were significantly smaller than the *D. rotundus* studied in Costa Rica in 1984. Moreover, our preliminary results suggest that these Trinidadian vampire bats might lose body mass more slowly. Trinidadian common vampire bats may differ from Costa Rican common vampire bats in social behavior and physiology. Future work will examine this possibility.

Ontogeny of Echolocation and Flight Performance in *Artibeus jamaicensis*
Richard Carter, Rick Adams, and Jason Shaw, University of Northern Colorado, Greeley, CO

The ontogeny of echolocation is fairly well studied in oral emitters; however, little is known about nasal emitters. We investigated the ontogeny of echolocation in *Artibeus jamaicensis* as it pertains to flight development. We hypothesized that calls will change in structure as flight performance progresses and predict that the calls will develop from lower frequency directives into higher frequency orientation calls as young bats learn to fly. Young were captive raised and calls were recorded as individuals were released from a 1-m high perch onto a foam pad beginning on day 1 postpartum. Calls were recorded on Pettersson D240X detectors and analyzed with Sonobat V2.9.2. Each bat's flight stage was classified as either flop (n = 7), flutter (n = 15), flap (n = 7), or flight (n = 3). We measured call duration, high frequency, low frequency, bandwidth, and frequency of maximum power. An ANOVA and a Tukey's HSD were run on all variables to test for significance differences among flight stages. F-values and means are reported below for each variable. Flight stage means together in parenthesis are not significantly different from each other, values with * are significantly different from each other. Call duration(ms), ($P > F$ 0.0060): flop = 3.24* SD = 0.41; flutter = 2.70 SD = 0.23; flap = 1.53 SD = 0.40; flew = 0.83* SD = 0.58. High frequency (KHz), ($P > F < 0.0001$): flop = 31.0* SD = 6.3, flutter = 47.9* SD = 4.7; (flap 65.7 SD = 6.2, flew = 76.5 SD = 7.4)*. Low frequency (KHz) ($P > F < 0.0001$): flop = 20.9* SD = 4.8, flutter = 33.3* SD = 3.4, (flap = 49.4 SD = 4.7, flew =

54.9 SD = 5.5)*. Bandwidth (KHz), ($P > F$ 0.0015): flop = 9.8* SD = 1.8, flutter = 14.7 SD = 1.3, flap = 16.4 SD = 1.8, flew = 21.7* SD = 2.1. Frequency of maximum power (KHz) ($P > F$ 0.0003): (flop = 26.4 SD = 5.9, flutter = 40.6 SD = 4.3)*, (flap = 57.2 SD = 5.8, flew = 66.2 SD = 6.9)*. These data suggest not only a shift to a higher frequency range but also an increase in bandwidth and frequency of maximum amplitude. These increases occurred at different stages of flight development providing a possible evolutionary trajectory of flight and echolocation in nasal emitting phyllostomids.

Bats: Conservation and Ecotourism, the Experience at Tirimbina Rainforest Center

Chavarría Carlos and Rodríguez-Herrera Bernal, Tirimbina Biological Reserve, Sarapiquí, Costa Rica

Located in Costa Rica, Tirimbina Biological Reserve is a nonprofit organization. We have been working for 10 years with the communities through an Environmental Education Program, trying to create conscience among students and their families about the importance of protecting the forest in the area. The program works with around 1500 kids per year from 10 different communities. It is a free program for the students and includes transportation, meals, and materials. To maintain a long-term education program, Tirimbina has developed different ecotourism programs. One of them is called the "Bat Program" and takes advantage of a long-term monitoring program on bats. The program is designed to provide information to our visitors about the natural history of bats through a multimedia presentation and also through "field work": tourists visit mist nets that are used by the assistants of the monitoring programs, who explain them how to work with the nets and the benefit of scientific research. Different issues are covered during the activity, from myths to environmental benefits provided by bats, both to humans and to ecology in general. The average tourist has little or incorrect information about bats, and this program contributes to "cleaning up" the bad reputation, which in general bats have. We generated a list of 62 bats, including rare species such as *Vampyrum spectrum*, *Centurio senex*, and *Eumops hansae*. Not only were the educational and scientific aspects of the program important, but it had financial benefits as well. From September 2005 to August 2009, the program generated net earnings of $79,912.64, from the 7733 people who participated in the activity. These visitors were from many different countries, including Costa Rica, the United States, Canada, France, and Germany. Additionally a percentage of these earnings were donated to the Costa Rican Bat Conservation Association, to help support education programs in other regions of Costa Rica. This is an example of a model that links ecotourism with research, education, and conservation, and benefits all of them.

Molecular Dietary Analysis of *Myotis lucifugus*, in Southwestern Ontario: Spatial and Temporal Heterogeneity in Dietary Preferences Indicate Habitat Type and Quality

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We employ the molecular methods of Clare et al. (2009) to profile the diet of *Myotis lucifugus* at three maternity colonies and a swarming site from May–October 2008 and describe spatial and temporal changes in diet over the active season. Because our data provide species level identification of prey, we can isolate environmental indicator species in the diet and make predictions about the location and type of their foraging habitat and the health of these aquatic systems. We identified 63 prey species from the Arachnida (2 species) and Insecta. Most identifications were made to species level while 15 are to genus. The majority of identifications (~50%) were the mass-emerging *Chironomus* sp. and *Caenis* sp. Bats roosting in two rural settings had significantly lower dietary richness than a roost located in the forest. We detected temporal fluctuations in diet between early, middle, and late summer, but this was only significant in the forest roost. The species detected suggest that bats in one rural roost foraged over local rivers while those in the other rural and forest roosts both feed over pond, lake, or lentic wetland habitat rather than flowing water. These predictions have been confirmed for the forest roost that forages over a small lake. All water sources are of fair-to-good quality, though no species detected is intolerant of pollution, thus the habitat cannot be classified as pristine. Our study outlines a model system to study the abiotic and biotic interactions between habitat factors such as water quality through this simple food chain to the top predator and reviews "best practices" for molecular dietary analysis.

The Colorado Bat Matrix: A Tool for Identifying and Evaluating Potential Threats to Colorado's Bat Populations

Colorado Bat Working Group

The goal of the Colorado Bat Working Group (CBWG), an affiliate of the Western Bat Working Group, is for various stakeholders to work cooperatively to conserve bat species and bat habitat throughout Colorado. The CBWG has completed a Colorado Bat Conservation Plan (2004) and a website that serves as a clearinghouse for information about bats in Colorado. While revising the Bat Plan, we identified the need for a stand-alone, readily accessible, reference document that identified and ranked potential threats (e.g., timber harvest, urbanization, energy development) for Colorado bat species. The Colorado Bat Matrix is the result of collaboration between CBWG members from universities, the private sector, and state and federal agencies, and is housed on the CBWG website for ease of access and revision. The primary audience for the Matrix is land managers who can use the rankings as a starting point for identifying threats to bat species. Researchers also may find the Matrix useful to identify gaps in knowledge for future study. We ranked the scope, severity, and immediacy of potential threats as high, moderate, low, or insignificant for 18 species of bats found in Colorado. These rankings were condensed into a value ranging from "A" (substantial, imminent threat) to "H" (unthreatened). To illustrate the Matrix results, we use Townsend's big-eared bat (*Corynorhinus townsendii*), a sensitive species for the USDA Forest Service and Bureau of Land Management in Colorado and a species of special concern for the Colorado Division of Wildlife. In Colorado, the greatest potential threats to this species are abandoned mine lands closure programs and renewed uranium mining, whereas grazing and fire management are unlikely to significantly affect Townsend's big-eared bat populations. The Colorado Bat Matrix may serve as a model for other states or regions looking to create a tool to rapidly identify threats to bat populations.

CBWG: http://www.cnhp.colostate.edu/RASwebpage/cbwg_website/cbwg_index.htm

Bat Diversity and Richness in the Monongahela National Forest

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Populations of eastern bat species have experienced significant declines in many areas, resulting in a reduction in species richness and diversity. This decline can be attributed to many factors, but some of the more influential are loss of summer habitat, wind power, and recently white-nose syndrome (WNS). The Monongahela National Forest consists of over 371,000 ha of land in the West Virginia highlands and is considered by the Nature Conservancy to be in an area of global ecological importance. Due to the concentration of suitable summer habitat and proximity to hibernacula, the Monongahela National Forest is a significant refuge for bats. However, a reduction in size of the populations of cave-dwelling bats after 2008 is expected as a result of white-nose syndrome, which was first reported in the state during winter 2008–2009. Data were collected by biologists from Sanders Environmental, Inc., at monitoring sites in the Monongahela National Forest, following mist-netting guidelines established by the U.S. Fish and Wildlife Service and the Monongahela National Forest. Over 280 sites were monitored during 2001 and 2003–2010, with greater than 8000 individual captures (2010 captures omitted). These data can be used to establish baseline information on capture success, species diversity, and richness in the study area prior to the documentation of WNS in the region. Number of captures each year will be analyzed to determine whether capture success has changed since the arrival of WNS, and whether there have been any changes in species richness and diversity. Eleven species were captured, including the endangered *Myotis sodalis* and *Corynorhinus townsendii virginianus.* Preliminary analyses suggest that fewer cave-hibernating species have been caught in summer since 2008.

How Do Tiger Moths Jam Bat Sonar?

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Many tiger moths defend against attacking bats by producing ultrasonic clicks. Recent work has confirmed the decades-old hypothesis that at least some tiger moth species use the sonic defense to jam bat sonar. The acoustic mechanism for how tiger moths accomplish this feat is unresolved. Three primary hypotheses have been suggested: 1) bats misinterpret the clicks as echoes from objects that do not exist, causing the bats to sharply veer away from the "phantom objects"; 2) the clicks mask the moth's echoes, making the moth temporarily invisible to the bat; and 3) the clicks interfere with the bat's neural mechanism for determining the distance to the moth (i.e., ranging interference), causing the bat to narrowly miss the target. For seven consecutive nights we observed bats attacking

tethered tiger moths (*Bertholdia trigona*) in an anechoic flight room using high-speed infrared videography and ultrasonic acoustic monitoring. We reconstructed the 3D flight trajectories of the bats and moths and analyzed the pattern of bat echolocation emissions to determine whether bats appeared to be avoiding phantom objects (as predicted by the phantom echo hypothesis), losing the targets altogether (masking hypothesis), or narrowly missing their aerial prey (ranging interference hypothesis). On the first two nights of the experiment bats frequently veered sharply away from the moths and aborted attack echolocation almost immediately after the moths clicked (7 of 13 trials; 56%). However, on nights three through seven, the bats rarely veered away from moths (6 of 36 trials; 17%); they instead frequently continued their attacks on the clicking moths, but narrowly missed their prey (15 of 28 trials; 54%; 17.8 ± 7.2 cm minimum bat-moth distance). These results suggest an initial startle response lasting two nights, followed by sonar jamming by means of ranging interference. Three-dimensional simulations also support the ranging interference hypothesis for sonar jamming.

Habitat Use by Bats in Forested, Edge, and Clear-cut Ponderosa Pine Forest in Boulder County, Colorado
Katelin Craven and Rick Adams, University of Northern Colorado, Greeley, CO

Current silviculture methods incorporate various selective harvesting techniques. We investigated how often bats were present in forest, edges, and clear-cut selections of ponderosa pine forest in Boulder County, Colorado. We simultaneously placed Pettersson D240x ultrasonic detectors with Samson Zoom digital recorders on tripods one meter above ground, tilted 300 to slope in each habitat usually throughout the night. Recorded calls were analyzed to species using Sonobat 3.0 software. We also netted in forested and clear-cut areas and identified individuals to species, sex, age, and reproductive status. Over 45 detector nights, we found that bat activity was highest in clear-cut areas (180 calls), activity in forested areas was second (64 calls), and edge totaled 50 calls. Clear-cut areas had the highest species richness with nine species, forested habitat had eight, and edge had five. Forested areas were used predominately by clutter specialists, *Myotis thysanodes* and *M. evotis*. *Lasiurus cinereus* and *M. ciliolabrum* used all habitats, whereas *M. lucifugus*, *Lasionycteris noctivagans*, and *Eptesicus fuscus* dominated calls gathered from clear-cut habitat. There was also an apparent relationship between moon-phase and foraging habitats wherein species activity was highest in forested areas on nights having higher illumination, and this was true even for open-aerial fliers such as *L. cinereus* and *E. fuscus*. Because habitat usage was diverse and may vary depending upon nightly conditions such as moon phase, forest management and treatment plans are more likely to satisfy the requirements of more species if harvesting creates a mosaic of patches with different habitat types.

Evidence of Mating Readiness in Certain Bats Killed by Wind Turbines
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Bats consistently die at wind turbines during late-summer and autumn. Migratory, tree-roosting species show increased susceptibility compared to other bats, yet the exact causes remain unknown. A hypothesized cause with strong conservation implications is that migratory tree bats die at turbines while seeking mates around tall treelike structures. In this pilot study we histologically examined reproductive tracts of hoary bats (*Lasiurus cinereus*) and silver-haired bats (*Lasionycteris noctivagans*), found dead beneath wind turbines, for evidence of mating or mating readiness. We sampled 61 *L. cinereus* and 31 *L. noctivagans* killed by turbines in New York, USA, and Alberta and Manitoba, Canada between early July and late September. By August most adult male *L. cinereus* had sperm in the caudae epididymides (CE), indicating readiness to mate. About half of juvenile male hoary bats had sperm in their CE by August, revealing reproductive activity just months after birth. Sperm were seen in the uterus of the only adult female hoary bat collected in September, but we found no sperm in the other 17 females sampled in previous months. Ovaries of most adult and juvenile female *L. cinereus* had growing follicles, but they did not appear to be in estrus. Evidence of sperm in *L. noctivagans* was more limited, yet sperm were found in the CE of some adult and juvenile males. No female *L. noctivagans* contained sperm, but most adults and juveniles had growing follicles. These results indicate that adult and juvenile males of each species were ready to mate when they were killed by wind turbines, although evidence of copulation with females was limited. Results were insufficient to disprove the mating hypothesis—more thorough analysis of bats killed by turbines from late August through October and from a broader geographic area will be the next important step in assessing its merit.

Differences in Structure of the Bat Community in Managed and Unmanaged Southeastern Pine-hardwood Forests

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The Piney Woods extend along the coastal plain from eastern Texas to Florida and northward into Maryland. This ecoregion is considered highly endangered due to fire suppression and extensive timber production. Sam Houston National Forest comprises nearly 66,000 ha of southeastern Texas "pineywoods." The western side of the forest has been managed for red-cockaded woodpeckers through managed burns since the 1960s, so it more closely resembles the historic condition (pine species dominate; little-to-no understory, thus is uncluttered). The eastern side of the forest has been mostly "unmanaged," most areas not burned for > 10 years. Hence, this area represents habitat degradation due to fire suppression (pine species not dominant; forest highly cluttered). However, due to differences in amount of understory vegetation between managed and non-managed areas, we expect to see differences in bat community structure. Managed areas should be dominated by species that are better adapted to forage in more open areas, while unmanaged habitat should be dominated by species more specialized for clutter avoidance. We sampled two sites, Kelly Pond (KP, managed) and Henry Lake Creek (HLC, unmanaged) using triple-high nets. Captured bats were identified to species, sexed, measured, and examined for reproductive state. During our pilot study at the KP in 2009, we captured > 120 individuals of 8 species: red, hoary, Seminole, big brown, evening, eastern pipistrelle, southeastern myotis, and Mexican free-tailed bats. Thus far during summer 2010 we have captured 102 bats at the HLC site, and 37 at the KP site. We have observed differences in bat communities between these sites: KP is dominated by Seminole and evening bats, while the HLC site is dominated by Seminole bats and big brown bats. By the end of the netting season, we expect to see further differences between these bat communities concerning the less abundant, bat species.

Harp Trap Bias: Differences in Relative Species Abundance Using Group and Individual Captures

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Mist nets and harp traps are common methods used for capturing bats. Although many studies have examined the use of mist nets and associated bias resulting from net placement, frequency of netting, species effects, and frequency of net checks, similar bias effects have never been assessed for harp traps. The purpose of our study was to examine sampling bias when using harp traps to determine population composition. We hypothesized that the proportions of species from traps left unattended would be biased as conspecifics are attracted to distress calls produced by the bats left in the traps. We predicted that estimates of species proportions would be biased in favor of the most common species, because this species is the most likely to be captured first and consequently, attract conspecifics. We used two different strategies to monitor the harp trap: group captures or individual captures. For group captures the trap was left unattended for 30-minute intervals, but for individual captures we immediately removed bats once they were captured in the harp trap. We found that the proportion of each species observed was affected depending on the method used to monitor the trap. We suggest that although impractical, individual captures are more likely to be representative of the true species composition at a given site. We therefore caution the use of group captures when using harp traps for determining relative abundance of species.

A Map of the Big Brown Bat Wing: "Typical" Damage and Scarring in an Urban Maternity Population Prior to White-nose Syndrome

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Wing damage is a clinical sign of white-nose syndrome (WNS) in hibernating bats, yet few if any studies have characterized typical damage and scarring in bat wings prior to WNS. We examined wing damage in big brown bats (*Eptesicus fuscus*) sampled from maternity colonies in buildings of Fort Collins, Colorado, from 2001–2005. This effort was part of a research project investigating rabies transmission in urban bat colonies. We individually marked bats using passive integrated transponders (PIT tags) and monitored their presence at five major maternity roosts. We regularly captured marked individuals from these roosts to gather body measurements and ectoparasite counts, sample blood, and examine wing damage. For each bat, we noted the locations of scars, fresh holes, and other wing anomalies on diagrams of each wing. We then tallied the total number of scars and fresh holes for each bat. We examined the effects of roost, sex, age, reproductive condition, number of ectoparasites, and year of capture on the number of scars and fresh holes using a generalized linear model. We also examined a subsample of bats recaptured within and among summers to look at changes in wing scarring (i.e., disappearance of scars, length of healing time). Average number of scars and fresh holes varied by roost, sex, and age. Wing damage did not vary by reproductive condition, ectoparasite load, or year. Adult females averaged 21.3 ± 5.5 (mean ± *SE*) scars, juvenile females 17.1 ±

6.2, male adults 18.8 ± 7.1, and juvenile males 16.6 ± 8.0. These results provide a baseline of information on the typical damage in wings of presumably healthy female *E. fuscus* and serve as a caution that not all wing damage is the result of WNS.

Long-term Monitoring of Central California Bats: What We Know from Ten Years of Acoustic Monitoring and Twenty Years of Roost Counts
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Automated Anabat bat detectors running 24/7 have been used in four National Park areas in the San Francisco Bay Area. The first detector was installed at Point Reyes National Seashore in 1999 and has been in operation ever since. An additional 12 detectors were subsequently deployed for periods of 4–8 years. These detectors provide information on the make up of local bat communities, as well as information on nightly, seasonal, and yearly patterns in bat activity. Some monitoring stations are in relatively close proximity, but have notable differences in patterns of activity and species occurrence. Some bats are not readily detected with bat detectors, largely due to their quiet or infrequent vocalizations. Townsend's big-eared bat (*Corynorhinus townsendii*) is a rare bat that has very quiet vocalizations and is not readily detected. A maternity roost in an abandoned house at Point Reyes National Seashore has been monitored with exit counts since the roost was discovered in 1987. Counts begin in March or April and occur monthly through September or October. More than 150 exit counts have been conducted. The spring counts document the number of females in the roost, and summer counts include females and their volant young. Hence, it has been possible to track the increase in the size of the maternity colony, as well as the annual variation in reproductive success.

The Evolution of Echolocation in Bats
Brock Fenton, University of Western Ontario, London, ON

Although it is evident from the morphology of the shoulder girdle that well-preserved fossil bats from the Eocene were capable of powered flight, the situation for echolocation is not as clear. Contact between the stylohyal and tympanic bones, sometimes involving fusion, clearly separates extant laryngeally echolocating bats from those that do not echolocate or echolocate with tongue clicks (Pteropodidae). One key to the evolution of echolocation is avoiding self-deafening. Another is registering the outgoing pulse in the brain for future comparison with returning echoes. I will consider the selective advantages associated with laryngeal echolocation and argue that this mode of orientation was ancestral in bats. Most echolocators, including most bats, separate pulse and echo in time (low duty cycle echolocators) and cannot broadcast and receive at the same time. This is true of most echolocators including most echolocating bats. However, some bats—species in the families Rhinolophidae and Hipposideridae, and the mormoopid *Pteronotus parnellii*—separate pulse and echo in frequency. These high duty cycle echolocators can broadcast and receive at the same time. I will consider the scenario in which high duty cycle echolocation might have evolved, considering what is known now about the echolocation behavior of extant high duty cycle bats (species of Rhinolophidae, Hipposideridae, and the mormoopid *Pteronotus parnellii*).

