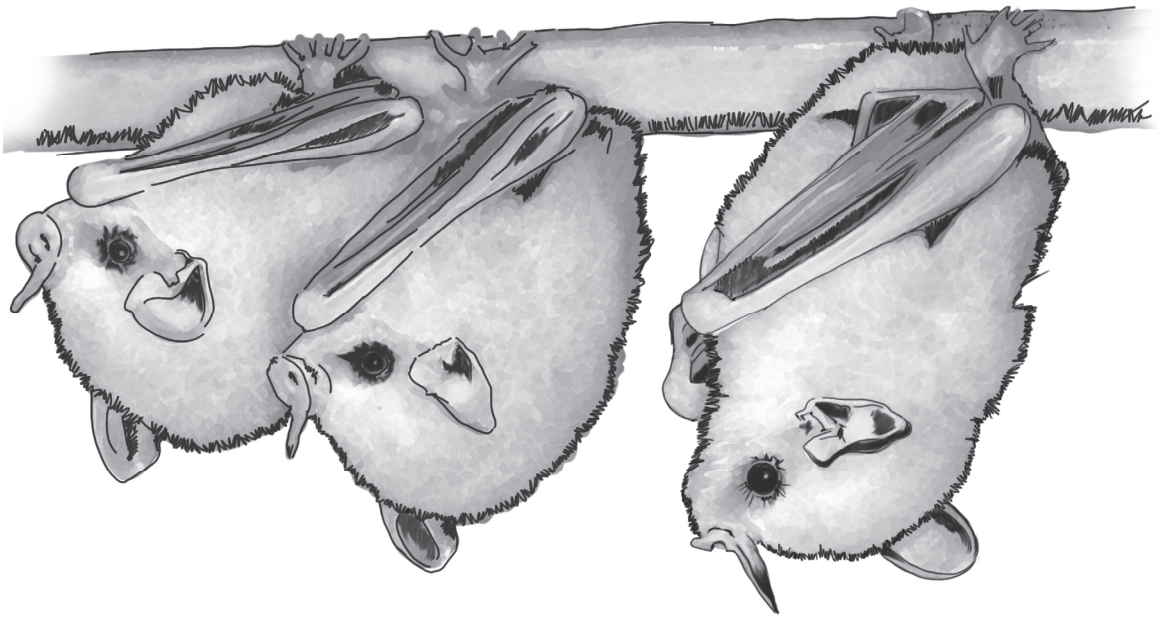
Abstracts

16th INTERNATIONAL BAT RESEARCH CONFERENCE

COSTA RICA 2013

43rd NORTH AMERICAN SYMPOSIUM ON BAT RESEARCH



Abstracts

16th International Bat Research Conference
43rd North American Symposium on Bat Research

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Abstracts are arranged in alphabetical order by first author.
Titles highlighted in green are oral presentations; those highlighted in orange are posters.
The presenting author is the first author unless indicated by an asterisk.

Value in Variation? Stationary Acoustic Transects to Account for Spatial Variation in Bat Activity

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The ability to identify and capture different sources of variation at a particular location can impact conclusions drawn from the data. It is important to account for variation to maximize the chances of obtaining unbiased measures of bat activity. When and how to sample is a question that is typically decided by time availability, manpower, and equipment limitations. My objective was to quantify small scale spatio-temporal variation in bat activity and demonstrate how it can affect acoustic sampling design. I used a stationary transect of bat detectors to i) assess variation in patterns of activity at each detector, ii) test whether spatial or temporal factors were more important for explaining variation in activity, iii) explore what sampling effort in space and time is required for species-specific activity levels. The picture of activity differs significantly within a site depending on detector placement so it is important to use multiple detectors simultaneously to collect accurate estimates of activity. I found that within site factors are very important to understanding variation in bat activity, being as or more important than differences among sites. The high degree of variation within sites can affect sampling design, including necessary effort and number of detectors recording simultaneously. Detector placement within a site will dramatically impact the depictions of activity, impacting estimates of levels and patterns of activity. An *a priori* understanding of the survey effort necessary will help ensure statistically powerful sampling designs, clearer data interpretation, and likely more successful management and conservation actions.

Will Increased Drought Alter Population Numbers and Community Structure of Bats in the Southern Rocky Mountains?