Hibernating Bat Counts in New Mexico Caves
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Information on size and stability of the bat population is important in cave and wildlife management, especially with the current threat of white-nose syndrome (WNS) looming over the West. Information presented will include historical data, techniques used to inventory hibernacula, and methodology to organize the data into useful forms to use in future WNS research. For more than ten years, volunteer cavers have conducted hibernating bat counts in several caves designated as hibernacula within the Roswell, New Mexico, Bureau of Land Management district. Historical data have been collected as far back as the late 1970s. The most common bat species inventoried were *Myotis velifer*, *M. ciliolabrum*, and *Corynorhinus townsendii*. The bat count at one hibernaculum has varied between 300–14,000 bats. A simple yet complete format for data collection needs to be distributed to western cavers to increase our body of knowledge about bats in caves in the West.

Measuring Habitat Improvement Along the Las Vegas Wash Using Bat Dietary Analysis
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The purpose of this study was to better understand the environmental characteristics of riparian restoration areas along the Las Vegas Wash, Nevada and determine if these restoration efforts are successful. Three sites were examined including an invasive saltcedar stand that represents a pre-restoration state, an actively created riparian revegetation site, and a back water area in a passively created wetland. Success was measured by combining bat capture and acoustic bat monitoring, bat dietary analysis, nocturnal invertebrate collection, and vegetation richness and cover monitoring. Bats were captured using triple-high nets in flight corridors on a monthly basis for three consecutive nights each month from May through October. After capture, bats were placed in cloth bags for a minimum of one hour to collect fecal samples. Bats were then identified to species and sex, reproductive status, and characteristic measurements were recorded. Fecal samples were collected from the cloth bags and analyzed for insect content at a later date. Insect parts in fecal pellets were identified by comparing them to insects collected using a UV light adjacent to bat capture sites. The UV light was positioned to reflect off of a white sheet, and unique and otherwise unknown insect specimens were collected. Digital photographs were taken of the sheet, which was divided into sixteen partitions. Insects were later identified and quantified using prints of the photos compared to keys and those insects previously collected. Finally, vegetation was monitored for species richness and cover of each site as a whole as well as how much each individual species contributed to the cover of each site. Success in this study is defined as having higher species richness and abundance of native species in bats, invertebrates, and plants in restored areas as compared to pre-restored areas.

***Fur Stable Isotope Ratios in Residential and Migratory North American Bat Populations**
Erin E. Fraser, Liam P. McGuire, M. Brock Fenton, and Fred J. Longstaffe, University of Western Ontario, London, ON
*** Erin Fraser** received the ***Bat Research News* Award**

Stable hydrogen isotope analysis is frequently used to determine the origins of migrating animals. There is a predictable latitudinal pattern of stable hydrogen isotope (δD) values in meteoric water that is reflected in local animal tissues. A general limitation of this method is that individuals within a residential population may display a wide range of δD values, and this is true in bats. We sampled resident and migratory bat populations to provide a better understanding of the causes and magnitude of this variation, which will allow for increased efficacy in the use of stable hydrogen isotope analysis to learn about bat migration. Stable carbon (^{13}C) and nitrogen (^{15}N) isotope analyses were used to investigate the role of diet in creating δD variation. Further, we investigated whether we could distinguish residential and migratory groups of bats using stable isotope results. We present fur δD, $\delta^{13}C$, and $\delta^{15}N$ values from seven residential and four migratory bat populations representing four North American species (*Myotis lucifugus*, *Lasiurus borealis*, *L. cinereus*, and *Lasionycteris noctivagans*). We show that δD variation is species dependent and that δD and $\delta^{13}C$ correlate significantly in some but not all residential groups. The magnitude of δD variation in residential and migratory *Lasionycteris noctivagans* populations did not differ; however, there was a significant δD and $\delta^{13}C$ correlation for the residential population but not the migrants, suggesting that the two groups may be isotopically distinct.

The Air as Habitat: Influence of Meteorology on Group Behavior Dynamics of a Nocturnal Aerial Predator (*Tadarida brasiliensis*)
Winifred F. Frick, Kenneth W. Howard, Philip B. Chilson, and Thomas H. Kunz, Boston University, Boston, MA; NOAA National Severe Storms Laboratory, Norman, OK; University of Oklahoma, Norman, OK

We examine spatio-temporal variation in foraging dynamics of Brazilian free-tailed bats (*Tadarida brasiliensis*) in south-central Texas, demonstrating the potential of radar aeroecology for advancing understanding of ecological interactions in the aerosphere. Brazilian free-tailed bats disperse nightly in dense columns from cave and bridge roosts and forage at high altitudes (300–2500 m AGL) over large spatial extents that are easily detectable with Doppler weather radar (WSR-88D) installations. Understanding variation in emergence behavior of Brazilian free-tailed bats provides a model system for testing hypotheses about the influence of abiotic factors on the dynamics of group behavior. Using high resolution Level II NEXRAD radar products, we test hypotheses about the influence of weather conditions such as surface temperature, precipitation, and cloud cover on timing and relative density of bat emergences to determine how atmospheric cues determine group behavior and foraging dynamics of an aerial nocturnal predator. We visualize bat emergences in 3-dimensional space and investigate seasonal variation in emergence behavior. In addition, we highlight the utility of radar visualizations for generating new hypotheses about

foraging behavior of aerial species by demonstrating how radar makes it possible to 'observe' behavior at temporal and spatial scales not previously possible.

***A Wing and a Prayer: Little Brown Myotis (*Myotis lucifugus*) Recover from Wing Injuries Associated with White-nose Syndrome**

Nathan W. Fuller, Jonathan D. Reichard, Morgan L. Nabhan, Spenser R. Fellows, Lesley C. Pepin, and Thomas H. Kunz, Boston University, Boston, MA

*** Nathan Fuller** received the **Speleobooks Award**

Since the appearance of white-nose syndrome (WNS) in North America, researchers have observed discolored, scarred, and necrotic wings on little brown myotis (*Myotis lucifugus*) at maternity colonies. Over the course of the spring and summer the apparent abundance of bats with severely damaged wings decreases, leading to the hypothesis that damaged wings reduces flight ability, thus making bats susceptible to increased predation, reduced foraging success. We tested the hypothesis that reduced observed frequency of severe wing damage results from healing. We trapped bats weekly at the time of nightly emergence, alternating between two maternity colonies in Massachusetts and New Hampshire. Bats were assessed for age, sex, reproductive condition, length of forearm, and wing damage index (WDI). Wings were trans-illuminated and photographed before bats were banded and released. For bats that were captured and recaptured at maternity roosts, wing damage was quantified as the proportion of the wing area affected at first capture and at subsequent recapture. The relative proportion of bats with severe and moderate wing damage decreased as the summer progressed. We recaptured 36 banded bats, of which 50% exhibited evidence of improved wing conditions, including at least two individuals whose wings improved from the most severe condition (WDI = 3) to a lesser one (WDI $\leq$ 2). The maximum observed rate of healing was 2.11% improvement per day by an adult female that healed 29.6% of the observable wing area over 14 days. Our results suggest that wings of little brown myotis can heal rapidly from injuries sustained during winter. Thus, decreased occurrence of severely damaged wings later in the summer does not necessarily signal increased mortality. Further studies are needed to investigate the foraging ability, long-term survival, and reproductive success of individual bats and population trends of little brown myotis at WNS-affected hibernacula and associated maternity colonies.

Affects of Call Structure on the Jamming Avoidance Response (JAR) in Brazilian Free-tailed Bats, *Tadarida brasiliensis*

Erin H. Gillam, North Dakota State University, Fargo, ND

Bats rely heavily on echolocation for orientation and prey detection. When flying in the presence of other bats, individuals have been shown to adjust their call structure to avoid frequency overlap with the calls of nearby conspecifics, known as a jamming avoidance response (JAR). Despite previous work, the dynamics of JAR are still not well characterized, and further research is necessary to understand how bats are able to detect and process weak echoes in the presence of jamming signals. The objective of this research was to examine how the characteristics of a jamming signal (i.e., echolocation calls) affect JAR in free-flying Brazilian free-tailed bats, *Tadarida brasiliensis*. Specifically, I broadcast five types of echolocations calls that exhibited the same minimum frequency, but differed in call shape and frequency modulation. I determined if bats differentially respond to each call type or give a generic response to all broadcast signals. This study provides additional insight into the signal processing capabilities of bats, and helps us better understand how bats are able to orient using sound in a noisy world.

Monitoring Summer Maternity Colonies of *Myotis lucifugus* in Massachusetts: Assessing Impacts of White-nose Syndrome

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Little brown myotis (*Myotis lucifugus*) populations in the northeastern United States have recently experienced major declines in some hibernacula. These declines parallel the arrival and spread of a psychrophilic fungus, *Geomyces destructans*, which causes a condition known as white-nose syndrome (WNS). For the past several years, we have monitored two established maternity colonies of little brown myotis in eastern Massachusetts. We present census results from these two colonies for comparison with colony sizes at hibernacula in the northeastern United States before and after the appearance of WNS. Our census data before the occurrence of WNS were based mostly on visual counts. With the first evidence of WNS in Massachusetts, we installed infrared AXIS cameras (BatCams) that record nightly emergence activity, even when weather conditions preclude reliable live visual counts. Computer

software was developed to automatically detect and count bats from the video recordings. Weekly flight counts were made directly from the video recordings, along with live counts in the field. Current analysis of video records from one site (Paxton Colony) showed that the adult colony size decreased by 70% from 2008 to 2009. Video recordings from the second site (Lincoln Colony), a slightly larger colony initially, also showed a decline, but we do not have a reliable record of colony size at this site in the pre-WNS period. Live visual counts of emerging bats were comparable to counts made directly from the video recordings, but the automatic computer counts were at times 20% higher than results from the two visual counting methods. Despite predicted regional extinction of little brown myotis, our current results suggest that there may be refuges of unaffected bats or perhaps survivors of WNS that will persist and may increase if suitable roosting sites are made available for small residual colonies.

Cheek Swabs as an Alternative to Wing Punctures for DNA Sampling in the Field

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Determining the best method to collect DNA in the field is critical to saving both time and money for the researchers. In non-lethal tissue collecting in bats, wing punctures have traditionally fulfilled this role. However, quantity of DNA extracted can be quite low requiring multiple extractions or several wing punctures per individual for enough DNA. Additionally, the long-term effects of punctures on bat health are poorly understood. Cheek swabs, traditionally used for human DNA extraction, can increase DNA yields and minimize physical damage to the bat. We compared DNA quantity and quality from cheek swabs and wing punctures from multiple individuals of several species collected in the summer of 2009 in the Dominican Republic and Puerto Rico. We found that cheek swabs produce significantly higher amounts of extracted DNA compared to wing punctures from the same individuals collected on the same date and preserved identically. Cheek swabs provide the best method for non-lethal DNA collection in the field and allow researchers to save both time and money in DNA studies while also minimizing potential adverse effects in the bats.

Hibernacula Microclimate and White-nose Syndrome Susceptibility

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Anecdotal evidence suggests that bats that hibernate in colder and drier caves and mines are less affected by the emerging infectious disease white-nose syndrome (WNS) and that WNS-affected bats shift roosts in early midwinter to cave entrances. To test the notion that colder microclimates offer protection against WNS, affected little brown myotis (*Myotis lucifugus*) were housed in captivity at different temperatures (4°C, 7°C, and 10°C). Likely due to energy savings and slowed growth of the putative fungal pathogen, bats hibernating at lower temperatures lived longer. To determine why WNS-affected bats shift to cave entrances, the thermal preference of WNS-affected and unaffected captive and free-ranging bats was tested. We predicted that WNS-affected bats hibernating at the front of the hibernacula would prefer colder temperatures than WNS-affected bats hibernating in 'normal' roosts deeper in the cave, but all bats selected relatively warm roosting sites (8.06°C ± 0.46 *SE*). This suggests that WNS-affected bats are moving to the entrances of hibernacula not to select colder roosts and thus conserve energy, but for some other reason. The results from this study will help predict which hibernacula are more likely to be infected and whether altering microclimate properties of mines may mitigate the disease.

Using Discriminant Function Analysis and Other Quantitative Techniques to Classify Bat Echolocation Calls

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Modern commercial-scale wind turbines are known to kill bats, and surveys to assess risk before construction are generally conducted. Pre-construction surveys at proposed wind energy facilities include the use of passive echolocation monitoring to estimate relative levels of bat activity, a proxy for potential risk. However, risk has not been shown to be equal among species, and the predictive value of this approach has not been conclusively demonstrated, and may be difficult to demonstrate given the typical broad-level classification (high- versus low-frequency). In addition, concern over risks to endangered species has spurred renewed interest in a generally applicable method of quantitatively determining presence based on echolocation call data. Therefore, a multivariate canonical discriminant function was developed based on 640 echolocation sequences from 11 species of bats, to classify unknown bat call sequences from passively collected Anabat data. Cross-validation for all 11 species

indicated that the model had a correct classification rate of 90%, ranging from 67–99%. Bootstrap simulations indicated that for most species, correct classification rates did not improve as the number of pulses per call increased over five. Application of the model to real-world data, including relative abundance of species thought to be at risk from wind turbine operation will be presented. In addition to discriminant function analysis, a neural network approach to species determination will be presented and compared to discriminant classification. Neural networks may provide a better method for discriminating bat echolocation calls, and may be more robust to variability in call quality. The application of both methods will be discussed in the context of analysis of potential and realized risk to bats from wind turbine operations.

A New Method for Reliable and Repeatable Searcher Efficiency for Post-construction Mortality Surveys at Wind Energy Locations

Benjamin Hale and Lynn Robbins, Missouri State University, Springfield, MO

Wind turbines are a fast growing form of sustainable energy. Unfortunately, bat mortality has been recorded at wind turbine locations due to blade impact and extreme pressure changes (barotrauma) caused by the spinning rotors. The U.S. Fish and Wildlife Service recommends that wind energy companies develop a Habitat Conservation Plan (HCP) to minimize the effects of turbine construction and operation on bats, specifically the endangered Indiana bat, *Myotis sodalis*. Following construction, surveys are necessary to assess the effectiveness of the habitat conservation plan. As part of this, searches are conducted to estimate fatalities in project areas. Currently, the most widely used method for mortality estimates are based on searching performed by humans, which has a searcher efficiency as low as 25% and is highly variable. These low and inconsistent success rates make estimating actual impacts statistically unreliable. Mechanical methods would eliminate human-based variance and provide a more cost and time efficient method of post-construction mortality surveys. This project tests a modified agricultural machine for its ability to pick up, or "search" for bat carcasses in vegetation. Formalin-prepared bat carcasses were randomly placed in transects across varying vegetations (4.5, 6, and 8 inches) to determine optimal height. Results of 20 repeated transect-trials in a vegetation height of 4.5 inches resulted in an average efficiency of 81% with a low variance among trials (0.011). Without reliable searcher efficiency, effects of turbine construction cannot be accurately and efficiently assessed and therefore types and level of turbine mitigation cannot be accurately determined. These data indicate that carcass searching using a modified machine reduces variability due to human bias, yields higher searcher efficiency than other methods, and allows for a repeatable and more scientific approach to mortality surveys.

Monitoring Bat Activity along Two Landscape Features in Southern Ontario, Canada

Rachel M. Hamilton, University of Western Ontario, London, ON

The purpose of this study is to explore the basic patterns of habitat usage at sites along the Niagara Escarpment and Lake Huron shoreline in southern Ontario, Canada. Levels of bat activity will be monitored through deployment of bat detectors (Songmeters and Batcorders) during the fall migration and swarming season. Collection of echolocation calls will signify the level of bat activity and identification of bat species active in the area. Data collected may indicate important areas for residential and migratory bat species and their use of the landscape. It has been suggested that crevices on the escarpment could serve as hibernacula for some hibernating bats. In addition, this forested stretch may also attract migratory species, acting as a fly way, in conjunction with the shoreline of Lake Huron. By comparing bat activity along these two land features to known active sites, we can test the prediction that these areas provide refuge for various bat populations. Data on the levels of bat activity in relation to landscape features may also inform the placement of future wind turbines.

The Role of Ecomorphology in Determining Response of a Forest-dwelling Bat Community to Management by Prescribed Burns

Cory Hanks, Anica Debelica, and Kenneth Wilkins, Baylor University, Waco, TX

Prescribed burn management can improve habitat conditions for certain forest-dwelling species (e.g., redcockaded woodpecker). However, the effect of such management practices on the forest-dwelling bat community is not well understood. We conducted our study in eastern Texas in Sam Houston National Forest, a large tract of mixed pine-hardwood forest that characterizes much of the southeastern United States. This forest comprises two districts: the area west of Interstate 45 (I-45) that is heavily managed by prescribed burns, and an unmanaged (unburned) area east of I-45. We predicted bat communities of these areas would differ in relation to the amount of

vegetative clutter present. The managed area would have predominantly open-adapted (clutter-intolerant) species characterized by larger body size, higher aspect ratio, higher wing loading, and relatively narrow range of echolocation call frequencies (e.g., Mexican free-tailed bat). We expected the bat community in unmanaged areas would contain more clutter-adapted bat species having smaller body size, lower aspect ratio, lower wing loading, and broader range of call frequencies (e.g., southeastern myotis). The study was conducted during summers in managed (Kelly Pond, 2009 and 2010) and unmanaged areas (Henry Lake Creek, 2010). We netted bats by using triple-high nets. Bats were identified to species, and their age, sex, and reproductive status recorded. We took digital pictures of the wings to determine wing parameters and recorded echolocation calls before releasing the bats. Preliminary findings are that Seminole bats dominate the community at both sites, with evening bats and Mexican free-tailed bats more abundant in managed areas and big brown bats and southeastern myotis more abundant in unmanaged areas. Field data collection continues through summer, with analyses of wing morphology and echolocation data to follow.

The Morphology of Muscles, Connective Tissues, and Vasculature along the Length of the Tongue in a Nectar-feeding Bat, *Glossophaga soricina*

Caroline J. Harper, E. L. Brainerd, and S. M. Swartz, Brown University, Providence, RI

During feeding, *Glossophaga soricina* extend their tongues into a flower and use the brush-like papillae at the tongue tip to collect nectar. At least two distinct mechanisms might produce tongue elongation in nectar-feeding bats. First, in a muscular hydrostat model, orthogonally arranged muscle fibers decrease the diameter of the tongue, which in turn causes the tongue to increase in length. Second, the vascular pump model suggests that muscle contraction and blood flow within the lingual vessels will act together to elongate the tongue. This study investigates the morphology of the muscles, connective tissues, and vasculature along the length of the tongue to determine if either or both models describe the mechanism of tongue elongation in nectar-feeding bats. The tongues from two *G. soricina* were serially sectioned in multiple orthogonal body planes and stained with hematoxylin and eosin. Micrographs show three distinct, orthogonally arranged muscle fiber populations within the tongue: the vertical, longitudinal, and horizontal muscle bundles. Contraction of these muscle fibers may decrease the tongue's diameter, causing a corresponding increase in tongue length. At the tip of the tongue, the relatively large lingual veins diverge into smaller branches, located within the center of each papilla. This architecture suggests that the horizontal and vertical muscle bundles are used to elongate the tongue, but that blood flow may inflate the brush-like papillae at the tongue tip. The morphology supports the muscular hydrostat model for elongation and the vascular pump model as the mechanism to inflate the papillae and increase the surface area of the tongue during feeding.

Experimental Infection of Jamaican Fruit Bats with Tacaribe Virus

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Tacaribe virus (TCRV) was first isolated from diseased and dying Jamaican fruit bats (*Artibeus jamaicensis)* in the early 1960s during a rabies virus surveillance program in Trinidad and Tobago. However, experimental infections were not performed to verify the etiology of the disease. We infected Jamaican fruit bats with TCRV to examine pathology, virus tropism, shedding, and transmission. Low dose inoculations led to persistent infection of most bats, while high dose inoculations resulted in death or required euthanasia of several bats. Prominent symptoms included lethargy, irritability, and tremors, with deaths occurring as early as 10 days post-infection. Histopathology indicated multi-organ involvement, including pathology of the liver, lungs, and hearts, and in the brains of all bats that exhibited tremors. No transmission was observed, although virus was detected in and recovered from most tissues examined. Several bats inoculated with a low dose of virus were viral RNA-positive in oral and rectal swabs after 45 days, suggesting persistent infection. These findings imply that TCRV is a natural pathogen of *Artibeus* bats but it is unknown how it may affect natural populations.