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The effects of climate disruption are underway in the Southern Rocky Mountains. Highest elevations are warming fastest thereby reducing winter snowpack and spring runoff. At lower elevations, warmer temperatures and reduced summer precipitation causes decreases in stream discharge rates, and water availability, once snowpack is exhausted. We show the results of reduced water availability on Rocky Mountain bat reproduction by both direct measurements of numbers of drinking visits by lactation versus nonlactating *M. thysanodes* (N_{lac} = 236, $N_{nonrepro}$ = 18; P = 0.0001) and by linking reproductive patterns of myotis species gathered under variable annual weather conditions across 13 years. Decreases in precipitation and stream discharge rates correlated strongly with decreased lactation (R = 0.85 and 0.79. respectively). We also show that intense activity at drinking sources immediately after evening emergence involves both cooperation and competition among species that appears to structure larger regional population numbers and coexistence. Shannon Diversity Indexes (H') for all bats captured (N = 2,299) was 1.65, which was consistent with four water sites where nine species of bats swarmed to drink: Ingersol Quarry (N = 147) 1.50; Geer Canyon (N = 522) 1.61; Shadow Canyon (N = 475) 1.51 and Bear Creek (N = 458) 1.61. Thus, the overall regional assemblage structure strongly correlated with species proportionality at individual water sources (R = 0.98) despite variability in which species dominated in numbers at each site. Thus, the loss of water sources in proximity to roost sites due to climate change may result in alterations in proportional population numbers at a larger regional scale.

How Flower Morphology Influences Flower-visiting Behavior of Bats and the Reproductive Success of *Mucuna urens* (Leguminosae)

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The genus *Mucuna* shows explosive flower opening and an impressive radiation involving different pollinators has taken place. Studies discovered that floral parts function as acoustic guides that help bats locate the flowers using echolocation. The aim of this study was to verify how flower morphology influences flower-visiting behavior of bats and the reproductive success of *Mucuna urens.* Pollination biology of *Mucuna urens* was studied in the southeastern Brazilian rainforest. Each inflorescence bears 36-54 greenish, fetid and medium size flag-flowers, but only 1-3 nocturnal flowers are in anthesis simultaneously with abundant nectar. These features are associated with bat pollination. The reproductive organs are enclosed in the keel, being released after explosive flower opening,

launching pollen against the pollinator. The principal pollinator is *Glossophaga soricina*, which have adequate behavior to trigger the explosive mechanism of this flower. During the first visit, the bat lands on the flower and triggers the explosive opening mechanism. The staminal tube of the flower then moves towards the standard and does not return to the original form. This changes the floral morphology, possibly affecting the acoustic guide. In subsequent visits to the same flower, bats hovered rather than landing, drinking nectar but failing to contact the reproductive organs. Thus, *Mucuna* flowers have just one chance to be pollinated. The changes in flower morphology modify flower-visiting behavior of bats, influencing the reproductive success of this *Mucuna* species.

Spectrum Echolocation Calls using HMMs, Fisher Scores, Unsupervised Clustering and Balanced Winnow Pairwise Classifiers

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A new classification technique for the identification of bats to species from their echolocation calls is presented. Three different datasets are compiled and split in half for training and testing classifiers. Combined, the data include 9,014 files (bat passes) with 226,432 candidate calls (pulses or extraneous noise) representing 22 different species of bats found in North America and the United Kingdom. Some files are of high quality consisting of hand-selected search phase calls of tagged free flying bats while others are from a variety of field conditions including both active (attended) and passive (unattended) recordings made with a variety of zero crossing and full spectrum recording equipment from multiple vendors. Average correct classification rates for the three datasets on test data are 100.0%, 97.9%, and 88.8% respectively with an average of 92.5%, 72.2%, and 39.9% of all files identified to species. Most importantly, classifiers in the third dataset for two species of U.S. endangered bats, *Myotis sodalis* (MYSO) and *Myotis grisescens* (MYGR) have a correct classification rate of 100% and 98.6% respectively and identify 67.4% and 93.8% of all files to species suggesting that the classifiers are well suited to the accurate detection of these endangered bats.