Potential Impacts of a Changing Climate on Fringed Myotis Populations in the Southern Rocky Mountains

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

The Southern Rocky Mountains are experiencing rapid climate changes, resulting in environmental modification with potentially negative impacts on some mammal populations. Recent research suggests that reproductive success of some Colorado bat species may be reduced during warmer, drier years. Fringed myotis (*Myotis thysanodes*) is a species of conservation concern in western North America. We used 15 years of capture

data, logistic regression, Akaike's Information Criterion (AIC), and multi-model inference to investigate relationships between reproductive condition in adult female fringed myotis and climate and surface water conditions during the spring and summer of the year captured. We created a balanced set of 15 models, each representing a competing hypothesis using four predictor variables: average maximum temperature; total precipitation; average streamflow; and peak streamflow. From 1995–2009, 155 adult female fringed myotis were captured in Colorado's Front Range, of which 137 were reproductively active (88.4%). The model with most support incorporated average stream flow, peak stream flow, and precipitation (w_i = 0.40). Average stream flow received the highest cumulative AIC_c weight (w_+ = 0.90), followed by peak stream flow (w_+ = 0.88), average maximum temperature (w_+ = 0.73), and total precipitation (w_+ = 0.71). The 95% confidence interval for the unconditional parameter estimates for average stream flow and peak stream flow did not overlap 0. In our study, we found that fringed myotis females were less likely to be reproductively active during warmer, drier years. We discuss prospects and challenges of this research, including use in population modeling, and potential biases introduced by mist-netting locations and bat behavior at water resources. We conclude by showing how these results can be coupled with down-scaled streamflow and weather variability models to provide insight into the potential impacts of a changing climate on fringed myotis, and other species of conservation concern, in the Colorado Rockies.

Patterns of Species Richness and Activity of Bats among Land-use Types in Southern Chile

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Very little is known about bat ecology in Chile despite the fact that Chile contains important global conservation priority areas and high endemism for other taxa. Landscape studies in other regions of the world demonstrate that bat activity may differ according to the habitat type and food availability and that bat species can be susceptible to landscape perturbations, such as forest fragmentation and degradation. In this study, we focus on characterizing bat diversity and occupancy patterns within three dominant habitats (native forest, plantation, grassland) in three distinct regions of the Valdivian watershed in southern Chile, including the Andean mountains, central valley, and coastal mountain range. We recorded bat echolocation activity with Anabat II monitoring stations to determine species presence and relative foraging activity in different habitat types. We conducted acoustic monitoring for seven consecutive nights at nine sites in each landscape during January and February of 2009. We compared recorded calls to a call library that we developed for the local fauna from hand-released bats captured during the study. We identified five bat species occurring in the Valdivian region during our study: *Myotis chiloensis*, *Lasiurus varius*, *Histiotus montanus*, *L. cinereus*, and *Tadarida brasiliensis*. Overall, *M. chiloensis* was the most common species in all three sites, and *L. cinereus* was the least frequently detected species. Our effort initiated a program of bat research in southern Chile in collaboration with local Chilean scientists and our results have broad implications regarding the impact of human land use on bat diversity patterns.

Fifty-year Trends in the Literature on Bat Research

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It would be interesting to determine how the research interests of the bat community have changed over the past half century. It would be a formidable task to survey all the major literature citation sources such as *Current Contents*, but fortunately *Bat Research News* has included a section on recent literature since its inception in 1960, which has served as a useful resource on published works concerned with research on bat biology. Initially this listing was somewhat limited but became more inclusive and far-reaching as more individuals became involved in its compilation and to date has included 10,147 titles. From its inception the listed titles were arranged into subject areas, such as echolocation, distribution, physiology, etc. Arranging these publications over time, it is possible to determine trends in the number of titles in each subject published by our colleagues worldwide, even though these lists of recent publications were essentially limited to articles in English. Titles were grouped into five-year sets. The number of citations for each subject was converted to that percentage of the total citations each subject represented. Interest in some subjects changed significantly over time. Titles in ecology were relatively low at only 5.7% of the total but over the next five decades showed a steady increase to 22.4% of all citations, while those concerning evolution and genetics, for example, remained fairly constant. Citations concerning pathology (virology and disease) showed a marked recent resurgence as more presentations appeared concerning new rabies vectors and other diseases, especially the recent appearance of white-nose syndrome. The relative interests in some areas over the

decades appear to be fairly constant but interest in other research areas fluctuate rather significantly. When presented in graphic form, these changes in relative interest seem obvious.

Formation Flight and Group Behavior in Bats Using 3-D Thermal Imaging
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The collective behavior of large groups of organisms continues to fascinate and inspire scientific inquiry. Recent work in insects, fish, birds, and terrestrial mammals has shown that a variety of sensory modalities and mechanisms can be responsible for the structure and maintenance of animal groups. Although bats represent an attractive model for the study of group behavior, currently, little is known about the structure and control mechanisms of their flight assemblages. We present the first such data using the Brazilian free-tailed bat (*Tadarida brasiliensis*) as a model. The emergence of a large colony of free-tailed bats was recorded using an array of time-synchronized and space-calibrated thermal cameras and the bats' three-dimensional positions and trajectories were reconstructed as a function of emergence rate and light conditions. Our results indicate a significant effect of these two variables on the structure and pattern of movement of individuals in the flight column. In addition, we describe non-uniform distribution of individuals in the group that make specific predictions about the sensory modality that bats use. Such information is important for further understanding the mechanisms that govern group behavior in this species, other colonial bats, and group-living organisms in general.

***Impacts of Land-use Intensification on Rainforest Bat Assemblages in Sumatra, Indonesia**
Joe C.-C. Huang, Elly L. Rustiati, Ipoel Bahrie, Koko Yustian, Krisantus U. E. Kusuma, Miswandi B. Katinu, Jani Master, Hesti Prastianingrum, Meyner Nusalawo, and Tigga Kingston; Texas Tech University, Lubbock, TX; University of Lampung, Indonesia; Wildlife Conservation Society-Indonesia Program, Indonesia
*** Joe Chun-Chia Huang** received the **Organization for Bat Conservation Award**

Tropical rainforests, where bat species richness is generally greatest, are likely to experience severe losses of bat diversity as a result of rapid deforestation. Of the threats to tropical forests, conversion to agricultural plantations is the most prevalent after logging. Agricultural land uses can result in significant losses and/or a modification of tropical biodiversity. In Indonesia the situation is critical as the region houses 225 species but relative rates of forest loss (up to 2.0% annually) are the highest among all tropical regions. However, the consequences of agricultural intensification on forest bat diversity in this region are virtually unknown. Here we study bat diversity along a gradient of agriculture intensification to understand how bat assemblages and functional groups respond to different land management strategies. We use harp traps and mist nets to conduct bat surveys in three habitat types in and around Bukit Barisan Selatan National Park southwest Sumatra, Indonesia: monocultural coffee farms; polycultural coffee farms (cultivation type comprises a variety of crops, such as coffee, cocoa, banana, rubber tree) ; and primary rainforests. The values of agroforests to conservation of bat diversity are also discussed. Future work will focus on how land uses shape ecological functions of insectivorous bat ensembles.

***Differences in the Foraging Capabilities between *Pteronotus davyi* and *P. personatus*: Its Relationship with their Echolocation Systems**
Carlos E. Ibarra-Alvarado and Antonio Guillén-Servent, UNAM, México, D.F.; Instituto de Ecología A.C., Xalapa, Veracruz, México
*** Carlos Ibarra-Alvarado** received the **Basically Bats Wildlife Conservation Society Award**

The foraging behavior of a species is closely related to its ability to detect potential prey in its environment. In the particular case of insectivorous bats, this ability is mostly due to the echolocation system, which enables bats to distinguish prey from background clutter. The ability to detect potential prey and the echolocation system are different for each species and vary according to the structural complexity of the space in which the bats fly. This study compares the ability to detect prey between two very closely related insectivorous bats, *Pteronotus davyi* and *P. personatus* (Mormoopidae), that have subtly different echolocation systems. The behavior of 20 individuals of each species was tested in a flight cage, by presenting different scenarios to determine if the horizontal or vertical distance from the prey to background objects affects the detection abilities of bats. The two scenarios were: 1) prey (*Tenebrio molitor* larvae) situated at different horizontal distances from a vertical synthetic grass carpet, and 2) prey situated at different vertical distances (heights) from the surface of a still pond. We found that as the distance

between the prey and the background increased, both species showed better capture success and spent less time finding the prey (as measured by the number of passes before capture). However, the key difference was that *P. personatus* captured prey at very short distances whereas *P. davyi* did not. Also *P. personatus* was considerably better at capturing prey over the still pond, which is its foraging preference—*P. personatus* almost always hunts its prey over water. The results reinforce that *P. personatus* has a more plastic echolocation repertoire than *P. davyi* and uses echolocation differently according to the spatial conditions in which it flies.

Accounting for Seasonal Effects with Additive Mixed Models for Counts of Bat Activity
Tom Ingersoll, William Rainey, Elizabeth Pierson, and Perry de Valpine, University of Tennessee, Knoxville, TN

We investigated the practicality of modeling the response of activity to the effects of season and a categorical covariate within an environment of random site effects and auto-correlated temporal errors. Specifically, we modeled spatially replicated time series of acoustic counts of bats in response to date, and two habitat categories, meadows and forest edges. Data for our analysis were digitally recorded counts of bat passes contracted by the National Park Service. These data were collected with twelve fixed-position bat detectors, one in each habitat type, paired at six locations, over a continuous period of 236 nights at Yosemite National Park, California. Ten species and acoustic clades of bats had been identified and counted in the recordings, across a broad range of abundances and detection probabilities. These data presented substantial modeling challenges of non-linear response to date, interactions between date and habitat, non-normality of errors, serial temporal correlation of errors, and random site effects associated with repeated measures. Additive and generalized additive mixed models implemented in the mathematical language R were found to adequately represent seasonal activity patterns in most species, and were favored over linear models, and linear mixed models by AIC model selection. While bats may represent an extreme case of seasonal effects, correlated errors, and overdispersed counts, these modeling approaches may be applicable to activity-dependent counts of other animal taxa.

A Test of the 'Reproductive Landmarks Hypothesis' as an Explanation for Mortality of Bats at Wind Turbines
Joel Jameson and Craig Willis, University of Winnipeg, Winnipeg, MB

Despite the benefits of wind power, thousands of bats die every year at wind energy facilities due to collision with the rotors and barotraumas. It is still unclear why so many bats enter the rotor-swept air space of the turbines. In North America, the migratory tree bats account for most of the fatalities at turbines and available evidence suggests that these species are attracted to turbines. One possible explanation, which has been termed the "Reproductive Landmarks Hypothesis," proposes that migratory tree bats are attracted to tall structures such as wind turbines during their fall mating/migration period because they perceive them as landmarks at which to find mates, much like some hibernating bat species use hibernacula as mating landmarks. Our objective was to test two questions arising from the Reproductive Landmarks Hypothesis: 1) Do migratory tree-roosting bats exhibit an attraction to tall structures such as wind turbines; and 2) Is there evidence that this attraction is associated with mating activity? We compared bat activity at open fields, woodlots, wind turbines, and other tall structures (telecommunication towers) by recording echolocation calls. We found strong evidence for an attraction to tall structures and the pattern of activity at tall structures varied with season. Determining whether bats are attracted to turbines is important because an attraction raises questions about the value of pre-construction monitoring. In addition, understanding why bats are attracted to turbines could be important for developing effective mitigation strategies.

Sounds Like Fun to Me: A Comparison of Six Ultrasonic Microphones
Meredith Jantzen and Amy Cameron, University of Western Ontario, London, ON; Ministry of Natural Resources, Pembroke, ON

Comparisons of bat activity in various habitat types using echolocation detectors are increasingly common, but no recent study has quantified the range or detection abilities of different brands of acoustic hardware. The purpose of this study was to compare five types of microphones in order to better inform future purchases of bat detectors. This study compared six different ultrasonic microphones: Songmeter SM2Bat (Wildlife Acoustics); Anabat SD (Titley Scientific); BAT AR125 125Khz ultrasonic receiver (Binary Acoustic Technology); Batcorder 2.0 (ecoObs); Bat Echo-Tracker (EchoTrack, Inc.); and Avisoft CM16/CMPA microphone (Avisoft Bioacoustics). Range was determined at 0, 90, and 270 degrees by triggering a DogDazer at 10-m intervals from 10–60 m away from the

microphone. Maximum intensity of each call was recorded in a series of three trials. Detection abilities were also compared at two natural settings along the Ottawa River. For two nights, detectors were set to record from 22:00–0:00 h. Calls recorded in wav. files were analyzed using auto-detection settings in callViewer18. Analook was used to analyze Anabat files. Call numbers varied substantially between recorders. These results suggest that recorder performance differs between brands, and care should be taken when comparing activity levels reported by different types of recorders.

Social Roosting Behavior in Colonies of *Corynorhinus rafinesquii* in Bottomland Hardwood and Upland Karst Regions of Kentucky

Joseph Johnson, Michael Lacki, and Garret Langlois, University of Kentucky, Lexington, KY

Understanding social interactions among bats during day-roosting has implications for reproductive success and discovery of alternative roosts and foraging areas. Evidence suggests several forest-dwelling bat species form colonies composed of individuals faithful to a number of roosts on the landscape, and that roosting associations among members of the colony is preferential, but not exclusive. Thus, determining if species, and populations of species in differing ecological settings, conform to this fission-fusion model of roosting behavior is important to conservation and management efforts. We captured and radio-tagged pairs of adult Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) from May through September 2009 and 2010 to test the fission-fusion model in populations of Rafinesque's big-eared bat. Work occurred concurrently at two study locations in Kentucky—a bottomland hardwood landscape and an upland karst landscape—where types of day-roosts and day-roost availability differed. As of mid-August 2010, we radio-tagged 30 pairs of big-eared bats in the bottomland hardwood study site and 40 pairs in the upland karst study site. Data presented will include analysis of pair association using the pairwise sharing index and individual sharing index. Data will be analyzed by sex and reproductive condition of individuals in the pair. These data will be used to evaluate the strength of day-roosting associations in Rafinesque's big-eared bat, and determine if differences exist between populations inhabiting different eco-regions.

Hoary Bat (*Lasiurus cinereus*) and Brazilian Free-tailed Bat (*Tadarida brasiliensis*) Mortality and Movements at the Montezuma Hills Wind Energy Region in Central California

David S. Johnston, J. A. Howell, N. Thorngate, S. B. Terrill, J. Castle, and T. Mabee, H. T. Harvey & Associates, Los Gatos, CA; ABR Incorporated, Fairbanks, AK

Few studies on wind turbine bat mortality have been conducted in California and none have included the necessary daily carcass searches to accurately study the environmental conditions and the timing of bats' movements. We investigated the relationship between wind speed, distance and direction to tree groves, temperature, barometric pressure, bat mortality, and the direction of bats and birds above and below the turbine height of 125 m AGL. This study comprised carcass searches at 48 turbines, radar sampling at 2 points, night vision observations at 2 points, and acoustic surveys at 8 stations for birds and 8 stations for bats using full-spectrum recordings. Survey techniques were conducted for four 10-day periods between August 15 and October 15, 2009. During the first of two seasons, we found that the lack of high winds (coefficient = -0.48, df = 18, $P = 0.03$) and presence of a high barometric pressure (coefficient = 0.512, df = 26, $P = 0.005$) were important predictors of bat mortality for *Lasiurus cinereus*. The hoary bat mortalities were unevenly distributed temporally (Pearson chi-squared in R, $X^2 = 80.6452$, df = 2, $P < 0.001$) suggesting this species moved in pulses, but *Tadarida brasiliensis* mortalities were distributed evenly suggesting movement was not clumped. Furthermore, a relationship exists between turbine mortality locations and the distance and direction to the nearest clump of Fremont cottonwood (*Populus fremontii*) (Rayleigh Test for Uniformity, $P = 0.007$) and for eucalyptus (*Eucalyptus globulus* and *E. camaldulensis*) trees ($P = 0.013$.) The mean flight direction of birds and bats at High Winds was 103° whereas at Shiloh it was 83°. There was no significant direction of bats and birds below 125 AGL suggesting strikes possibly occur when bats are searching for a roost.

Optimization of Hibernation in *Myotis lucifugus*—the Thrifty Female Hypothesis

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Cold, prolonged torpor bouts have often been considered the ideal pattern of hibernation because they maximize energy conservation. However, deep torpor appears to be accompanied by physiological and ecological costs, which means that patterns of torpor during hibernation are influenced by an optimization between the energetic benefits

and physiological/ecological costs of torpor. The relative importance of spring energy reserves should affect this optimization. Females, which rely on fat reserves at emergence to fuel spring reproduction, should be thrifty with their energy compared to males during hibernation by relying more heavily on deep, prolonged torpor bouts and/or short arousals. We used temperature telemetry and measurements of body condition index (BCI, mass/forearm) to test this hypothesis in *Myotis lucifugus* from hibernacula in Manitoba, Canada. Adult females exhibited a smaller decline in BCI throughout hibernation (24.8%) than adult males (30.7%), juvenile females (28.7%), or juvenile males (33.0%). Our results support the thrifty female hypothesis and have implications for understanding energy balance in hibernating mammals and suggest that female *Myotis lucifugus* may be more tolerant of disruption of energy balance during hibernation, including that associated with white-nose syndrome.

Modeling Current and Future Potential for Peripheral Populations of Southeastern Bats to Mitigate Effects of White-nose Syndrome in Core Populations

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Bat species impacted by white-nose syndrome (WNS) are characterized by winter hibernation in caves. Peripheral populations of WNS-affected bats at the southern edge of their species range in the southeastern United States may not hibernate. If core and peripheral populations of bats differ in behavior or physiology, peripheral populations may mitigate regional species extinction from WNS in core populations. Understanding how species' behavior and physiology vary across space in relation to the environment is essential to understanding the potential mitigating effects of peripheral populations in the face of WNS. We determined with ecological niche modeling (ENM), current and future probabilities that peripheral populations will mitigate core extinctions in WNS-affected bat species by: 1) using ENM to predict the location and distributional limits of peripheral and core populations; 2) determining the behavioral and physiological differences between peripheral and core populations; and 3) using ENM to identify regions where bat populations should have low susceptibility to WNS and high viability. We focused on *Myotis lucifugus*, *M. septentrionalis*, and *Perimyotis subflavus*. Preliminary models show that ENM based on current climate data predict known peripheral populations of bats at the southern extent of the species range. For example, peripheral populations of *M. septentrionalis* in coastal North Carolina are predicted based on core localities alone. In addition, ENM models based on future climate trends increase the likelihood for peripheral populations of the two *Myotis* species to be established in the Gulf Coastal Plain at localities further south than current distributional limits. ENM models show high variability in peripheral population locations along the southern extent of species distributions. Our ENM results underscore the potential for peripheral populations of bats in the southeastern United States to mitigate effects of WNS on core populations.

Bat Activity across the Vertical Gradient of an Old Growth Redwood Forest

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Throughout the world, bats vary in their use of the microhabitats along vertical strata of forests. High-flying bats may avoid capture or be under-represented in assessments using ground-based detection methods. We assessed bat activity and species stratification along the vertical gradient at two coast redwood (*Sequoia sempervirens*) trees in Humboldt Redwoods State Park, Humboldt County, California. This is the tallest forest in the world, containing 70% of known trees over 107 m. We equipped both trees with full-spectrum automated bat detector units at upper canopy, middle canopy, and ground level (108, 50, and 5 m, respectively) from April 2008 to November 2009. We sampled 1365 detector nights and recorded 3796 echolocation sequences. We identified the presence of 12 species: *Corynorhinus townsendii, Eptesicus fuscus, Lasionycteris noctivagans, Lasiurus blossevillii, L. cinereus, Myotis californicus, M. evotis, M. lucifugus, M. volans, M. thysanodes, M. yumanensis,* and *Tadarida brasiliensis*. Two species, *L. blossevillii* and *T. brasiliensis*, were undocumented in previously published surveys from redwood forests. Highest activity was recorded at upper canopy level and least activity at middle canopy detectors. A greater number of species was observed at ground level. Non-*Myotis* species composed, on average, 95% of the calls at the upper canopy, 87.5% at middle canopy, and 21% at ground level. Calls from all *Myotis* species averaged 71% of all calls recorded from the ground level compared to less than 4% at both middle and upper canopy detectors. There was a marked decline, but not an absence of activity during late fall through early spring. The presence of migratory species during winter months suggests the potential for resident populations or inland migrants overwintering in these forests. Our findings illustrate the need to consider the full vertical habitat when designing bat habitat use studies, as species composition varies across the vertical layers.

Behavioral Syndromes and their Social Implications in Adult Female Big Brown Bats, *Eptesicus fuscus*
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Behavioral syndromes are consistent and correlated behaviors found between and within individuals, and have become the focus of much research in the last decade. They have been studied in a wide range of taxa, both vertebrate and invertebrate, and have important implications on how animals interact with their surrounding environment and as well as with conspecifics. This study examines behavioral syndromes in adult, female big brown bats and explores their social implications. We created behavioral profiles for 28 individuals brought temporarily into captivity over the typical reproductive season of this species. The behavioral profiles consisted of 11 behavioral variables, including aggression, activity, competition, learning ability, and stress response. Several of the behavioral variables were compared between solitary and social contexts. Additionally, we examined the potential influence of several non-behavioral variables, including body size and colony of origin. The variables were reduced using principal component analysis and factors compared using correlation analyses. We used cluster analysis to determine how bats could be grouped according to similarity in behavioral profiles and found that profiles changed consistently over the reproductive period: pregnant females behaved differently than post-lactating females. The results to this experiment indicate that the behavior of bats is constrained by behavioral syndromes and that these syndromes may change over the course of the reproductive period. Alterations in the behavioral patterns of adult females may also be a reflection of social changes that take place in this species during the summer, and these implications are discussed.

Landscape and Temporal Variability of Insectivorous Bat Assemblages in a Malaysian Rainforest: Just What Is a Bat Assemblage?
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Tropical bat assemblages are among the most species-rich and trophically diverse vertebrate assemblages in the world. They are both a source of inspiration for community ecologists, and, given the rapid loss of tropical habitats, a cause for concern for conservation biologists. Confounding both research foci are practical issues concerning the delineation of assemblages in both time and space. Few studies have addressed the spatio-temporal variability of bat assemblages, particularly that within contiguous undisturbed habitats. In this study, we used a standardized harp-trapping protocol to sample insectivorous bat assemblages at five study sites within the contiguous, undisturbed lowland rainforest of Krau Wildlife Reserve, Malaysia. The study sites were a minimum of 6 km apart, and comprised trail networks of 14 km (one study site with an irregular grid) and 22 km (four 1-km^2 study sites). Over a period of seven years, each assemblage was sampled four times. After standardization for weather, total trap effort exceed 6600 harp-trap nights and generated over 16,000 captures of adults of 31 species from six families. Estimated species richness varied slightly across space and time, but spatio-temporal variability in the composition of the assemblages was pronounced, underpinned by complex and asynchronous interactions at the species level. These findings have important consequences for our understanding of the processes determining assemblage structure, the design of diversity surveys, and the conservation of species-rich assemblages in the face of habitat disturbance and fragmentation.

Thermoregulation and Roost Selection During Early Development in the Solitary, Tree-roosting Hoary Bat (*Lasiurus cinereus*)
Brandon Klüg and Robert Barclay, University of Calgary, Calgary, AB

Raising young in cold environments results in slowed growth rates. Previous studies have suggested that neonate bats are unable to maintain a high body temperature following parturition, so keeping young warm to promote rapid growth seems imperative. For temperate-zone bats, providing young with enough nutrients and warmth to facilitate rapid development while sustaining their own energy needs can be challenging. Many bat species form sheltered maternity colonies, which provide the benefit of ambient warmth. For the solitary, tree-roosting hoary bat (*Lasiurus cinereus*) this strategy is not available. However, we hypothesize that like other bat species reproductive *L. cinereus* refrain from using torpor during lactation regardless of environmental conditions. We also hypothesize that neonate hoary-bat pups are able to maintain a high body temperature immediately after birth and that roosts are selected that minimize convective heat loss and maximize radiant heat gain, thus lessening the thermoregulatory demand of the mother and allowing rapid growth of the pups in her absence. We captured and

radio-tagged 15 *L. cinereus* families and monitored thermoregulatory patterns of both mothers and pups. We also measured roost variables, including wind speed and sun exposure, to determine if roosts are selected for physical and microclimatic characteristics. Preliminary analyses suggest that reproductive *L. cinereus* females are using torpor differentially throughout the reproductive period and choosing roosts with less variable sun exposure and more shelter from wind than randomly chosen roosts. It also appears that *L. cinereus* pups are able to maintain a high body temperature in as little as two days after birth, but continue to use torpor in the mother's absence. Further data analyses and conclusions will be presented.

Ectoparasites of Nectar-feeding Bats *Erophylla sezekorni* and *Monophyllus redmani* on Puerto Rico
Allen Kurta, John O. Whitaker, Jr., Brian Schaetz, and Olivia Munzer, Eastern Michigan University, Ypsilanti, MI; Indiana State University, Terre Haute, IN

The buffy flower bat (*Erophylla sezekorni*) and Greater Antillean long-tongued bat (*Monophyllus redmani*) are phyllostomid species that are endemic to the West Indies, where they typically roost in the cooler portions of hot caves. Between February 2007 and February 2008, we examined about 180 adult individuals of each phyllostomid for ectoparasites at Culebrones Cave, near Arecibo, Puerto Rico. Both species harbored large numbers of spinturnicid mites—*Periglyhus cubanus* on *E. sezekorni* and *Periglyschrus vargasi* on *M. redmani*. However, despite living in the same cave and having similar foraging strategies, there were many differences in the ectoparasitic assemblages. For example, streblid flies (*Nycterophilia* and *Trichobius*) were abundant on *M. redmani*, but uncommon on *E. sezekorni*. Conversely, ticks were common on *E. sezekorni* but rarely found on *M. redmani*. Unlike mormoopid bats that live in the same cave, these phyllostomids rarely were parasitized by chiggers.

Deployment of Heat-trapping Roost Modules: A Strategy to Help Mitigate the Decline of Little Brown Myotis Populations Caused by White-nose Syndrome
Thomas H. Kunz and D. Scott Reynolds, Boston University, Boston, MA; St. Paul's School, Concord, NH

In the wake of the massive regional population collapse of little brown myotis from white-nose syndrome (WNS) in the eastern United States, we describe a heat-trapping roost module that can be installed in the attics of buildings that are currently or were previously occupied by large maternity colonies. The premise of this proposal is that colonies of little brown myotis that have been significantly reduced in size from the affects of WNS are likely to be most successful if small colonies can roost in buildings where heat-trapping crevices facilitate euthermic body temperatures. Based on expectations that there will be some survivors following the recent declines in colony size from WNS, every reasonable effort should be made to protect these survivors and to facilitate colony recovery. Roost modules, modeled after unintended but successful bat roosts in some buildings, are designed to accommodate small colony sizes by providing a roost environment that can trap metabolic heat, thereby reducing energy expenditure and thus promoting reproductive success of bats that now comprise these small colonies. We describe a roost module that is relatively inexpensive and easy to construct and install in existing or new buildings that provide roosting space to accommodate small and potentially growing colonies. As colony size increases, additional roost modules could be installed to accommodate colony expansion. Roost occupancy can be monitored by collecting guano from beneath a relatively small roosting space and using molecular markers derived from feces to periodically and unobtrusively monitor colony size. If desired, roost occupancy and colony size and dynamics could also be monitored by strategically placing temperature probes in roost crevices and installing a passive integrated transponder (PIT) system or infrared video camera to automatically census bats as they emerge nightly from roost modules or from the buildings in which these systems have been installed.

***Identifying the Confounding Factors in Resolving Phylogenetic Relationships in Vespertilionidae**
Justin B. Lack and Ronald A. Van Den Bussche, Oklahoma State University, Stillwater, OK
*** Justin Lack** received the **Karl F. Koopman Award**

Resolving phylogenetic relationships within Vespertilionidae has been difficult, with large data sets (> 100 taxa, > 7 kilobases) resolving portions of the phylogeny, but leaving intertribal relationships within the Vespertilioninae unresolved. As a result, the evolutionary history of the most speciose chiropteran family is largely unknown. The presence of short internodes followed by long terminal branches relative to other chiropteran phylogenies suggests evolutionary rates of DNA substitution and lineage diversification may be inhibiting phylogenetic resolution. To test this hypothesis, we obtained sequences of the mitochondrial DNA 12s rRNA, tRNA-VAL, and 16s rRNA as well as the nuclear exon RAG2, resulting in over 3 kb of digenomic DNA sequence data for representatives of all

subfamilies and tribes within Vespertilionidae and Phyllostomidae, a family of bats that radiated at approximately the same time as Vespertilionidae. Analyses revealed substitution rates for Vespertilionidae were significantly higher than Phyllostomidae, with the majority of fast-evolving lineages found within Vespertilioninae. Cladogenesis analyses characterized the vespertilionid radiation as compressed toward the root, with a rapid initial diversification, while the phyllostomid diversification was much more gradual. We suggest ecological differences between tropical and temperate environments may have influenced diversification rates for Vespertilionidae and Phyllostomidae.

Variability in Call Structure in *Pteronotus quadridens* (Mormoopidae)
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Intraspecific variation in the time and frequency structure of biosonar calls has been described in previous studies. Variation relates to proximity to targets as well as to proximity to environmental structure. Variations in timing and frequency related to proximity to targets have been described as phases of echolocation behavior (search, approach and terminal phases). Variations made in response to environmental structure can be seen within the search phase, and since these are considered to be the calls best suited to species identification, they must be treated with caution. *Pteronotus quadridens*, endemic to the Greater Antilles, uses distinctive search phase calls consisting of an initial frequency modulated (FM) segment of low slope starting at or above 80 kHz, that breaks sharply into a steeply sloping FM. The slope of the steep FM declines gradually. These calls typically range from 5 to 7 ms in duration and have a bandwidth of 18–20 kHz. Two or three harmonics are typically recorded and the second harmonic usually has the highest amplitude. Recent recordings made on Isla de Mona, 50 km west of Puerto Rico show calls of a different structure that appear to be attributable to *P. quadridens*. These calls eliminate the initial low-slope FM and consist solely of a concave-up FM call with gradually diminishing slope. Variant calls have a similar duration and harmonic structure as typical calls but have a narrower bandwidth (8–12 kHz). The onset of the second harmonic of the variant calls is usually about 70 kHz in contrast to typical calls. The current data set is insufficient to attribute these differences to proximity to environmental structure, or even to be sure that they are limited to search phase. Variant calls are of interest in that they could easily be attributed to a different species. They also may have functional differences; understanding the functional differences could shed light on the function of the typical calls with the initial, low slope FM seen in other species of mormoopids. [This work was supported by a Research and Creative Activities award from CSU, Sacramento.]

Declines of Six Hibernating Bat Species from White-nose Syndrome in the Northeastern United States
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Variation in susceptibility to pathogen infection among species can provide valuable insight into the causes and consequences of emerging infectious diseases. White-nose syndrome (WNS) is thought to be associated with the newly described psychrophilic fungus *Geomyces destructans*, with documented infections in all six hibernating bat species in the northeastern United States. The greatest prevalence of WNS infection has been observed in this region, with overall declines at hibernation sites ranging from 70–100%. Based on surveys conducted at hibernacula during pre- and post-WNS periods, the little brown myotis (*Myotis lucifugus*), northern long-eared myotis (*M. septentrionalis*), and tri-colored bats (*Perimyotis subflavus*) have shown the largest overall population declines. Substantial declines in northern long-eared myotis at hibernacula have caused serious concern among natural resource managers that this species may be in immediate danger of regional extinction. Despite its highly gregarious winter roosting habits, the Indiana myotis (*M. sodalis*) has experienced less severe overall decline as compared to little brown myotis, northern long-eared myotis, and tri-colored bats, however this effect is largely site dependent. The relatively rare eastern small-footed myotis (*M. leibii*) may be less susceptible to WNS, with overall positive population growth (lambda > 1). Big brown bats also appear to be less susceptible to WNS, although surveys of hibernacula alone do not adequately assess the viability of this species. Variation in disease susceptibility among the six species of bats affected by WNS in North America suggests that environmental, behavioral, and innate biological factors may contribute to differences in susceptibility to infection from *G. destructans*.

Preference in Bat House Design by the Evening Bat (*Nycticeius humeralis*)
Kristen M. Lear, Elizabeth C. Braun de Torrez, and Thomas H. Kunz, Ohio Wesleyan University, Delaware, OH; Boston University, Boston, MA

Since the early 20th century, people have used bat houses to attract bats. Factors that increase bat house success include appropriate external color, large landing areas, and mounting on buildings in areas with low disturbance, and low canopy cover. However, little research has been conducted to determine the most effective design for attracting specific species of bats. We attempted to create roosting sites specifically for evening bats (*Nycticeius humeralis*). Preliminary findings from our research, as well as published information on evening bats, suggest that they may be especially beneficial in pest suppression because they forage within the canopy of pecan orchards, have small foraging ranges, prefer orchards with old pecan trees, and consume pecan nut casebearer (*Acrobasis nuxvorella*) moths, one of the most devastating nut-feeding insects that occur in pecans. In addition, evening bats are thought to be in decline due to loss of old growth forest habitat. We tested two commonly used bat house designs for their effectiveness in attracting and maintaining colonies of evening bats. We installed nine pairs of bat houses in three organic pecan orchards in central Texas. Each pair consisted of one two-chamber rocket box and one standard medium three-chamber house. We monitored each house for evening bat occupancy by documenting the presence of guano beneath the roost, visually monitoring the bats inside the house during the day, and recording echolocation calls during nightly emergences. Preliminary results suggest that evening bats prefer rocket boxes to standard bat houses. These findings will allow us to better attract this species to conventional pecan orchards and other areas where there are no large, old trees with suitable roosting cavities. These cavities are beneficial to farmers wishing to reduce pests in pecan orchards and to evening bats that require suitable roost sites to sustain viable populations.

Modeling Indiana Bat Maternity Roost and Capture Site Habitat
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The preservation of Indiana bat habitat has important implications to a variety of projects including wind farm locations, power transmission line corridors and forest management. Determining presence of Indiana bats, especially reproductive females, is a high priority for all projects requiring land use changes. Modeling potential habitat before this occurs can help expedite sampling effort, minimize impact on the species, and reduce cost. Twenty-eight reproductive female Indiana bats were captured during the summers of 2007 through 2010 and were radio-tracked to roost trees. Exit counts were performed to confirm maternity tree status, either > 30 bats present or repeated use. Twelve primary maternity roosts and twenty-one capture sites were documented. Spatial attributes including distance to water source, distance to forest edge, soil type, and land classification type were compiled and extrapolated in ArcGIS 9.3.2. The capture sites and maternity roost sites were modeled separately. The results of the model are shapefiles representing probable habitat for capture sites and maternity roost locations. These polygons can be overlaid with aerial photos to focus sampling efforts within expansive project boundaries or loaded into a handheld GPS unit to confirm specific "in habitat location." Also, these areas designated as "probable habitat" could be a recommendation as a metric to be used in defining areas of land that must be evaluated prior to disturbance.

Roost Use and Selection by Rafinesque's Big-eared Bats (*Corynorhinus rafinesquii*) Varies with Habitat
Susan C. Loeb, USFS Southern Research Station, Clemson, SC

Rafinesque's big-eared bat (RBEB) is a relatively rare and sensitive species found throughout the southeastern United States In the Coastal Plain Region, RBEB roost primarily in bottomland hardwood forests and surrounding areas. Some general patterns of roost site use and selection have been found across studies of Rafinesque's big-eared bats (e.g., use of large hollow trees), but variation in roost characteristics has also been found. The objective of this study was to test the effects of roost availability on roost use and selection by Rafinesque's big-eared bats in two sites in the Savannah River floodplain: the Webb Wildlife Center (Webb), a relatively undisturbed site, and the Savannah River Site (SRS), a site with a long history of disturbance. Thirty-eight transects (28 on SRS, 10 on Webb) 50 m wide and approximately 2 km long were established perpendicular to the floodplain. All trees with basal openings and cavity volumes > 150 dm^3 were examined for the presence of RBEB. Trees were classified by tree type (Type 1—basal opening only or Type 2—basal and chimney opening), and dbh, tree height, tree species, cavity texture, and decomposition state were recorded. Potential roost trees at Webb were significantly larger, more likely to be Type 2, and more likely to be tupelo or bald cypress. RBEB at Webb used Type 2 trees significantly more than bats at SRS and roost trees had a significantly larger dbh than those at SRS. RBEB at SRS used a wider variety of tree species and selected larger dbh trees; no selection for large trees occurred at Webb. These results

suggest that roost use and selection by RBEB is dependent on roost availability and that full understanding of the roosting requirements of RBEB in the Coastal Plain Region requires examination of a wide variety of site qualities and types.

Hips Don't Lie: The Phylogeny and Morphology of the Bat Pelvic Girdle
Aja C. Marcato, William A. Schutt Jr., and Nancy B. Simmons, C. W. Post Campus of Long Island University; American Museum of Natural History, New York, NY

Compared to the extensive information on the bat cranium, relatively few phylogenetic studies have examined the postcranial skeleton. In this study, we examined anatomical variation in the chiropteran pelvic girdle and associated vertebra (sacral and caudal), focusing on the potential phylogenetic relevance of the observed characters among all families. We examined pelvic and vertebral morphology in adult male and female specimens from all recognized bat families. Skeletons were examined using stereoscopic microscopes equipped with a digital camera or camera lucida. Data sources also included scientific illustrations and casts from fossil specimens. In addition to developing new characters (e.g., variation in the pubic spine, presence or absence of an iliac fossa, the shape of the obturator foramen), we also reexamined previously analyzed characters, such as the presence of fused or unfused vertebrae. Finally, Morphobank was employed to organize the data for comparative purposes and to facilitate phylogenetic analysis.

Large-scale Movements of Individual Little Brown Bats throughout Manitoba and Northwestern Ontario
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Understanding distribution and social networks of bats is crucial for understanding their ecology and important for developing effective conservation strategies, especially for species affected by white-nose syndrome (WNS). Recent research has shown that *Geomyces destructans*, the putative causal agent of WNS, can be transmitted through direct bat-to-bat contact and also via contact with affected hibernacula. It is now critical that we better understand the movements and social networks of individuals to understand how the disease is spreading throughout North America and, potentially to inform strategies for conservation. Our objectives were to: 1) identify seasonal movements of little brown bats throughout Manitoba, Canada, and 2) examine connectivity between bats from Manitoba and northern Ontario, where WNS was confirmed in winter 2010. We analyzed a band-recapture data set of 10,147 bats banded between 1988 to present in Manitoba and northwestern Ontario. We recaptured 1365 banded bats at summer roosts, in mating swarms, and in hibernacula during spring. Consistent with past studies we found high fidelity to both summer colonies and hibernacula, but some individuals switched sites between years. Seasonal movements from hibernacula and/or mating swarms to summer nursery colonies ranged widely from 10.1–647.1 km. We found females banded at a nursery roost in Ontario using hibernacula in central Manitoba. Our data provide a mechanism to explain apparent jumps in the distribution of *G. destructans* and highlight the current vulnerability of populations in western North America to WNS. We present a hypothesized framework to explain patterns of association and movement among little brown bats during winter and summer and will assess this hypothesis by examining genetic relatedness of individuals within and between different hibernation sites and summer roosts.

Phenotypic Plasticity of Migrating Hoary Bats, *Lasiurus cinereus
Liam P. McGuire, M. B. Fenton, and C. G. Guglielmo, University of Western Ontario, London, ON
*** Liam McGuire** received the **Titley Scientific Award**

During periods of migration, some bats travel hundreds or perhaps thousands of kilometers between winter and summer grounds. We investigated the energetic consequences of migration for bats and resulting phenotypic plasticity. We hypothesized that migration is an energetically demanding activity and would result in numerous phenotypic changes to improve energy efficiency. We predicted that migrating bats would have larger digestive organs to facilitate rapid refueling, greater nutrient stores, and elevated oxidative capacity as a result of the increased energetic demands of migratory flight. We collected hoary bats during spring migration (n = 30) and non-migrating hoary bats during summer (n = 15). We measured the mass of the pectoralis and six organs. We also determined fat and lean mass by Soxhlet extraction. Finally we measured aerobic enzyme capacity (carnitine palmitoyl transferase, citrate synthase, and 3-hydroxyacyl-CoA dehydrogenase). There was no difference in pectoralis mass or heart mass between migrating and non-migrating bats. Contrary to our predictions, migrating bats had smaller stomach (-15%), intestines (-43%), kidneys (-7%), and liver (-11%). Migrating bats had larger lungs (+23%). A significant

sex*migration interaction indicated that spring migrating females carry more fat than males. Results of aerobic enzyme capacity are pending. The reduction of digestive tract organs suggests that bat migration has selected for lower mass to reduce energetic demands during flight, rather than increased digestive tract organs to facilitate rapid refueling. Larger lungs reflect an increased capacity of aerobic exercise. We suggest that differences in thermoregulatory strategies during spring migration may have resulted in the differences observed in body composition between sexes. During migration, bats may use torpor to minimize energetic costs during non-flight periods, thus reducing the need for refueling along their route.