Anoura geoffroyi as a Pollinator of the Epiphytic Bromeliads *Tillandsia heterophylla* and *T. macropetala* in Central Veracruz, Mexico

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Tillandsia heterophylla and *T. macropetala* are two epiphytic bromelias of the severely threatened tropical montane cloud forest ecosystem in central Veracruz, Mexico. Both species have floral characteristics that are typically associated with nocturnal pollinators, particularly bats; however, their anthesis begins at dusk and lasts until the following day, which also offers the possibility of daylight visitors. Since the majority of the period the flowers remain open occurs during the night, the most efficient pollinators would be the nocturnal visitors. In order to determine if this is the case, observations and recordings were made of both diurnal and nocturnal visits, along with mist net trapping of the visitors. The nectar production pattern was determined, as well as the duration of stigma receptivity and the presentation of pollen. The bat *Anoura geoffroyi* was the only observed pollinator of *T. macropetala*, while in *T. heterophylla*, this bat was the most common pollinator, followed by hummingbirds. *T. heterophylla* is autocompatible and presents no differences in the number of seeds per fruit produced by diurnal or nocturnal animal visits. Conversely, *T. macropetala*, also autocompatible, only produces fruit following visits by nocturnal animals. Extending anthesis into the daytime has given *T. heterophylla* access to new pollinators, while for *T. macropetala*, diurnal visitors simply steal nectar while providing no reciprocal benefit to the plant.

The Latin American Bat Conservation Network (RELCOM)

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With over 360 species of bats living in a variety of ecosystems in Latin America and the Caribbean, the region constitutes the most bat-rich area in the world. Landscapes range from coastal areas in the Caribbean to highlands in the Andes. Within each of these ecosystems, bats fulfill crucial ecological roles. In addition to helping to control insect pests, it is estimated that at least 800 plant species depend on bats for pollination and/or seed dispersal, and at least 10 percent of them would fare less well without bats. However, this importance is contrasted by a large number of threatened species in the region (57 according to IUCN). These regional risks led in 2007 to

the creation of the *Latin American Bat Conservation Network* (RELCOM), which now includes local bat conservation organizations in 19 countries. Here, I describe this regional initiative and the impact it has to protect bats. The network seeks to guarantee the persistence of healthy bat species and viable populations in Latin America and that in all the countries their importance is acknowledged and recognized. In 2009 we developed a strategy that is orienting all our conservation efforts. Several actions have been accomplish regionally, including a vast number of research projects, the creation of a network of Important Bat Conservation Areas/Sites, education campaigns coordinated regionally, courses and congresses, among others.

Survey of Alpine Bats by a Novel Mist-netting Technique

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Bats have been barely studied in alpine environments, probably due to an expected low abundance and the working difficulties entailed by a physically demanding environment. With the main purpouse of studying Mountain Long-eared Bats *Plecotus macrobullaris,* we sampled bats in alpine environments of four mountain chains in Europe: namely the Pyrenees, Alps, Pindos Mountains and Caucasus. We trapped bats by means of mist-nets, covering an elevational range of 1450–2450 m. Nets were set in open areas such as alpine meadows and rockies, chained up in lines up to 140 m long, and were kept open for 3-4 hours after sunset. The best results were obtained in flat alpine meadows –e.g. high elevation valley bottoms, clogged lakes or alpine terraces– with low vegetation. We captured 285 bats belonging to 10 different species in 48 out of the 54 sampled locations. *Plecotus macrobullaris* was the most abundant species (69% of captured individuals), followed by *Myotis nattereri* –sensu lato- (%12) and *Myotis myotis* (%6). *P. macrobullaris* were almost exclusively caught in the two lowest net bags, i. e. flying within 1 m above the ground. The reported mist-netting technique has proven valuable to catch low-flying bats in alpine supraforestal environments, but it may be a cost-effective trapping estrategy also in other bat communities where open habitats occur.

The Interplay between Weather and Reproduction in Three Cave-dwelling Insectivorous Bats in a Malaysian Tropical Rainforest

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High energetic and nutritional demands during pregnancy and lactation force many bat species to time their reproduction with availability of resources (eg. food). Mistiming parturition with the maximum food availability can incur high individual fitness costs. Long life spans and slow reproductive rates in bats mean that repeated mismatches can potentially lead to population declines. In this study, we investigated the correlation between reproductive patterns in three insectivorous cave-roosting bats (Hipposideros bicolor 142-kHz, H. cervinus and H. diadema) with local weather patterns. Bats were trapped during five consecutive nights per week, from February 2009 to October 2010, at Krau Wildlife Reserve, Malaysia. We also sampled at nearby caves once a month during the study period. Rainfall and temperature were recorded in the forest using a HOBO Automated Weather Station. Female reproductive condition was assessed by observation of external secondary sex characteristics and abdominal palpation. We found two rainy seasons in the study area (first: April-May; second: October-November), but the three species showed restricted seasonal monoestry (Rayleigh Test, $p<0.001$), associated with the Apr-May rain season. Lactation correlated with measures of monthly temperature of the month of lactation and up to two months preceding. However, pregnancy showed the greatest relationship with temperature two-three months earlier, correlating negatively. We hypothesize that these relationships reflect the interaction between insect availability and local weather variables. If such is the case, hipposiderids may set the time of reproduction to coincide with the period of maximum food abundance, which is the direction of our next research.