Using a Predictive Indiana Bat Habitat Suitability Model to Inform a Tiered Curtailment Strategy for an Ohio Wind Power Project

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The rapid expansion of wind power development within the range of the federally endangered Indiana bat, *Myotis sodalis*, has highlighted the need for increased scientific understanding of potential impacts and solutions to avoid and minimize those impacts. We created a predictive habitat suitability model to inform a tiered curtailment strategy for a wind power project in Champaign County, Ohio. We used a partitioned Mahalanobis D2 model based on 1124 nighttime radio-locations and 43 roost locations from 19 Indiana bats radio-tagged in the vicinity of the project area during summer mist-netting in 2008 and 2009. We used a Geographic Information System (GIS) to measure spatial characteristics of forest patches, habitat heterogeneity, slope, elevation, and distance to stream, wetland, and forested stream within 2-km buffers of each pixel in the project area. The distances (D2) between the vector of environmental conditions measured at each pixel and the mean vector of environmental conditions at known Indiana bat roosting and telemetry locations were rescaled using a Chi-square distribution, converted to *p*-values, and divided into four quantiles, representing most to least suitable. Indiana bat foraging habitat suitability was strongly associated with the configuration and spatial relationships of forested patches; the three most important variables were the degree of fragmentation, the connectedness of forest patches, and the total core area of forested habitat. This differed from roosting habitat suitability, which was driven largely by distance to forested streams, distance to streams, and distance to the nearest forest edge. A tiered approach to operational curtailment was developed based on the predicted Indiana bat habitat suitability at each proposed turbine location. Curtailment regimes differed in terms of cut-in speeds, duration, and seasonality, with turbines located in the most suitable Indiana bat habitat having the highest cut-in speeds applied over the longest duration.

Does Personality Correlate with Energetics in Little Brown Bats (*Myotis lucifugus*)?

Allyson K. Menzies, M. E. Timonin, and C. K. R. Willis, University of Winnipeg, Winnipeg, MB

Basal metabolic rate (BMR), the minimum amount of energy needed to maintain an animal at rest, is highly variable within and between species. Expression of torpor, an energy-saving state used by many endotherms (i.e., mammals and birds), is also highly variable. Understanding individual differences in these traits is central to understanding how individuals budget energy and allocate resources to ensure survival and reproductive success. One potential correlate of variation in energetic traits among individuals is animal personality. Defined as differences in patterns of behavior that are repeatable over time and across situations, personality has been well studied in a range of taxa (e.g., rodents, songbirds, fish) but so far there has been little work on personality in bats. We devised an ecologically relevant, novel-environment test to measure exploratory behavior in little brown bats (*Myotis lucifugus*) and measured BMR and torpor expression in the same individuals using open-flow respirometry. Some behavioral traits were repeatable in bats and behaviors clustered into three main categories—activity, exploration, anxiety—as seen in past studies with rodents, songbirds, and fish. We found limited evidence supporting the hypothesis that personality is correlated to individual differences in BMR but some aspects of personality were significantly related to torpor expression. This suggests that the tendency to express torpor may reflect an additional aspect of personality in bats and that some of the variation in torpor expression among individuals is mediated by similar physiological mechanisms as variation in behavioral aspects of personality (e.g., glucocorticoid hormones).

Bat Use of Artificial Roosts in Ponderosa Pine Forests

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Bats use large (> 69 cm diameter) ponderosa pine snags for maternity roosts in northern Arizona. Fire suppression, grazing, and logging have drastically altered forest structure, increasing density of live trees but

decreasing average diameter. Large snags are thus more uncommon and their recruitment uncertain. To increase roost availability, we supplemented forested areas with artificial roosts. We selected 26 sites and tested 2 types of roosts (resin, wood) in 2 configurations (grouped, single). We placed 52 roosts of each type on live ponderosa pine trees (> 45 cm dbh). At each site, we installed four roosts with a group of three roosts (south-, east-, or west-facing; < 20 m apart) and a single roost (south-facing) 250–350 m away. We checked roosts every two weeks from May to October in 2009 and 2010 (ongoing), and collected guano and captured bats if present. Bats used 35% of roosts (19 roosts in 2009, 31 in 2010). Resin roosts were selected more often (20%) than wood (14%). Bats used south- (10%) and east-facing (9%) roosts more than west-facing (5%). We had higher use at groups of roosts (16 groups) than at single roosts (11). To date, we have identified four species using artificial roosts (*Eptesicus fuscus*, *Myotis volans*, *M. occultus*, and *M. evotis*). Based on this and a comparative study, colonization and use appears to increase with time with initial use by males and maternity colonies forming after several years. The selection of resin over wood roosts may be because resin roosts offer greater concealment and area. Forest managers who want to supplement natural with artificial roosts should consider south- or east-facing resin roosts placed in groups.

Stable Isotope Analysis of a Behaviorally Novel Colony of *Tadarida brasiliensis mexicana* in West Texas

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

***Can Hibernating *Myotis lucifugus* Mount Cutaneous Immune Responses to *Geomyces destructans*? Histological Analysis of Responses to the Phytohemagglutin (PHA) Skin Test**

Marianne Moore, Elizabeth Buckles, Jonathan Reichard, Timothy Murtha, Elizabeth Braun de Torrez, and Thomas Kunz, Boston University, Boston, MA; Cornell University, Ithaca, NY

*** Marianne Moore** received the **Luis F. Bacardi Conservation Award**

We tested the hypothesis that hibernating little brown myotis (*Myotis lucifugus*) have morphologically detectable reductions in cutaneous cellular inflammatory responses during deep torpor, and are therefore incapable of mounting sufficient responses against *Geomyces destructans*, the fungus responsible for the characteristic skin infections associated with white-nose syndrome (WNS). We used subcutaneous injections of phytohemagglutinin (PHA) and collected tissue biopsies for histological examination across a time series in pregnant, post-lactating, and hibernating *M. lucifugus*. Using a four point ordinal system, we individually scored the presence of six leucocyte types, edema, vascular reaction, and vasculitis in PHA and control injected tissues. We also summed the scores for individual categories to generate an overall response score. In tissues of post-lactating bats, we found significantly more neutrophils, eosinophils, edema, vascular reaction, and vasculitis in PHA injected tissues starting at 6 h post-injection and a significant increase in cellular infiltration over time. Significant differences between treatments also appeared in pregnant bats but not until 12 h post-injection. Although significant differences between treatments were observed in individual response categories in hibernating bats starting at 6 h post-injection, responses in this group lacked a cellular component and no increase occurred over time. In bats challenged during the hibernation period, responses to PHA were positively correlated with body mass index (mass/length of forearm) and time spent in euthermia. Additionally, bats affected by WNS exhibited significantly greater responses to PHA and had significantly more leucocytes in their tissues regardless of treatment compared to bats collected from unaffected sites. Overall, results show that during the first 24 h, neutrophils and eosinophils are the primary cellular component of response to PHA in *M. lucifugus*, that hibernating bats have reduced cutaneous immune responses compared with active season bats, and that WNS-affected *M. lucifugus* have elevated cutaneous immune responses compared with unaffected bats.

The Case for Using in situ Recordings to Study Echolocation of Bats in Flight: A Comparison of Bat-based Versus Traditional Ground-based Devices

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Current hypotheses about how bats echolocate, such as determining speed, direction, size, shape, and fine structure of targets, are largely based on acoustic principals. Most of these hypotheses have not been tested empirically because researchers have been limited to using ground-based microphones. We recorded echolocation by big brown bats (*Eptesicus fuscus*) during flight, simultaneously using in situ (bat-based) and ground-based devices made with identical components. Bats were released along a zip-line and were presented with spherical metal targets to produce echoes. At least one bat was recorded as it attempted to forage. Recordings from both systems were compared to identify differences in bat calls and target echoes. Bat calls obtained in situ were significantly louder, and had shorter duration and higher maximum and minimum frequencies than ground-based recordings. This likely was due to relative proximity of microphones to the bat and bias caused during post-hoc delineation of bat calls (i.e., the start and end of calls were more difficult to identify in ground-based recordings). Using the in situ device, target echoes were visible in spectrograms and discernable using Principal Components Analysis. These echoes were spectrally distinct from and arrived before environmental echoes. Echoes of targets were not discernable in ground-based recordings because they coincided with environmental echoes. Results suggest in situ devices can record high fidelity bat calls, but more importantly, allow assessment of echoic information received by bats in flight. In situ devices also can be used to study foraging in bats not attached to a zip-line.

Comparing Two Methods of Acoustic Surveying for Bats: Point Counts and Moving Routes

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The emergence and spread of white-nose syndrome is decimating many populations of eastern bats. In order to quantify and monitor its effects on breeding populations, many states are beginning annual summer acoustic surveys. Traditionally, acoustic recording has been done at stationary locations, or points along a route. Recently, some states are switching to a moving route, where one drives a set route at a slow speed with an ultrasonic microphone attached to the roof of the vehicle. In order to compare the two methods, we designed eight routes throughout western Maryland, each between 32 and 40 km (20–25 miles). From 1 June through 11 July 2010, one route was driven each night, simultaneously employing each method. Starting at 30 minutes after sunset, one vehicle drove the route at 20 mph, while another vehicle stopped approximately every kilometer (0.6 miles) and recorded for five minutes. When using a point count, activity is presented as passes per minute, while moving routes are typically given as passes per mile or kilometer. Using GPS coordinates with time stamps, the moving route was split into kilometer sections. The results for each section were converted to passes per minute and compared with the corresponding points. We compared the two methods to determine: 1) if either has a species bias (if any species is more likely to be detected when using one or the other method); 2) which method allows you to identify a higher percentage of the calls recorded; and 3) how point data and moving data can be compared. This can be important if moving route data need to be compared to historical point data.

Thermal Ecology of *Pteronotus* in a High-temperature Sea Cave in Costa Rica

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Bats of the genus *Pteronotus* (Mormoopidae) commonly occupy hot, humid caves. Here we report on the microclimate of a high-temperature sea cave on the Osa Peninsula of Costa Rica inhabited by three species of *Pteronotus*: *P. gymnonotus* (most abundant), *P. parnellii*, and *P. personatus*. The cave floor fills with water during high tide, but is accessible by descending a 10-m cliff during low tide. After about 7 m, the main entry tunnel opens to a large bowl-shaped upper chamber. Diurnal temperatures on the ceiling of the upper chamber, which was entirely covered with roosting individuals, were recorded by infrared thermometer at 40–41°C during low tides. During low tide at night (with bats absent), temperatures of 38–39°C were measured in the equivalent parts of the cave. A Hobo temperature sensor was left inside the cave to evaluate two hypotheses: 1) influx of water into the cave with high tide significantly lowers ambient temperatures, and 2) that temperatures are higher when bats are in the roost than when they are absent. The sensor was placed on the floor of the upper chamber and recorded air temperatures continuously for six days. Two-way ANOVA detected no significant effect of tide levels (low vs. high) on ambient

temperature, but found that temperatures at the bottom of the cave were significantly lower when bats were present. The sensors were then placed on a pole to measure temperatures in the upper part of the cave for three days. Near the ceiling of the cave, temperatures were significantly higher with bats present, but again the effect of tide was not significant. One possible explanation is that heat is stored in the rock of the cave and reabsorbed by roosting bats, but this heat is lost by convection and radiation when the bats are not present.

***Population Genetic Structure of the Bat Fly (*Trichobius major*) Based on Amplified Fragment Length Polymorphism Analysis**

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*** Randilea Nichols** received the **Avinet Award**

The bat fly, *Trichobius major*, is a blood-feeding, obligate ectoparasite of the cave myotis (*Myotis velifer*). Although *T. major* possesses a spiraling flight pattern conducive to locating a host, this flight pattern is highly limiting in terms of dispersal. This limited self-dispersal ability has lead previous researchers to hypothesize that *T. major* disperses via the host. In a previous mitochondrial DNA (mtDNA) phylogeographic study, the cytochrome oxidase I and NADH dehydrogenase 4 genes revealed no sequence variation between individuals from caves over 740 km apart, providing no insight into the dispersal and population genetic structure of *T. major*. To further investigate population genetic structure and gene flow of *T. major*, we examined amplified fragment length polymorphisms (AFLP) from 173 individuals collected from caves in Kansas, Oklahoma, and Texas. Using 8 primer pairs, we identified 233 polymorphic loci. Heterozygosity and gene diversity were low, with most populations possessing no private bands, and with no populations possessing more than two private bands. A principle coordinate analysis revealed a clear geographic clustering of populations, and an analysis of molecular variance (AMOVA) was statistically significant, indicating the presence of significant population structure. In concordance with mtDNA results, our nuclear analysis suggests a recent and dramatic population bottleneck for *T. major*, significantly reducing the amount of standing genetic diversity, as well as weak population structure. Comparisons of these results to the population genetic structure of *M. velifer* is necessary to understand the role the host is playing in bat fly dispersal.

Survival Estimates for Pre-White-nose Syndrome Little Brown Bats (*Myotis lucifugus*) from Manitoba and Northwestern Ontario

Kaleigh J. O. Norquay, J. E. Dubois, and C. K. R. Willis, University of Winnipeg, Winnipeg, MB; Manitoba Conservation, Winnipeg, MB

Basic information on the natural history of North American hibernating bats has become even more vital since the appearance and rapid spread of white-nose syndrome (WNS). A range of factors is thought to influence survival in bats but few long-term studies exist. Knowledge of overwinter survival for populations before and after the arrival of WNS will be important for precisely quantifying between-population variation in mortality. It will also help identify populations with already low survival rates, which presumably will be at greatest risk from WNS. We report on results of a mark-recapture analysis quantifying overwinter survival in little brown bats across Manitoba and southwestern Ontario. We banded or pit-tagged 10,147 bats captured at hibernacula, mating swarms, and summer roosts between July 1989 and May 2010. So far, we have recaptured 1365 of these individuals, allowing us to examine factors influencing annual survival prior to the arrival of WNS in western Canada, including the influence of sex, hibernaculum microclimates, winter duration, and other climatic variables. These data will improve our understanding of factors influencing survival in bats and will provide an important baseline for comparison to survival rates after the arrival of WNS.

The Effects of Prescribed Fire on Roosting Habitat of the Endangered Indiana Bat, *Myotis sodalis*

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Little information exists about the effects of fire on Indiana bat (*Myotis sodalis*) roost habitat. Studies in the southern Appalachians, where fire is an important restoration tool for oak-pine forests, have shown that Indiana bats selectively roost under sloughing bark in tall, low decay conifers (typically yellow pines) on upper and middle slopes. We measured snag availability, characteristics (species, height, dbh, and decay measures), and the effects of prescribed fire on snags in the southern Appalachians. In winter 2009–2010, we located mature stands with a conifer component, searched stands for dense snag patches, and measured ≥ 40 snags and all live trees in 23 variable size

plots on lower, middle, and upper slopes. Temperatures were measured in nine plots that received prescribed fire (hand or aerial ignition) in Spring 2010; these plots were reassessed post-burn. Snag characteristics were compared with known Indiana bat maternity roosts (n = 50, 1999–2010) from the same region. Of 1063 snags, 75.3% were yellow pine, 12.2% were white pine, 6.4% were hemlock, and 6.1% were hardwoods. Pine snags were shorter and more decayed than known roosts, while hemlock snags were taller and less decayed than known roosts ($P < 0.0001$). Known roosts and yellow pines had 25–28% bark remaining, while white pines and hemlocks had significantly more bark (58–96%). Fire temperature and effects on snags varied with weather, ignition method, and slope position; snags were mainly lost on upper slopes, with lesser effects on mid- and lower-slope snags. Although yellow pine snags are abundant in pine-hardwood forests, most will soon be too decayed to be suitable for roosting and recruitment of yellow pine snags is low. Although prescribed fire could be a critical management tool for restoration of yellow pine forests, managers must consider the potentially negative short-term effects of fire on snag populations.

The Role of *Artibeus jamaicensis* and *Brachyphylla cavernarum* in the Dispersal of Seeds with Emphasis on the Endangered *Stahlia monosperma*, Leguminosae, in Puerto Rico

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In this preliminary report we present data on the diet and activity of the phyllostomid bats, *Artibeus jamaicensis* and *Brachyphylla cavernarum*, as well as on food choice experiments performed with the endangered tree, *Stahlia monosperma*. Mist nets were set for two consecutive nights each month from December 2008 through July 2010 as part of an ongoing project. Mist nets remain open for a period of four hours from sunset. Bats were removed from the nets and placed in cloth bags to collect feces. In addition, we released bats in a flight cage, where they were presented with two food choices for the purpose of assessing their role in the dispersal of *S. monosperma*. The distribution of *S. monosperma*, for which no dispersal vector is known, is restricted to a few locations around the island of Puerto Rico and eastern Hispaniola. It has been speculated that bats or land crabs might be the dispersal vector, that the extinct echimid rodents could have been the dispersal vector, or that the tree is thalassochorous rather than zoochorous. *A. jamaicensis* and *B. cavernarum* commonly carry fruits about the size or larger than those of *S. monosperma*. Our preliminary results reveal that when presented only with *S. monosperma*, bats will feed on the fruits. When presented with a choice, *B. cavernarum* will occasionally select *S. monosperma*. However, both species of bats show a strong preference for the introduced mango (*Mangifera indica*), and commonly feed on fruits from the family Piperaceae. The activity of *A. jamaicensis* appears to correlate with increased fruit set in the area; *B. cavernarum*, on the other hand, shows a more erratic activity. The fact that some bats will carry and feed on the fruits of *S. monosperma* has important implications for the conservation of this endangered species.

Fatty Acid Metabolism and Lipid Transport by *Geomyces destructans*

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White-nose syndrome (WNS) is a fungal disease associated with *Geomyces destructans* and is decimating cave-dwelling bats in North America. Bat species are risking extinction and the rapid spread of the disease leaves little time to find a cure. One of the symptoms of WNS is an increase in the number of times bats exit and enter torpor, which leads to emaciation and death. Polyunsaturated fatty acids, specifically linoleic and α-linolenic acid, are important for inducing mammalian torpor. Bats heavily affected by WNS have been shown to exhibit different amounts of linoleic and α-linolenic acid in their white adipose tissue. In order for *G. destructans* to be pathogenic to bats it must survive on the pelage of the host. Dietary fatty acids can be excreted through sebaceous glands onto the bat integument and provide vital carbon sources for fungal metabolism. Our study shows that *G. destructans* is unable to metabolize linoleic acid as a sole carbon source but readily metabolizes α-linolenic acid. If bats differ in their relative ratios of fatty acids this may play an important role in species specificity to WNS and bat survival. We also show that fluorescent dyes with hydroxyl groups can go through a Fisher esterification with the carboxylic end of fatty acids. When fatty acids have been fluorescently tagged they can be used to image lipid transport in fungal cells. This research provides important evidence on the metabolic fate of essential nutrients to the fungus. Finally, if *G. destructans* cannot utilize specific compounds, this research could lead to topical prophylactics to slow down the spread of WNS.

A Review of Factors Affecting Cave Temperature and Implications for White-nose Syndrome
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Geomyces destructans, the fungus likely responsible for white-nose syndrome (WNS) in bats, is cold-loving and grows optimally between 5–10°C; its growth is marginal above 15°C and it generally does not grow above 20°C. Consequently, temperatures of hibernacula may potentially affect the southward spread of this disease. Here, I review factors that determine temperatures of caves and mines. In the absence of other factors such as airflow, temperature of caves and mines approximates the mean annual surface temperature (MAST) of the area. However, temperatures in many caves and mines deviate from MAST. These temperature deviations result from differences in aspect, elevation, geothermal processes, radioactive decay, water flow, and airflow. In most caves, airflow is primarily responsible for deviations in cave/mine temperatures from MAST. Airflow in caves and mines results from direct flow, the venture effect, thermal convection, the chimney effect, and barometric pressure changes. In caves/mines with little airflow, cold-air sinks and warm-air domes can occur. Thus, large, complex caves/mines can have many different thermal environments, and potential southern limits to spread of WNS based on MAST are complicated by physical structure that makes individual caves/mines deviate from MAST during winter. Furthermore, many bat species may actively select the coldest caves in an area based on these thermo-structural conditions.

The Relationship between Clutter Orientation and Bat Activity in Forest Canopies and Edges
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Bat biologists have long recognized a strong inverse relationship between bat activity and vegetative clutter. However, few have investigated the relationship between clutter orientation and bat activity. We sampled bat echolocation activity in forest edges and canopies in aspen (*Populus tremuloides*) forests in north-central Utah during four summer field seasons (2006–2009). We compared bat activity levels to clutter orientation (as indicated by slope of edge structure, or the degree of physical edge contrast), along with several common measures of vegetative clutter, including diameter at breast height, stem density per unit area, canopy base height, etc. Forestry metrics were compared both to general bat activity and to species-level or echolocation-call-guild-level activity. Strong correlations were discovered between clutter orientation (slope of the edge) and general bat activity levels, exposing a positive relationship between clutter orientation and bat activity levels in aspen forest edges. Results highlight the importance of edge structure in our understanding of bat habitat use.

Between a Rock and a Hard Place: Impact of Anthropogenic Disturbance on Cave-roosting Bats
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In Southeast Asia, limestone outcrop (karst) formations represent critical areas for biodiversity, with high levels of species richness and endemism due to their isolated distribution and rugged terrain. Solution caves formed within karst formations are of inherent importance to cave-roosting bats, providing secure shelter from adverse weather and predators, and for roosting and rearing young. Tragically, cave-roosting bats are being threatened by anthropogenic activities at karst formations, most directly by the destruction of roosting sites by commercial quarrying operations. Forest conversion for urban and agricultural expansion has resulted in the loss of suitable foraging habitats. Thus, this study seeks to document assemblage characteristics of cave-roosting bats in peninsular Malaysia, a landscape experiencing rapid anthropogenic modification, in order to determine the significance of specific karst formations to bat conservation. With approximately 50 cave-roosting bat species, peninsular Malaysia is a biodiversity hotspot within Southeast Asia. Surveys conducted during June–August 2009 at a karst formation, Kota Gelanggi, in central peninsular Malaysia documented 20 species—4 species of Old World fruit bats and 16 insectivorous species—at 6 caves within this single karst. A total of 18 species were captured utilizing standard trapping methods (i.e., harp traps, mist nets) and 7 species were identified using acoustic monitoring methods. Our samples represent approximately 20% of all bat species found in peninsular Malaysia; however, surveys at additional karst formations, particularly those experiencing a range of disturbance levels, are needed in order to make comparisons. Ultimately, data resulting from this study will provide fundamental information for monitoring cave-roosting bat assemblages in relation to surrounding anthropogenic activities, and enable us to devise effective conservation policies for karst protection.

Monastic *Myzopoda*: The Foraging and Roosting Ecology of a Sexually Segregated Malagasy Endemic Bat
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The Myzopodidae is endemic to Madagascar and represented by two species, *Myzopoda aurita* in the east and *M. schliemanni* in the west. Because few have hitherto been caught, little is known about the ecology of either species, although on the basis of a single observation, H. Hoogstraal reported *M. aurita* roosting in the partially unfurled central leaf of the traveler's tree, *Ravenala madagascariensis*. The discovery of a population of *M. aurita* at an agricultural extension station at Kianjavato, southeastern Madagascar allowed an ecological study to be planned. All 138 bats mist-netted on trails in secondary forest were males, 18 of which were radio-tracked. The areas individual bats used for foraging varied between 7 and 108 ha. Bats foraged close to their roosts for the first hour after emergence, then traveled up to 1.8 km away. Compositional analysis revealed that they selected coffee plantations, degraded humid forest, and wooded grassland more than any other habitats. All 133 roosts located consisted of the partially unfurled leaves of *R. madagascariensis* and housed between 9–51 individuals. Bats changed roosts every 1–5 days. No ectoparasites were found on any bats. Their diet comprised mainly Lepidoptera (79%) and Coleoptera (12%), with a significant variation of these orders between seasons. Because *R. madagascariensis* is characteristic of secondary forest, *M. aurita* is one of the few mammals endemic to Madagascar that is not threatened by deforestation, although it may be affected by loss of roosts for building materials. The search for females continues.

Identification and Characterization of Swarming Sites Used by Little Brown and Northern Long-eared Bats in Nova Scotia
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With the imminent threat of white-nose syndrome (WNS), there is a pressing need for baseline population data in regions not yet affected by the pathogen, such as the province of Nova Scotia. There are records of hundreds of abandoned mines and caves in Nova Scotia, many of which have the potential to be important overwintering resources for bats. However, few have ever been surveyed for bat activity. An inventory of swarming and hibernation sites will be important in understanding the spread of the fungus associated with WNS and in implementing any monitoring and management initiatives. During the autumn swarming period of 2010, surveys of abandoned mines and caves in Nova Scotia are being conducted to determine which are important swarming (and thus likely hibernation) sites for *Myotis lucifugus* (little brown bat) and *M. septentrionalis* (northern long-eared bat). In addition, local and landscape external characteristics, as well as any known internal characteristics (depth, etc.), are being measured in order to explain differences between used and unused sites. These results will facilitate predictions about the likelihood of there being other sites of interest in the province. This poster will discuss preliminary results and implications of this research.

Patterns of Fat Accumulation and Depletion in Little Brown Myotis Affected by White-nose Syndrome
Jonathan Reichard, Marianne Moore, Catherine Kang, Lucille Nichols, Timothy Murtha, and Thomas Kunz, Boston University, Boston, MA

Loss of critical fat reserves during hibernation is a leading hypothesis for proximate cause of death for bats affected by white-nose syndrome (WNS). We used destructive body composition analysis to quantify changes in fat reserves in little brown myotis (*Myotis lucifugus*) during prehibernation and hibernation at affected and unaffected hibernacula to test the following hypotheses: 1) bats at affected sites do not deposit sufficient fat reserves in autumn; 2) bats at affected sites deplete fat reserves prior to entering hibernation; and 3) bats at affected sites deplete fat reserves prematurely during hibernation. A subset of bats was tested for aspects of immune response. Although bats at Aeolus Cave in Vermont (affected) deposited similar total body fat (TBF) in autumn 2008 compared to 1976, TBF in late autumn was lower in adult bats at affected sites than at unaffected sites. In early winter, mean percent body fat at unaffected sites (28.1% and 24.9% for adult females and males, respectively) was significantly greater than at affected sites (20.1% and 19.4% for adult females and males, respectively). At Aeolus Cave, mean percent body fat of adult bats declined from 17.1% in early winter to 8.9% and 5.5% in mid- and late-winter, respectively. For juvenile bats, mean percent body fat declined from 18.0% in early winter to 7.7% and 7.0% in mid- and late-winter, respectively. Bats swarming at WNS-affected sites appear to deposit sufficient fat reserves during autumn, but fat decreased more rapidly at these sites compared to unaffected sites. At affected sites, hibernating bats appear to reach critically low fat reserves by midway through the hibernation period. Body composition was significantly correlated with immune function to varying degrees depending on WNS-status and the type of response. Thus, fat

reserves are likely to impact a bat's ability to maintain effective immune function.

The Behavioral Function of Social Calls in the Migratory Hoary Bat *Lasiurus cinereus*
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The hoary bat *Lasiurus cinereus* is a migratory tree-roosting bat that has been experiencing high rates of mortality at wind energy development sites during the fall migration/mating season. Seasonally variable social and behavioral factors may contribute to hoary bats' susceptibility to turbines, and understanding these factors may be vital for developing mitigation strategies. This study aims to: 1) determine how hoary bats respond to conspecific social call broadcasting, and if these responses are seasonally variable; 2) assess the effectiveness of using acoustic lures to aid in the study of hoary bats; and 3) describe social call behavior in hoary bats. We broadcasted social calls through an ultrasonic transducer (Binary Acoustic Technologies AT800) at sites located near known flyways and water sources, placed in locations to minimize incidental captures. Each trial ran for one hour and consists of 30 minutes of broadcasting and 30 minutes of silence. We captured approaching bats using mist nets and filmed trials with infrared cameras. Additionally we used mist nets and bat detectors (Pettersson D240X) to assess bat activity in proximal flyways and record hoary bat social vocalizations. This is a summary of preliminary results from fieldwork conducted in the Sandia and Jemez Mountains of New Mexico during May and June 2010. During trials, 22 hoary bats were captured during call playback but only 2 during control, suggesting that hoary bats are attracted to conspecific social call broadcasts. In addition we present a quantitative descriptive analysis of hoary bat social calls. We are continuing fieldwork during the fall migration in both New Mexico and California. Examining seasonal variation in hoary bat social behavior may provide insight into both the underlying causes of mortality at wind energy sites and the natural history of this elusive species.

Re-evaluating the Role for Banding in the Population Biology of Bats
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Understanding the demographics of long-lived and highly mobile species requires long-term research and coordination across wide geographic areas. For bats, one critical tool in this research has been the use of wing bands. Although most of the information we have on bat movements, longevity, and migratory activity comes from mark-recapture data collected from banding efforts, a concern about banding injuries has resulted in very limited banding over the last 30 years. In light of conservation issues that require knowledge of bat movement patterns and demographics, such as wind-related bat mortality and white-nose syndrome (WNS), it may be time to look back on the 1972 moratorium on banding and re-evaluate whether large-scale banding research could provide some of the valuable information we need to confront these novel threats to bat populations. A review of the historic banding injury data suggests that much of the population-level impact of banding was due to the methodology and not to direct injury. A comparison of several different bands used on little brown myotis (*Myotis lucifugus*) over the last 20 years suggests that new metal alloy lipped bands have substantially lower injury rates compared to older bands, and recent studies have shown the value of banding for collecting data on population demographics and migration patterns that are critical for the surveillance of WNS and the ultimate population recovery. Although banding and other marking techniques are not risk-free, the data gathered using these techniques may be worth the risk if they contribute significantly to the conservation biology of species.

Riparian Trees Big and Small—Day Roost Selection by *Noctilio* in a Costa Rican Dry Forest Mosaic
Jody Rintoul, Kyla Kotchea, and Doris Audet, University of Alberta—Augustana Campus, Camrose, AB

In spite of greater bat species diversity in tropical forests, most work on forest and tree characteristics that are favorable to bats has been conducted in temperate forests. As part of a study of the bat fauna in the Taboga reserve and surrounding area, we located and characterized the roosts used by five radio-tagged *Noctilio* (three *N. albiventris* and two *N. leporinus*) during an undergraduate field course in February 2009. We also surveyed the area for potential roosts based on those characteristics and evaluated long-term roost use by the two species using data collected from a total of 12 bats (7 *N. albiventris* and 5 *N. leporinus*) radio-tagged between 2005 and 2009. As in previous years, all *Noctilio* roosts were located within 50 m of water and of the seven roost trees that were identified since 2005, four were occupied by bats tagged in 2009, indicating long-term roost occupancy. Four of the roosts were in *Terminalia oblonga* with relatively small trunk diameter (dbh < 0.8 m compared to 1.2–2 m for the other roost tree species), growing near water and forming extensive cavities that extend to the smaller branches. Those

cavities provided significant buffer from the high daytime temperatures (t = 3.27, P = 0.01; mean outside $T°_{max}$ = 37.6 ± 5.5 vs. mean inside $T°_{max}$ = 33.2 ± 2.1°C). The substantial use of *Terminalia* suggests that in spite of its moderate size, this tree may be an important resource for *Noctilio* species, which each represented about 5% of bat captures in the area. Our results also suggest that the large size of trees based solely on their diameter is not a sufficient indicator of the conservation potential of tropical forest fragments for bats.

Passive Acoustic Monitoring to Determine Pre-White-nose Syndrome Community Structure
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Permanently mounted solar powered Anabat detectors are presently collecting data in Missouri near three gated caves with large summer and winter concentrations of species known to be susceptible to white-nose syndrome (WNS), including two species of endangered *Myotis*. Comparisons of nightly, weekly, monthly, and seasonal data on species composition, relative abundance, and overall activity will be presented in terms of describing and predicting changes that may occur in community structure. Results of species composition from one location in July 2010 showed variation when daily, weekly and monthly data were compared. These temporal differences resulted in 416 calls on July 4th, 2988 calls during the week of July 4–11, and 11,256 calls during the entire month of July. Species percentages from one day, one week, and one month were as follows: *Eptesicus fuscus* (0.7, 0.3, 0.6); *Lasiurus borealis* (13.0, 7.7, 8.3); *Lasiurus cinereus* (0.5, 0.2, 0.3); *Myotis grisescens* (12.9, 11.7, 15.4); *Myotis lucifugus* (2.2, 4.0, 3.8); *Myotis septentrionalis* (1.0, 0.7, 0.8); *Myotis sodalis* (3.4, 4.9, 5.0); *Nycticeius humeralis* (2.2, 3.5, 3.3); and *Perimyotis subflavus* (56.5, 62.1, 55.6). These results indicate that population distribution within an area change not only among sampling periods but within sampling periods. Although WNS was found in two species in Missouri in the spring of 2009, no mortality was observed. It is hoped that the data collection that began in April represents pre-WNS community structure.

Lessons from Mom: Maternal Investment of *Ectophylla alba* in Costa Rica
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We describe and quantify maternal investment of the tent-making bat, *Ectophylla alba*, to determine if maternal investment is the same throughout the development of the offspring. We worked in Tirimbina Biological Reserve, Sarapiquí, Costa Rica and, using video and infrared lights, recorded the nocturnal behavioral of a group (two males, two females, and their offspring) during two different periods: the lactation period (9 nights) and the fledging period (8 nights) (204 hrs total). We analyzed the first 10 minutes of the behavior of each individual each night they spent at least 30 minutes in the tent. We defined three behavioral categories: self-grooming, female grooming towards the offspring, and lactation. We analyzed a total of 910 minutes (91 visits) in which one female made 45 visits and the other female made 46 visits. We found the females spent more time in the tent than the males during both periods. We found no difference in the presence of lactating behavior (G = 0.51, df = 1, P = 0.48) or grooming behavior (G = 0.94, df = 1, P = 0.57) between periods. We made two uncommon observations that demonstrate a learning process of feeding the offspring: one female nursed both pups simultaneously (from different mothers), and another instance in which the mothers brought their offspring *Ficus* fruits to eat a few days before fledging. Our results indicate that mothers invest a considerable amount of time in raising the pups, and also teaching their young to feed.

Dietary Analysis of the Antillean Ghost-faced Bat (*Mormoops blainvillei*) and Sooty Mustached Bat (*Pteronotus quadridens*) using PCR and Various Preservation Techniques
Ashley K. Rolfe, Eastern Michigan University, Ypsilanti, MI

The Antillean ghost-faced bat (*Mormoops blainvillei*) and sooty mustached bat (*Pteronotus quadridens*) are insectivorous members of the Mormoopidae that are endemic to the Greater Antilles. Newly developed molecular approaches, such as the use of polymerase chain reaction (PCR), provide the opportunity to analyze the diet of bats in more detail than conventional dietary analysis by targeting the DNA of trace materials found within feces. Bats were captured at the Mata de Plátano Field Station, located ca. 7 km SW of Arecibo, Puerto Rico. Feces collected in the field was preserved in one of three ways: air dried and stored in individual Ziploc bags; placed in individual vials with ca. 2 ml of 95% ethanol; or placed in individual vials with ca. 2 ml of lysis buffer. All samples were frozen at -20°C within 2 h of collection regardless of preservation method. DNA was later isolated from ca. 900 insect fragments taken from the fecal pellets. The isolated DNA was used to amplify a 648-bp target region of the mitochondrial cytochrome oxidase *c* subunit 1 (COI) gene using robust forward and reverse primers and was

unidirectionally sequenced using the forward primer. COI sequences recovered from fragments of insects will be compared with the reference database from the Barcode of Life Data Systems (BoLD) to provide species-specific identification of the insects within the diet of the *M. blainvillei* and *P. quadridens*. The percent yield of identified prey species from each of the three preservation techniques will be compared using *t*-tests.

Effects of Take on the Indiana Bat (*Myotis sodalis*) Population at a Proposed Wind Energy Facility
Shannon E. Romeling, Ryan Allen, and Lynn W. Robbins, Missouri State University, Springfield, MO

Methods for determining allowable Indiana bat Take for an Incidental Take Permit (ITP) are still in their beginning phases. We developed a method of estimating the long-term effects of Take on a closed population of Indiana bats using the little brown bat (*Myotis lucifugus*) as a surrogate and Lefkovitch Matrix Models to estimate growth rates. Jain (2005) demonstrated a 54.5% decrease in turbine-related mortality of little brown bats versus relative acoustic activity. Using this number and estimated yearly Take per megawatt from three geographically similar wind farms, potential Indiana bat mortality was calculated for a proposed wind farm site. In 2009, a mist-netting and radiotelemetry study at the proposed site determined the presence of a minimum number of female Indiana bats during maternity roost counts within or adjacent to the project area. Three sets of demographic information were used to produce a range of potential growth rates for this Indiana bat population. These three growth rates along with five potential Take numbers (range = 0–11.6 Indiana bats/500 MW/year) were used in effect analyses to produce 540 scenarios. The effect analysis equation estimated the population size over 30 years using the three growth rates and took into account dependent young, additive mortality, and recruitment. Of the 432 scenarios involving Take, 75% resulted in reduction in size or extinction of the population within 30 years. Assuming this population is viable, the 108 scenarios involving zero Take showed this population has growth rate and recruitment values above the line $Y = -330.97X + 431.24$, $R^2 = 0.999$, resulting in growing or stable populations 68% of the time. The methods used to conduct effect analyses and the resulting information gained are repeatable and can be used in the ITP process to make the best possible decision for the future of an endangered species.

Is Social Structure Amenable to Fixation of Chromosomal Rearrangements? Perspectives from the Peter's Tent-roosting Bat, *Uroderma bilobatum*
Maria Sagot, Caleb Phillips, Richard D. Stevens, and Robert J. Baker, Louisiana State University, Baton Rouge, LA; Texas Tech University, Lubbock, TX

Closely related mammalian species often differ karyotypically due to fixation of chromosomal rearrangements. Heterozygotes for rearrangements tend to be the least fit; therefore, the mechanism for fixation is unclear. It has been proposed that small and inbred social groups are necessary to promote these high rates of chromosomal evolution found in mammals. However, this hypothesis lacks empirical evidence and the role of molecular factors and positive selection driving chromosomal evolution has been overlooked. In the tent-roosting bat, *Uroderma bilobatum*, three chromosomal races have been described. In this species there is low genetic divergence between races and two hybridize, making this a suitable system to test proposed mechanisms leading to fixation of chromosomal races. If small isolated demes are required to fix chromosomal rearrangements, we expect to find social groups formed from single matrilineal lines. To test this hypothesis, we sequenced the cytochrome-*b* gene from 10 social groups of *U. bilobatum* captured from their roosts to determine the number of matrilineal genealogies present. We found that groups are composed by multiple matrilineal lines, implying that female assemblages are likely composed of individuals that are not closely related and that female dispersal occurs among tents. Population sizes do not appear to be amenable to fixation of detrimental chromosomal rearrangements simply as a byproduct of demography and breeding structure. Our study will help to illuminate mechanisms that lead to fixation of different rearrangements and speciation in mammals.

Metabolic Rates of *Brachyphylla cavernarum* and *Stenoderma rufum* in Puerto Rico
Jean M. Sandoval and Armando Rodriguez-Duran, Universidad Interamericana, Bayamon, PR

We provide data on metabolic rate for two species of Neotropical bats, *Brachyphylla cavernarum* and *Stenoderma rufum* (Phyllostomidae), endemic to the West Indies. Despite its abundance on the island of Puerto Rico, relatively little is known about the biology of *B. cavernarum*. *B. cavernarum* is known to roost in the frigidarium and tepidarium of caves. *S. rufum*, an endemic to the Puerto Rican Bank, is one of the least abundant species within its range. It is known to roost in trumpet tree, bullet wood, and sierra palms, as solitary or in small groups. We measured oxygen consumption of 38 *B. cavernarum* and 2 *S. rufum*. The estimated basal metabolic rate

(BMR) averaged 1.53 $O_2g^{-1}hr^{-1}$ for *S. rufum*, which was 85% of the predicted value for a 20-g eutherian mammal. The BMR of *B. cavernarum* was 1.01 $O_2g^{-1}hr^{-1}$, which was 78% of the predicted value for a 45-g eutherian mammal. Both species conform to the pattern of lower than expected metabolic rates for insular mammals.

Monitoring of Microclimate within Three Abandoned Railway Tunnels Used by Bats in Western Maryland
Jennifer Saville and J. Edward Gates, Frostburg State University, Frostburg, MD; University of Maryland Center for Environmental Sciences, Frostburg, MD

Three abandoned Western Maryland Railway tunnels (Indigo, Stickpile, and Kessler) located in the Chesapeake and Ohio Canal National Historical Park are currently serving as hibernacula for several bat species. Indigo, the longest tunnel, receives high use by bats and is the largest hibernaculum in Maryland for the very rare and state-endangered *Myotis leibii* while the other two tunnels are much shorter and are used by fewer bats. To better understand how these tunnels function as hibernacula, environmental conditions (including ambient temperature, surface temperature, and relative humidity) were measured every 4 h throughout the tunnels from summer 2008 to summer 2010. Because surface temperature is thought to be an important but difficult-to-measure factor in roost selection, data-loggers measuring both ambient and surface temperature were employed to determine whether ambient temperature can be used as a predictor of surface temperature. Preliminary results will be discussed.