Revalidation of *Myotis chiriquensis* Allen, 1904; *M. osculati* (Cornalia, 1849), *M. punensis* Allen, 1914 and *Myotis alter* Miller & Allen, 1928

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Myotis is a highly diverse vespertilionid genus, with 103 species recognized so far, in addition to another 94 species whose taxonomical status has not yet been completely evaluated. Twelve species are known to South America, among which five are considered polytypic. To characterize, both morphologically and molecularly the Neotropical *Myotis*, we examined 1018 individuals from scientific collections. Twenty-five characters from external and cranial morphology were analyzed and 32 measures were took. To characterize intra and interspecific genetic diversity from taxa in the genus *Myotis,* we selected one mitochondrial gene, cytochrome *b* (720bp), and nuclear gene, RAG2 (602bp). From these two genes, we obtained 78 sequences. From the data obtained, we elevated *Myotis osculati*, a taxon hitherto considered a subspecies of *M. nigricans* to specific level, and recognized *Myotis punensis* and *Myotis chiriquensis* as valid species; both taxa they were previously considered synonyms of *M. n. nigricans*, and *Myotis alter* previously considered synonyms of *Myotis levis.* In this context, we recognized 15 species for the genus *Myotis* in South America, representing an increase of 25% in the previously known diversity for the group in that continent. Qualitative characters from the skull, such as presence or absence of a sagittal crest and the arrangement of upper premolars, associated to those from external morphology were fundamental in diagnosing taxa occurring in the South America. The understanding of the processes involved in the diversification of the group will be favored by the inclusion of samples of the other populations distributed in the Neotropical Region.

Bats from Rio Madeira: Species Richness and Impacts Related to the Jirau Hydroelectric Reservoir, Southwestern Brazilian Amazonia

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The Brazilian Amazonia is a complex species-rich biome with most of its area presenting major knowledge gaps. Among these poorly known regions, concerning bat communities, is the southwestern Amazonia, where the Jirau hydroelectric reservoir is being implemented. In this context, we described the bat community of this area and assessed the impact of environmental changes to the bats. Thirteen sampling campaigns were performed in three-month intervals, from 2010 to 2013, on the implementation area of the hydroelectric dam and its vicinities, along both banks of the upper Rio Madeira, Porto Velho municipality, Rondônia state. A total of 3171 captures represented 72 species, 37 genera and six families. Most species (56) were rarely caught, comprising each less than 1% of the total captures, seven of them were captured once and eight twice. *Carollia perspicillata* represented 31.37% of the captures. This associated with the other three more abundant species, *Artibeus lituratus*, *A. planirostris* and *A. obscurus*, represented 56.24% of the captures. Considering seasonal fluctuations and relative abundance differences, a decline of Phyllostominae species, regarded as disturbed areas indicators disturbed areas, was observed between the pre- (D=0.06) and post-flood (D=0.03) periods along with a concurrent increase in *C. perspicillata* abundance (D=0.33 and 0.68, respectively), a generalist species. The Kuskal-Wallis test, however, did not show significant relative abundance variation of neither the Phyllostominae (H=2.46; p>0.05) nor *C. perspicillata* (H=4.91; p>0.05) between the periods. Sampling will be done for one year more, providing an opportunity to verify whether the observed pattern is maintained or not.

Comparison of Echolocation and Capture-flight by *Myotis capaccinii* when Hunting Insects and Fishing in the Wild

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Formerly thought to be a strictly insectivorous trawling bat, recent studies have shown that *Myotis capaccinii* also preys upon fish in some circumstances. Due to the large differences in size and behavior between the two prey types, changes in the capture-flight pattern and echolocation calls would be expected when targeting them.