Utility of Passive Acoustic Monitoring to Conduct Surveillance for White-nose Syndrome
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Interior surveys of hibernacula are likely the most effective method of white-nose syndrome (WNS) surveillance; however, the possibility of human transmission, increased disturbance to hibernating bats, and/or the large number of hibernating sites serves to easily overwhelm resource managers. As early reports documented abnormal activity levels at hibernacula entrances, we investigated the ability of Anabat II detectors to detect differences in bat activity levels at WNS-symptomatic (infected) and asymptomatic (assumed WNS-free) hibernacula. We deployed Anabat systems from 21 December 2009 to 13 April 2010 to automatically record bat activity at seven hibernacula (three second-year infected sites; two first-year infected sites, only one of which was confirmed by PCR; and two asymptomatic sites). Second-year WNS-sites showed higher activity than both first-year and asymptomatic sites. Additionally, mean daytime activity was lower for asymptomatic sites than the other two groups. While more data are needed on the relationship between the degree of WNS infection and activity rates, acoustic monitoring appears to offer a noninvasive, effective, and affordable approach for WNS surveillance.

A Transcriptome Approach for Studying Immune Responses in Jamaican Fruit Bats
Tony Schountz, Ann Hawkinson, and Rick Adams, University of Northern Colorado, Greeley, CO

Tacaribe virus (TCRV) was first isolated from *Artibeus* spp. bats with a fatal disease resembling rabies in Trinidad. The virus is a member of the family Arenaviridae and is closely related to the viruses that cause the South American hemorrhagic fevers, although it is not known to cause serious human disease. Arenaviruses with known hosts are rodent-borne with the exception of TCRV, which has only been repeatedly isolated from Jamaican fruit bats (*A. jamaicensis*) and great fruit-eating bats (*A. lituratus*). However, it is unknown if these species are natural reservoirs of TCRV or if the bat infections were incidental. We have experimentally demonstrated that TCRV can cause dose-dependent fatal disease or persistent infection in Jamaican fruit bats and we are now developing genomic reagents and cellular methodologies for studying the immune response to infection. We are currently sequencing and processing hundreds of thousands of cDNAs representing transcriptomes of activated T cells, B cells and mononuclear cells, poly-IC-induced primary kidney cells, and several other organs for use in constructing immunoarrays. We will use these arrays to identify pathways involved in pathogenic and non-pathogenic immune responses in bats infected with TCRV.

Philippine Cave Bats in Crisis? An Assessment of Cave Bats on Siquijor Island
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Currently 76 species of bats are recognized in the Philippines, and more are likely to be described. Approximately one third of these are particularly vulnerable because of their need for caves. Despite their formal

protection through the government's Cave Act, many are heavily disturbed by swiftlet nest gathering, treasure hunting, guano collecting, and mineral mining. Over the past few years, we have begun to collate existing data on cave bats nationally and conduct field surveys in key karst areas to better assess the problem. Between 18 June and 5 July 2010, we conducted an assessment of 20 large caves on Siquijor Island, a small (343.5 km^2) karst-covered island in the central Philippines. Trapping and mist netting in forest resulted in the capture of 19 species, including 13 cave-dwelling bats. We used visual and acoustic methods to survey bats in caves. Thirteen caves had insectivorous bat populations; however, only four caves had relatively large (> 100 individuals) colonies. Only 5 of the 20 large caves had fruit bats (*Rousettus* sp. or *Eonycteris* spp.) present and of these, only 2 had large populations. Despite the low numbers of bats present, we observed large (i.e., > 50 m^2) areas of staining in 10 caves indicating formerly large populations. Interviews with locals revealed that bats were collected for food throughout the island. Low species richness, small cave bat populations, and the conspicuous absence of fruit bat colonies and other, less common, cave-associated insect bat species such as *Rhinolophus rufus*, distinguish Siquijor from other less disturbed karst areas in the Philippines. The apparent decline of cave-dwelling bats in Siquijor and other areas may mean not only a decline in biodiversity, but in the ecosystem services they provide as pollinators, seed dispersers, and consumers of crop pests.

The Relationship between Wing Morphology and Bite Force in a Species-rich Bat Assemblage from Malaysia
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Wing morphology has a clear relationship with ecological and behavioral traits of bat species. In insectivorous bat assemblages, species can be divided into ensembles based upon their wing morphology, which is believed to be molded by the degree of vegetative clutter they encounter when foraging. Differences within ensembles in these characters may further facilitate niche differentiation. Furthermore, differences in food processing capabilities, particularly bite force, may further mediate resource partitioning in species-rich assemblages. Bats that bite harder tend to eat larger and harder prey. However, little is known of the relationship between these partitioning dimensions in complex bat assemblages. Here we investigate the relationship between wing morphology (relative wing loading) and bite force among 27 insectivorous bat species of 6 families from Krau Wildlife Reserve, Malaysia.

Ontogeny and Phylogeny: Evolutionary Divergence of Closely Related Bat Species
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Flight in vertebrates has lead to an evolutionary diversification of species, inhabiting many new and unused habitats. Differences in developmental patterns important to diversification are produced through heritable variation of the onset/offset and timing of juvenile growth. As the size and shape of an organism changes during ontogeny, morphological and behavioral components must adjust to accommodate proper function. The purpose of this study was to explore the ontogenetic pathways of two closely related Phyllostomids that differ in flight ability, body size, life history strategies, and developmental state at birth. We hypothesized that *Artibeus jamaicensis* (AJ) and *Carollia perspicillata* (CP) will show ontogenetic differences that account for the diversification of morphological, body size, and behavioral patterns. Comparisons between the two species' flight development, growth rates, and morphometrics were made from day 1 of parturition to adult size (AJ, $n = 45$; CP, $n = 25$). Forearm length, mass, wing area, and wingspan were measured on a daily basis. Flight behavior was compared using the flop, flutter, flap, flight method, with juveniles being dropped from a 1-m high roost from day 1 postpartum. Logistic growth equations were used to compare growth rates of all measured parameters and *t*-tests ($P < 0.001$) showed significant differences between the two species of all measured variables. There were significant differences between the day of first flap ($P = 0.01$) and flight ($P < 0.0001$) with *C. perspicillata* achieving flight at 22 days and *A. jamaicensis* achieving flight 33 days postpartum. Our data suggest that growth trends are significantly different with the more altricial *A. jamaicensis* developing at a faster rate than the more precocial *C. perspicillata*. Data suggest that *C. perspicillata* is able to achieve flight at an earlier stage, as they are born with more developed wings and have a shorter postnatal developmental time period. Ontogenetic comparisons are important in determining evolutionary diversification of closely related species.

Inferring Echolocation in Ancient Bats

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Most living bats use laryngeal echolocation to form images of their surroundings and to detect flying prey. Echolocation is considered a key innovation largely responsible for the evolutionary success of bats. Paleontologists have long sought osteological correlates of echolocation that can be used to infer behavior of ancient fossil bats, particularly Eocene taxa representing basal branches of the bat family tree. Four osteological traits have been postulated as indicators of laryngeal echolocation in bats: 1) an enlarged orbicular apophysis on the malleus—one of the middle ear ossicles that transmit sound from the ear drum to the inner ear; 2) an enlarged cochlea—providing increased sensitivity to high frequency sounds in the inner ear; 3) an enlarged paddle-like or bifurcated cranial tip on the stylohyal; and 4) an articulation between the stylohyal and the tympanic—providing a direct chain of transmission between the larynx and the ear. We examine these traits in light of new evidence from bats and other mammals, including high-resolution CT scans of the holotype of the Eocene bat *Onychonycteris*. We conclude that an enlarged orbicular apophysis cannot be considered an indicator of echolocation. The other traits remain good markers, but stylohyal modifications and an articulation between this element and the tympanic represent two parts of a single complex. Analysis of basicranial morphology indicates that many Eocene bats were echolocators (e.g., *Icaronycteris*, *Archaeonycteris*, *Palaeochiropteryx*, *Hassianycteris*, *Tachypteron*, *Tanzanycteris*). Contra recent suggestions that *Onychonycteris* might have been capable of laryngeal echolocation, we conclude that available evidence is best interpreted as indicating that it could not echolocate. Because postcranial morphology indicates that *Onychonycteris* could fly and phylogenetic analyses place it on the most basal branch within Chiroptera, the "flight first" hypothesis for the origin of flight and echolocation in bats remains the best-supported hypothesis for the origins of these key features.

Bat Activity in the Vicinity of Proposed Wind Power Plants along the Mid-Atlantic Coast

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Although wind power plants are considered a renewable source of energy, they have tremendous effects on wildlife in the eastern United States. Bat fatalities at some wind facilities in the Appalachian Mountains have been estimated in the thousands. Other possible migration routes for bats include areas near and off the Atlantic Coast. A comprehensive study of offshore bat activity has not been conducted despite bat occurrences on boats at sea for decades. Recently, wind power plants have been proposed off the Atlantic Coast, rendering a comprehensive assessment of offshore bat migration dynamics necessary to prevent potential detrimental effects to their populations. Determining if there are predictors for high activity, such as favorable weather patterns, is also vital. Bat species richness and density will be studied using acoustic monitoring equipment near and offshore in the Mid-Atlantic region. Four sites have been set up onshore to record year-round nightly bat calls in New Jersey, Delaware, and Maryland beginning in spring of 2009 and ending fall 2010. Offshore acoustic monitoring is conducted from boats traveling close to shore during the migration seasons of 2009 and 2010. Early findings include a substantial number of *Lasiurus borealis*, *Eptesicus fuscus*, and *Lasionycteris noctivagans* near the coast. One bat, a *L. noctivagans/E. fuscus*, was recorded 8.53 km from the New Jersey coast in the spring of 2009. Preliminary fall detections total 69 offshore calls from 2 boats traveling the New Jersey and Maryland coast. Bats were recorded up to 19.31 km from shore with an estimated average of 9.64 km. The most frequently recorded species was *L. borealis* suggesting that these bats use offshore pathways in fall. Other species detected included *L. cinereus, E. fuscus/L. noctivagans*, and *Myotis* species. Therefore, their occurrences at these distances suggest that planned offshore wind energy developments could affect migratory bats.

Multiple Harmonics in the Calls of Echolocating Bats

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Recorded echolocation calls of bats may contain a single (the fundamental frequency or a higher harmonic) or multiple harmonics. We hypothesize that the presence of multiple harmonics varies significantly by three factors: 1) species; 2) situation; and 3) recording quality. To test our hypothesis, we analyzed approximately 2300 calls

recorded from 17 species plus 1 subspecies in 6 families of bats using 1- and 4-microphone arrays. The percentage of all calls with multiple harmonics varied from 0–83% across species. Recordings from a 4-microphone array (1-m tetrahedron arrangement) revealed that the percentage of calls detected with multiple harmonics across microphone channels varied by up to 50%, indicating the effect of bat position relative to the microphone. By comparing frequency of maximum energy (FME) with maximum energy (maxE), we found that calls formed clusters, and that detection of multiple harmonics varied significantly among clusters. In one cluster multiple harmonics were detected in calls with sufficiently high maxE (threshold varied by species) due to less-intense harmonics falling below the noise floor of the recordings. Five species exhibited another cluster in which multiple harmonics were detected in low-intensity calls with FME in the fundamental. To test the effect of situation, we recorded the echolocation calls of big brown bats (*Eptesicus fuscus*) flying in three environments (anechoic flight room, roost emergence, and foraging area). Call energy shifted to lower harmonics as clutter decreased. Comparing flight room calls with foraging calls revealed that the second harmonic decreased by about 30 dB with respect to the fundamental. Our results show that 1) multi-harmonic usage varied significantly among species, and 2) relative harmonic intensity changed with situation and, along with bat-microphone spacing, affected which harmonics remained above the noise floor of recordings.

Bat Activity within Organic versus Conventional Apple Orchards in Southern Michigan
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Conventional orchards use pesticides to decrease insect damage to fruit, whereas organic orchards do not. I hypothesized that use of pesticides in conventional apple orchards will result in less bat activity compared to organic orchards, by decreasing prey potentially available to bats. To test this hypothesis, I am quantifying composition and abundance of the insect community, composition and abundance of the bat community, diet of captured bats, and levels of ultrasonic activity within four organic and four conventional orchards in southern Michigan. An ultrasonic detector (Anabat) was raised to a height of 6 m in each orchard, programmed to record from sunset to sunrise, and moved to a new location every seven days. Between 5 June 2009 and 2 August 2010, there were 292 nights of recording in organic orchards, yielding 12,774 bat files, whereas 285 nights of recording in conventional orchards yielded 18,679 files. Most calls appear to be from *Eptesicus fuscus* (big brown bat), with far fewer calls from *Lasiurus borealis* (red bat) and *Lasiurus cinereus* (hoary bat). Mist netting was performed on a total of 75 nights, and 136 bats were captured: 131 *Eptesicus fuscus* and 5 *Lasiurus borealis*. I collected feces from each individual for analysis of their diet, using standard fecal analysis and molecular techniques. For DNA analysis of insect fragments within the feces, I am targeting a 648-bp region of the mitochondrial cytochrome *c* oxidase subunit I then amplifying this region using specific primers. The product will be sequenced and then compared to reference sequences present in the Barcode of Life Data System. Preliminary data suggest the level of bat activity was not significantly different between types of orchards.

Comparison of Activity Rates Collected by Different Bat Detectors under Controlled and Natural Conditions
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Assessing potential risk to bats at proposed wind energy facilities relies primarily on estimates of overall bat activity collected by ultrasonic detectors. To date, the Anabat™ ultrasonic detector has been the industry standard for passive monitoring of bat activity. However, full-spectrum detectors such as the Pettersson D500x and Wildlife Acoustics SM2 are becoming more prevalent at wind-energy studies, largely due to their increased potential for species identification. Because Anabat and full-spectrum detectors use different types of microphones, utilize different sensitivity settings, and process the data differently, they are unlikely to produce comparable activity rate data and could potentially yield very different risk assessments. For example, while the Anabat has a single input control (sensitivity) that varies between 1 and 10, the D500x has four different controls that may affect sensitivity, each having between 5 and 46 settings. The goals of this study were to determine what combinations of settings on the D500x and SM2 produce similar activity rates to the Anabat SD1 under controlled conditions, and to test these settings under natural conditions. For the controlled experiment, all possible combinations of settings for each of the detectors were tested by repeatedly broadcasting a 45-second sequence of echolocation calls, and calculating the number of calls per unit time (i.e., activity rate) recorded by each detector. The quality of the recordings for species identification by the full-spectrum detectors was also assessed using the SonoBat 3 automatic species classification algorithm. For the natural experiment, the three detectors were programmed using the settings that produced comparable data in the controlled experiment, and were placed side-by-side in the field to collect bat activity. The results of this study will be useful to ensure consistency in measured levels of activity across studies.

Preliminary Studies of Nectarivorous Bat Foraging in Fragmented and Continuous Forest Landscapes in a Mexican Tropical Dry Forest

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Tropical forests are increasingly fragmented as land is converted into agricultural and urban areas. This fragmentation may impact animal pollinators, which perform an essential ecosystem service of pollinating wild plants that have important cultural, medicinal, or economic value. Due to the ability of bats to move long distances, it is assumed that they are less affected by forest fragmentation. This study seeks to understand the impact of forest fragmentation on the pollinating bat community in a tropical dry forest in Jalisco, Mexico, in and around the Chamela-Cuixmala Biosphere Reserve. Our objectives are to test whether diversity and abundance of nectarivorous bats, and species diversity of pollen found on bats, differ between fragmented and continuous forest landscapes. To test abundance and diversity of bats, bats were captured using mist nets near flowering resources of bat-pollinated *Crescentia alata* trees at three fragmented forest sites and three continuous forest sites, for two nights at each site. The total number of nectarivorous bats captured was 260, among 3 species: *Leptonycteris yerbabuenae*, *Glossophaga soricina*, and *Choeroniscus godmani*. We caught significantly more individuals of *G. soricina* than the other species, but found no effect of landscape type on abundance. To investigate pollen species diversity differences between landscape types, pollen was collected from bats in the field using fucshin-stained gelatin cubes, and later identified to morpho-species using light microscopy in the lab. There was a significantly greater number of pollen species in continuous landscapes than fragmented ones (*t*-test, $P = 0.035$), suggesting that bats in continuous forests forage on a wider array of resources. In the future, we plan to extend our mist-netting efforts to more nights per site, and across a broader geographic range, as well as commence studies on pollen movement of *Crescentia alata* using neutral genetic markers.

Histological Assessment of Cellular Immune Response to the Phytohemagglutinin Skin Test in Brazilian Free-tailed Bats (*Tadarida brasiliensis*)

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Bats are known reservoirs for numerous emerging infectious diseases, to occupy unique ecological niches, and to occur globally except for Antarctica. Given their impact on human and agricultural health, it is critical to understand the mechanisms underlying immunocompetence in this reservoir host. To date, few studies have examined immune function in the Order Chiroptera, particularly among natural colonies of bats. The phytohemagglutinin (PHA) skin test has been widely used to measure delayed-type cellular immune response in a wide variety of vertebrates, and has been routinely employed in immuno-ecological studies. Although this test is frequently described as a measure of T cell proliferation, recent studies indicate it may represent a combination of immune responses. In mammals, the immune response is differentially, temporally, and spatially regulated; therefore, we characterized the infiltrating leukocyte response to the PHA skin test in bats by examining a time-series of histological sections from PHA and saline injection areas in 41 Brazilian free-tailed bats (*Tadarida brasiliensis*). Results suggest that bats exhibit diverse leukocyte traffic within 6 h and up to 24 h following subcutaneous PHA injection. There was a significant presence of lymphocytes and neutrophils, as well as eosinophils, basophils, and macrophages, observed in the PHA-injected tissues, compared with saline-injected control tissues. We observed a highly significant negative correlation between the number of lymphocytes and neutrophils in PHA-injected tissue, with peak lymphocyte response at 12 h, and peak neutrophil response at 24 h post-injection. These results indicate substantial variation in the immune response of individuals, and may aid our understanding of disease emergence in natural populations of bats.

Diets of the Sympatric Pacific Sheath-tailed Bat (*Emballonura semicaudata rotensis*) and Mariana Swiftlet (*Aerodramus bartschi*) on Aguiguan, Mariana Islands

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We investigated the food habits of Pacific sheath-tailed bats (*Emballonura semicaudata rotensis*) and Mariana swiftlets (*Aerodramus bartschi*), two rare taxa restricted to the southern Mariana Islands in western Micronesia. Diet was determined by examining guano collected from two roosting caves during a two-week period in June and July at the onset of the rainy season on the island of Aguiguan. Important orders of insects consumed (% volume) by bats roosting at one cave included hymenopterans (64%), coleopterans (10%), lepidopterans (8%), isopterans (8%), and

psocopterans (5%), whereas those at a second cave included lepidopterans (45%), hymenopterans (41%), coleopterans (10%), and isopterans (5%). Swiftlets, which roosted in only one of the caves, fed mostly on hymenopterans (88%) and hemipterans (6%). Significant differences existed between the two taxa in several insect orders eaten, with *E. s. rotensis* consuming more lepidopterans and coleopterans and *A. bartschi* taking more hymenopterans and hemipterans. Within Hymenoptera, bats fed more on ichneumoideans, whereas swiftlets ate more formicid alates and chalicidoideans.

Molecular Phylogenetics of *Myotis* Indicate Familial-level Divergence for the Genus *Cistugo*

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The genus *Myotis* has undergone significant taxonomic revision since the advent of DNA sequencing techniques. Prior morphological examination of *Myotis* indicated as many as four subgenera correlated with foraging strategies. Recent studies using mitochondrial DNA (mtDNA) sequence data questioned the validity of these subgenera and indicated that several taxa may require reevaluation as to their position within Vespertilionidae. Nevertheless, no study has used large-scale nuclear DNA sequencing to examine relationships within *Myotis*. We generated 4656 base pairs (bp) of nuclear intron (PRKC1, STAT5A, and THY) and exon (APOB, DMP1, and RAG2) sequence data in addition to 2866 bp of mtDNA sequence data to test previously hypothesized subgeneric groupings of *Myotis*. We included 21 species of *Myotis* from all morphological subgenera previously suggested, representatives of all subfamilies and tribes currently recognized in Vespertilionidae, and multiple representatives of all other families currently included in the superfamily Vespertilionoidea. We also included a representative of the rare African genus *Cistugo*, because significant doubt exists about its familial position. Our phylogenetic analyses did not support the morphologically defined *Myotis* subgenera and confirm that morphological similarities among *Myotis* are the result of convergent evolution. Divergence estimates derived from the total data set were concordant with previous studies, suggesting a middle Miocene trans-Beringian dispersal from Asia colonized North America, with subsequent South American colonization and diversification prior to the formation of the Isthmus of Panama 3–4 million years ago. *Myotis latirostris* fell outside of *Myotis*, and the high genetic distance separating it from other *Myotis* suggested that *M. latirostris* represented a distinct genus. The genus *Cistugo*, previously a subgenus within *Myotis*, fell basal to all vespertilionids, with a high genetic distance separating it from Vespertilionidae. We conclude that *Cistugo* should constitute a distinct family within Vespertilionoidea.