In order to test and assess those putative differences we designed a field study where the flight and echolocation behavior of *M. capaccinii* were observed by means of synchronized high-speed video and sound recording. We focused on the last step of insect and fish captures to get some insights into the sensory clues and mechanisms deployed for those tasks. Both echolocation and flight patterns correlated with prey type. When capturing insects bats used both buzz I and buzz II parts of the terminal phase to the same extent, and performed short and superficial drags on the water surface. Conversely, when preying upon fish buzz I was considerably longer and buzz II shorter, and they made longer and deeper dips into the water. These results show that *M. capaccinii* are able to regulate the temporal components of echolocation buzzes and modify their capture technique according to the target. Moreover, the changes observed in the terminal phase of echolocation suggest that *M. capaccinii* obtain advantages from using buzz I pulses rather than buzz II, maybe related to the echolocation scanning needs of less conspicuous and hardly detectable prey such as fish.

The Alpine Playground: Roosting Ecology of *Plecotus macrobullaris*

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Most data on the roosting of the Mountain Long-eared Bat hitherto reported refer to use of buildings at relatively low elevation. However, many captures carried out by the authors at supraforestal habitats suggest that its affinity to the alpine belt could be higher than previously thought. In order get some insight into its roosting behavior, we radio-tagged 49 bats captured at 17 sites above timberline (1600 – 2450 m) in the Pyrenees mountain range (top elevation, 3404 m). We successfuly tracked 37 bats (2-6 tracking day/bat) and located 54 different roosts, 45 of them at supraforestal environments. Bats used three types of structures: natural rock crevices (27 roosts), screes (24) and human-made buildings (3). Screes were used for roosting by 13 bats, mainly males and nulliparous females, and most of the pregnant or breeding females roosted at natural crevices, up to 2400 m. Just three maternity colonies were located at buildings, all below the timberline. The low use of buildings (5% of all roosts) in the Pyrenees contrasts with reports from the Alps, where it has been found roosting mainly in buildings at lower elevations. This difference could be the result of different roosting preferences produced by contrasting climatic and habitat conditions, but a biased sampling of the altitude range in the Alps cannot be ruled out. The observed ability to breed at alpine environments and the use of screes as a common roosting resource reassert, along with recent findings on its foraging behavior, the alpine nature of *Plecotus macrobullaris*.

Insectivorous Bats in Agroecosystems: The Case of Banana and Pineapple Plantations in Northern Costa Rica

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Biodiversity loss has a strong relationship with habitat fragmentation, destruction, and transformation. In Costa Rica, nearly 2% of the country's area is dedicated to banana and pineapple plantations (around 1% each), and these numbers have been growing in the past years. We sought to determine the impact of these two industrialized agroecosystems on the aerial insectivorous bat assemblage of Sarapiquí, Costa Rica. We expected lower bat activity (passes min^{-1}), richness, and feeding activity (feeding buzzes min^{-1}) in plantations in comparison with control forests. To test this, we used simultaneous acoustic monitoring during 54 half-nights (17:30-0:00) in four pineapple-forest and five banana-forest pairs. 3,156 bat passes were counted with 18 different species recorded (eight shared, eight only in plantations, and two only in forests). Overall bat activity was higher in the plantations, however almost 50% of it was represented by the species complex *Molossus currentium/sinaloae* (Molossidae). *Centronycteris centralis* (Emballonuridae) accounted up for over 80% of bat activity in forests, and was not recorded in plantations. Rarefied species richness was higher in the control forests. Feeding activity was also higher in plantations, suggesting a possible relationship with potential preys. According to our data, the vulnerability, as well as habitat requirements and morphological traits, of each species play an important role in defining the aerial insectivorous bat assemblages in banana and pineapple plantations in Northern Costa Rica. Due to the intensive use of agrochemicals in these plantations, it is essential to consider the effects they have on the bats from the area.

The Science and Management of Emerging Wildlife Diseases: Gd in Bd's Slipstream

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Emerging infectious diseases in wildlife appear to be on the rise, with fungal pathogens implicated in mass mortality events among diverse taxa including amphibians, reptiles, and mammals. Mass mortality events from fungal pathogens appear to be a relatively novel concern for wildlife, either due to their being a cryptic scourge relative to our notice in the past or due to new levels of virulence or transmission. Fungi can spread quickly within populations, decimating local abundances, and may be able to move easily among populations, rapidly dispersing across broader regions. Furthermore, human globalization patterns may assist fungal migration. For instance, Chestnut Blight (*Cryphonectria parasitica*) is believed to have been introduced to North America from Europe. Amphibian trade, including species like the African Clawed Frog *(Xenopus laevis)* and American Bullfrogs *(Lithobates catesbeianus*), has been linked to transportation of the amphibian chytrid fungus (*Batrachochytrium dendrobatidis, Bd*) around the world. Recent evidence indicates that the fungus *Geomyces destructans*, *Gd*, in bats arrived in a New York cave via human-mediated transport from Europe. Hence, in several regards, fungal pathogens present a very different wildlife problem than other microbes, and their ecology and epidemiology is relatively little known. What can herpetologists and mammalogists learn from each other that may contribute not only to dealing with these current threats; but to those that may arise in the future. We examine the similarity and contrasts between *Bd* and *Gd* in pathogen characteristics as well as scientific and management approaches to understanding and arresting the diseases they cause.