Monitoring of Four Bat Species for the Lower Colorado River Multi-species Conservation Plan

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This project was initiated to satisfy measures within the Lower Colorado River Multi-species Conservation Program. To determine distribution and habitat use in riparian areas of the western red bat (*Lasiurus blossevillii*), yellow bat (*L. xanthinus*), pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens*), and California leaf-nosed bat, acoustical bat detectors have been deployed since March of 2008, at 72 sampling locations that include 4 vegetation types. Detection rates for California leaf-nosed and western red bats were high in all habitat vegetation types, slightly lower for western yellow bat, and lowest for Townsend's big-eared bat. The four bat species appear to be present in the four vegetation types. Four permanent acoustic detector stations along the river are providing data useful for analyzing migration movements and correlating bat activity with environmental variables. Data collected thus far from permanent stations suggest that bat activity was low during the winter but increased dramatically in early February, remaining high through March. There was much night-to-night variability during this time, which may have corresponded to migration pulses or to the influence of temperamental weather patterns. Call minutes were highly correlated to nightly mean temperatures (r^2 = 0.107). Activity declined during April and remained steady in May, perhaps a result of less influence from migrants and more consistent weather. During the colder months, bats apparently had a greater preference for foraging during the warmer hours early in the night. Negative correlation between call minutes and humidity were found, and no relationship with moon phase or mean wind speed. Data from permanent stations have not yet been analyzed separately for each species and it is possible that individual species may have responded differently to the environmental variables measured. All conclusions are based on a small incomplete sample and are likely to change as we accrue more data.

How Smart Are Flying Foxes? Megachiropteran Bats Use Human Referential Stimuli to Locate Hidden Food
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Spontaneous point following behavior is considered a sign of advanced social cognition typically reserved for humans. Recently the domestic dogs' (*Canis lupus familiaris)* success on point following tasks has led scientists to ask whether the domestication process itself might lead to human-like social cognition in other species. We investigated this hypothesis by testing the socio-cognitive skills of a suborder made up of highly social but non-domesticated species, megachiropteran bats (*Pteropus* spp.). Three subjects were highly successful in following a human point to a target location, providing the first empirical evidence of cross-species social referencing in bats. Furthermore we demonstrate that bats experiencing human contact from birth are more sensitive to human stimuli than wild-born bats, and that this responsiveness generalizes to unfamiliar humans. This study provides additional evidence that referential point following behavior is not restricted to domesticated animals or primates. Our data provide evidence that other social species can develop behavioral responses to unfamiliar human stimuli. possibly through early experience or enculturation. When considering the origins of human-like social cognition in distantly related species, more attention should be placed on the ecological relevance of social referencing and cooperation to the species in question. Megachiropteran bats may prove to be an excellent model for such behaviors.

Evaluating Changes in Bat Activity and Species Composition from White-nose Syndrome at Fixed Acoustic Monitoring Locations in Vermont
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White-nose syndrome (WNS) was first documented in southeastern Vermont during the winter of 2007/2008, one year after first appearing in New York. Since then, WNS has spread throughout the region and has caused unprecedented mortality to cave-hibernating bats. It is vital to verify and model expected declines in northeastern bat populations due to the possible future extirpation of local or regional populations. Long-term acoustic monitoring surveys along a forested ridgeline in central Vermont provided an opportunity to assess the affect of population change on recorded bat activity. The first year of acoustic monitoring occurred in 2007, prior to WNS documentation in Vermont. The second year of monitoring, in 2008, occurred during year one of WNS in the state. The 2009 season marked the second full year of WNS in Vermont, and additional surveys focused on documenting the progression of WNS and the projected decline in bat activity. Five Anabat detectors were deployed in the same locations for all survey years. Recorded files containing pulses with minimum frequencies above 30 kHz were used in a discriminant function analysis to assign species identification. Acoustic rates for all files recorded, for high frequency echolocators, and for *Myotis* species identified were compared among years. Overall activity was lowest in 2009, and yearly variation in activity patterns was driven by high frequency echolocators. Monthly detection rates varied among identified species, but were often lowest in 2009. Activity rates did not drop as much as expected based on mortality at nearby hibernacula, raising questions about the relationship between the amount of bat activity and the number of individuals present. Comparisons of bat activity at a single site are governed by site-specific influences and may not be representative of the larger geographic area. Continued sampling in 2010 will help determine if this observed trend continues.

Evaluating the Use of Stable Isotope Analysis to Infer Sex-specific Seasonal Movements of Silver-haired Bats in Northwestern California
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Effective conservation of bat populations requires understanding of their full range of seasonal movements and behavior patterns. In the western United States, silver-haired bats, *Lasionycteris noctivagans*, are thought to undertake long-distance seasonal movements between their summering and wintering habitat. However the summer destinations, and potentially the distances moved between summer and winter habitat, appear to differ between males and females. Previous research in redwood forests of northern California suggested that female silver-haired bats were present during fall through spring while males were present year-round. We confirmed these patterns using mist-net capture surveys and evaluated the use of stable isotope analysis as a means of assessing sex-specific

movements between summer and winter habitat. We analyzed hair samples from 16 female and 51 male silver-haired bats. To better understand expected levels of variation in a presumably resident population of bats, we analyzed hair samples from 22 female and 34 male *Myotis yumanensis*. The mean hydrogen isotope (δD) value for *L. noctivagans* females was -77.6‰ (range: -93.6 to -52.9‰) while the mean value for males was -75.2‰ (range: -112.6 to -38.5‰). Mean δD values for *M. yumanensis* females were -67.2‰ (range: -104.5 to -41.3‰) while mean values for males were -74.6‰ (range: -110.7 to -52.8). Using results from *L. noctivagans* alone might have led us to conclude that the summer whereabouts of male and females are drawn from a similar range of geographic locations across western North America. However, combined results from both species indicate that further work, possibly with additional isotopes (e.g., $\delta^{34}S$), is necessary to understand isotopic signatures in bat hair if this technique is to be used to understand their seasonal movements.

A Proportional Hazards Model to Identify Hibernaculum-level Variables Associated with White-nose Syndrome

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White-nose syndrome (WNS) has spread rapidly across 14 states and two provinces from the first documented case in Howe Cave near Albany, New York in 2006. Little is known about the factors that influence the spread of WNS among hibernacula, or about the characteristics that predispose particular populations to WNS. We used a Cox proportional hazards analysis to determine the characteristics of hibernacula in the northeastern United States associated with yearly risk of becoming infected with the putative fungal pathogen associated with WNS, *Geomyces destructans*. We tested the influence of distance from the first identified WNS site, distance to the nearest infected site, site elevation, size of the total bat population within the hibernaculum, bat species richness, diversity and evenness, and the proportion of each species within the hibernating population. The best model included distance to Howe Cave ($P < 0.0001$), the proportion of *Perimyotis subflavus* within the population ($P = 0.042$), and a *P. subflavus* by total population size interaction ($P = 0.031$). Time to infection was negatively associated with distance to Howe Cave ($e^{coeff} = 0.989$), with each additional kilometer decreasing the yearly risk of infection by a factor of 0.989. Time to infection was negatively associated with the percent of *P. subflavus* within the population ($e^{coeff} = 0.921$), with the association decreasing in magnitude for larger hibernating populations. Our results indicate that distance from the first infected site is a strong predictor of the timing of *G. destructans* infection, which is consistent with the scenario of a pathogen spreading from an original focus. Our results also suggest that species composition may influence risk of becoming infected. Our analysis demonstrates the importance of spatial location for determining risk of infection and suggests that multi-host dynamics may play a significant role in the rapid spread of this devastating disease.

Nuclear DNA Phylogeography Reveals Sex-biased Dispersal in the Pallid Bat, *Antrozous pallidus*

Jeremy E. Wilkinson, Justin B. Lack, and Ronald A. Van Den Bussche, Oklahoma State University, Stillwater, OK

Male-biased dispersal with female philopatry is a common pattern for many mammalian taxa. Due to the maternal inheritance of mitochondrial DNA (mtDNA), biparentally inherited nuclear markers are necessary to obtain correct estimates of population structure and gene flow. The pallid bat (*Antrozous pallidus*) exhibits a relatively continuous distribution across arid western North America, and a previous mtDNA study suggested little gene flow among populations and identified three distinct phylogroups. We examined population structure of *A. pallidus* using amplified fragment length polymorphism (AFLP) in 187 individuals from 29 localities across the distribution of the species. Eight primer pairs identified 797 polymorphic loci. All analyses indicated that populations in California and British Columbia were distinct from each other and all other populations. *A. pallidus* from the Baja peninsula were also distinct, but cluster analysis indicated gene flow has been occurring with more eastern populations. The pallid bat appears to be characterized by male-mediated dispersal and gene flow, while females are largely philopatric. The overall pattern is indicative of isolation by distance and does not support the presence of distinct phylogroups, suggesting significant gene flow has been occurring since populations diverged during Pliocene desert formation and mountain building.

Hibernating Rodents at a Bat Meeting: "Animal Models" and the Potential for Natural Selection to Help Bats Rebound from White-nose Syndrome

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White-nose syndrome (WNS) is causing a tremendous bottleneck for North American bats and has little, if any, precedent among wildlife populations. Such rapid population declines have the potential to exert a rapid response to selection on any phenotype that confers resistance to, or tolerance of WNS, as long as that phenotype is heritable. Such phenotypes could include aspects of immune response but, given apparent links between hibernation energetics and mortality, traits affecting energy balance during hibernation could be especially important for survival. We present a quantitative genetic ("animal model") analysis, based on a multi-generational pedigree and phenotypic measurements of individuals, which addresses the heritability of hibernation behaviors in Columbian ground squirrels (*Urocitellus columbianus*). The analysis confirms that hibernation emergence date, body condition at emergence, and estrus date following emergence (all traits closely linked to hibernation energy balance for this species) are significantly heritable and potentially subject to strong directional selection. We also present data on repeatability of the tendency for individual little brown bats to express torpor, which provides an 'upper-limit' estimate of heritability for this energetic trait in bats. These results emphasize the urgent need to identify any traits that provide a survival advantage in the face of WNS and highlight the potential value of detailed pedigrees and animal models to quantify the heritability of potential "WNS-survival phenotypes" in bats.

Babies and Rabies: Transference of Immunity from Mother to Infant

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It is well known that adaptive humoral immunity developed in response to infectious agents may be transferred in eutherian mammals from mother to offspring during gestation and nursing, providing newborn animals with important immunological defenses. Less studied, however, are the efficacy with which immunity acquired through vaccination is conveyed and the persistence of this specific immunity in the offspring. Such transference of immunity to the rabies (*Lyssavirus*) virus has not been described previously in humans. Despite the medical and economic importance of this zoonotic disease, particularly for mammal biologists and others for whom contact with hosts is likely, its lethality makes *in vivo* studies of the rabies virus difficult, especially in humans. Herein, we report a case of transference of rabies virus-neutralizing antibodies during pregnancy and lactation from a rabies-vaccinated adult female human to her unvaccinated infant. We also suggest the utility of additional studies of this unique and potentially important immunological process in consideration of the methods of maternal transfer of immunity in mammals.

Observations of Patterns and Behavior of a Migrating Hoary Bat

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Tree bat fatalities at wind facilities in the eastern United States remain a concern among bat conservationists. Research into the migratory patterns and behavior of these species provides data to help develop methods to minimize bat mortalities and direct mitigation efforts. We conducted a project in southwestern Pennsylvania during fall migration in 2007 and 2008 to capture, radio-tag, and track migrating species of tree bats. We intended to observe the bats': 1) movement, foraging, and roosting behavior; 2) landscape use; and 3) response to weather patterns that may initiate migration. In 2008, one adult male hoary bat (*Lasiurus cinereus*) was followed via telemetry-equipped ground vehicles and airplane for four nights before the signal was lost permanently. The hoary bat's movement was predominately in the eastern to southeastern direction, but this individual also moved north/northeast twice over the four-night period for distances of 13–16 km. The bat also followed the contour of one forested ridge and bisected another ridge, traveled over open fields in valleys and stopped to forage on a lake, within a stream corridor, and a field. During its flights, the bat passed within 6 km of an operating wind facility. We found no strong correlation to movement and weather patterns such as changes in temperature, pressure, and/or wind. The average temperature over a 24-hr period throughout the four-night movement and on the night of capture ranged between 13–17ºC, pressure was between 1022–1027 mb, and wind was between 1.0–2.6 m/s. However, on the night the bat was lost, the average temperature increased to about 2ºC greater than the previous 24-hr periods and the wind levels prior to movement dropped to under 1.2 m/s from over 2.0 m/s the previous 24 h.

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BOOK REVIEW

Bats of Missouri. Justin Boyles, John Timpone, and Lynn Robbins. Indiana State University, Center for North American Bat Research and Conservation, Terre Haute, Indiana. 60 pp., 2009. ISBN 978-0-9817096-2-8. ($10 United States)

Bats of Missouri is the third publication in a series of books from the Indiana State University Center for North American Bat Research and Conservation, following *Bats of Indiana* and *Bats of Michigan*. This new volume is written for a general audience, though it will be a useful resource for naturalists, teachers, and wildlife professionals. The book is well organized and written in a way that conveys important information and concepts about bat biology to the reader in understandable language. The information reflects recent advances in our understanding of bat biology and should engender appreciation for bats and their roles in the ecosystems of Missouri.

Students advised by Dr. Lynn Robbins of Missouri State University have contributed to the understanding of summer roosting habits and habitat of the Indiana bat in northern Missouri and, more recently, made exciting discoveries concerning winter ecology of bats in southern Missouri. Two of these students, Boyles and Timpone, have joined with Robbins to produce this book.

Bats of Missouri opens with a foreword by J. O. Whitaker, Jr., who sets the stage by introducing the mission of the Center and this series of publications. He also gives a brief synopsis of the ecology of bats and their importance in the environment. Next, the authors' preface invites the reader into the book by picking up on themes brought out in the foreword, as well as identifying the authors' hope that the reader will come away with a greater knowledge and appreciation of bats.

There are three main sections to the book: Introduction, Bat Identification, and Species Accounts. The first of these, the Introduction, occupies just under a quarter of the book. It opens with a one-page description of what bats are and how diverse they are as a group. This is followed by information through which the authors dispel common misconceptions concerning bats and briefly mention the place of bats in culture and folklore. Then follows a meatier section examining bat biology, food and feeding, habitat, reproduction, echolocation, migration and hibernation, and predators and parasites. The relation of bats to humans is discussed, including their benefits and control of nuisance bats. Information is provided concerning threats to bats, such as habitat loss and degradation, disturbance of cave roosts, direct persecution by humans, pesticides, and two recently added threats—wind power and white-nose syndrome. There is a brief discussion of bat conservation, and the section concludes with a look at how biologists investigate these difficult-to-study animals.

The next section, Bat Identification, contains a dichotomous key to separate and identify the 16 species of bats that have been recorded in Missouri. The authors emphasize features that minimize the need to handle bats, and in fact, they discourage handling without proper training and pre-exposure vaccination for rabies. Included are pictures of two key characteristics that are useful in separating species that in general appear to be very similar: toe hairs and shape of the tragus.

Most of the book (over half) is devoted to comprehensive Species Accounts, which incorporate both recent findings and long-held knowledge. Each account begins with the common and scientific name, including an etymology of the scientific name. This is followed by a detailed description of the species and high-quality photographs that help the reader visualize key characteristics and the overall appearance of each species. A

discussion of similar-looking bats allows the reader to separate species that are easily confused with one another. Measurements are presented in both English and metric units, as they are throughout the book. The conservation status of the species is discussed and its range is depicted, both in North America and Missouri. The state maps, which are based on maps prepared for the Missouri Department of Conservation in 2006, contain different patterns of shading to indicate whether a species is known from a particular county, is likely to occur, or has not been recorded. Finally, a section on habits gives information on life history and ecology, including foraging, roosting, and reproduction for each species. The information is presented in such a way that the reader is led, season by season, through a bat's yearly cycle of activity and behavior.

A glossary follows the species accounts and contains definitions of 24 terms that may be unfamiliar to the reader, and a list of references includes 25 articles and books that cover a spectrum of subject matter. Two thirds of the references are from 2000 or later and most are specific to Missouri. The book concludes with a brief biography of each of the authors.

Accompanying the text are 56 color figures. Most of these are high-quality photographs of bats or interesting, characteristic features of bats. Other photographs display habitats, parasites, research tools, threats, conservation measures, etc.

This book will be a valuable source of information and reference for persons interested in the bats of Missouri, whether they are professional biologists or amateur naturalists. The more than reasonable price makes the book even more attractive. I am pleased to recommend it.

Richard L. Clawson, Missouri Department of Conservation (retired), New Bloomfield, MO. E-mail: clawsonrandg@wmconnect.com

NEWS

As of 31 December 2010, **David Saugey** retired from the Jessieville-Winona-Fourche Ranger District, Ouachita National Forest, in Jessieville, Arkansas, after 34+ years as a Forest Service biologist. David has assured me that he will continue to work with bats, in one capacity or another, and remain actively involved with the Southeastern Bat Diversity Network (SBDN) and the Arkansas Academy of Science. He plans to write up information regarding his long-term work with Rafinesque's bats, as well as do some field work during bat season. Thank you, David, for your years of service to the District, the Forest Service, the SBDN, the NASBR, and to the bats and wildlife in Arkansas. Congratulations and best wishes for a long and happy (and well-deserved) retirement, David!

Tom Kunz and **Margrit Betke** (Boston University) are part of a team of researchers recently awarded a five-year, $7.5 million grant ($3.1 million of this to BU researchers) from the Office of Naval Research. The grant will fund a project entitled AIRFOILS (Animal Inspired Flight with Outer and Inner Loop Strategies), which will focus on the development of unmanned aircraft inspired by the flight mechanics and flight behavior of bats, birds, and insects. The focus of the project is to build a process for translating biological capabilities for agile flight in a range of environments for engineered flight vehicles. The proposed research will produce innovative methods for studying and integrating biological and engineered systems. In addition to Tom and Margrit, the research team includes three other Boston University engineering faculty, plus researchers at the University of Washington, the University of Maryland, and the University of North Carolina at Chapel Hill. Congratulations, Tom and Margrit!

DeeAnn Reeder (Bucknell University, Lewisburg, Pennsylvania) recently received more than $500,000 in grants to study white-nose syndrome. The most recent grants, awarded this fall, include $409,000 from the U.S. Fish & Wildlife Service to study the effects of white-nose syndrome on bats' behavior and physiology during hibernation, and $105,000 from the State Wildlife Grant Program to buy four state-of-the-art environmental chambers or "bat caves" for testing potential treatments for white-nose syndrome. The Bucks County-based Woodtiger Fund, a private, environmentally-minded foundation, also contributed $50,000 for DeeAnn's general white-nose research. Congratulations, DeeAnn!

ANNOUNCEMENTS

Request for Manuscripts — *Bat Research News*

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

Change of Address Requested

Will you be moving in the near future? If so, please **send** your **new postal and e-mail addresses** to Margaret Griffiths (griffm@lycoming.edu), and include the date on which the change will become effective. Thank you in advance for helping us out!

FUTURE MEETINGS and EVENTS

23–25 February 2011
The joint meeting of the Southeast Bat Diversity Network, the Northeast Bat Working Group, and the Midwest Bat Working Group will be held in conjunction with the 21st Colloquium on Conservation of Mammals in the Southeastern United States, at the Seelbach Hilton Hotel in Louisville, Kentucky, on 23–25 February 2011. For more details about the meeting please see http://www.sbdn.org/meetings.html.

2–5 May 2011
The Conference on Wind Energy and Wildlife Impacts will be held in Trondheim, Norway, May 2–5, 2011. For information please see: http://www.cww2011.nina.no/.

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

26–29 October 2011
The 41st Annual NASBR will be held in Toronto, Ontario, Canada, October 26–29, 2011. Please check the NASBR Web site at http://www.nasbr.org/ for upcoming information.

2012
The 15th Australasian Bat Society Conference will be held in Melbourne, Australia, dates TBA.

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

2013
The 43rd Annual NASBR and the 15th International Bat Research Conference will be held in Costa Rica, dates and city TBA.