Do Bats Talk Funny In Helium? A Test of Echolocation Flexibility

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Our study aimed to test the extent of flexibility in an active sensory system - echolocation, in insectivorous bats. We conducted flight experiments with *Pipistrellus kuhlii* in a helium-enriched environment to test two aspects of flexibility: **1.** Speed-of-sound: As target ranging depends largely on measuring the time interval between an emission and its echo, an accurate reference of the speed-of-sound is crucial to an echolocating bat. Our goal here was to test the bats' ability to deal with changes in speed-of-sound which also occur in the natural environment. **2.** Call parameters: echolocation calls are produced by the vocal cords, and are then filtered by the vocal tract. The lower density of helium should thus increase the frequency of the emitted call, and our goal here was to check whether bats cope with the altered calls or try to actively compensate. Bats were held in a flight tank containing either regular air or 80% heliox, in which speed-of-sound was increased by 20%-25%, and were required to fly a short distance and land on a target. We analyzed echolocation parameters and target ranging (hits or misses) to assess heliox effects and bats' responses to them. While echolocation appears to be unaffected, target ranging was severely impaired and bats repeatedly underestimated target distance even after long periods in heliox and much training. Our results show flexibility is limited when faced with drastically altered speed-of-sound. The exact limits and the reason for lack of effect on emission parameters are currently under further research.

Marburg Virus Outbreaks: Understanding Virus Spillover from the Natural Reservoir

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Marburg virus (MARV) causes sporadic outbreaks of Marburg hemorrhagic fever (MHF) in Africa. The Egyptian fruit bat (*Rousettus aegyptiacus*) has been identified as a natural reservoir based most recently on the repeated isolation of MARV directly from bats caught at the Kitaka mine and Python Cave (~50km apart) in southwestern Uganda where miners and tourists separately contracted MHF from 2007-08. A long-term study of *R. aegyptiacus* at these locations determined that 2-5% of the population was actively infected, that bat and human virus sequences were genetically similar, and that twice-yearly birthing seasons produced pulses of juvenile bats that, when ~6 months old, were 5-6 times more likely to be infected than adults. These seasonal pulses coincide with the dates of 83% (54/65) of all known MARV bat to human spillover events. These data are the first to forecast periods of increased-risk for human infection. There are still many unanswered questions however; how is the virus shed? Are there symptomatic infections in bats? Can experimental infection on captive bats be achieved? To answer these questions and more, we captured, tested, and imported a breeding colony of *R. aegyptiacus* to perform

experimental infections with filoviruses in a high containment setting. Experimental infections with Marburg virus and captive *R. aegyptiacus* are currently being conducted. Preliminary results reaffirm conclusions from our field data, which indicates these bats are capable of maintaining the virus within a population. Further analysis of experimental infection data hopefully will elucidate more aspects of virus spillover from this reservoir host.

Annual Fluctuations in the Colony Size of *Leptonycteris nivalis* in Texas Estimated Using Thermal Imaging

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The Mexican long-nosed bat, *Leptonycteris nivalis*, is an endangered, migratory species that occurs throughout much of Mexico, and occurs in only two known colonies in the United States. We used a FLIR P65 infrared thermal imaging camera to record the emergence of *L. nivalis* from a cave roost in Big Bend National Park (BBNP), Texas. Annual censuses were conducted 3–5 July in 5 different years (2008–2012) when young were volant and side fidelity was high. Digital recordings were manually analyzed to determine the number of *Leptonycteris* and other species leaving the cave. The total number of *Leptonycteris* counted ranged from 294 to 3238. On average, emergences began approximately 30 minutes after sunset (range=18–41) and peaked an average of 46.3 minutes after sunset (range=33–61). Environmental conditions during each census varied among years and might have influenced the observed patterns of emergence rates (bats/minute). Counts of *Agave havardiana* (the primary food source for *L. nivalis*) during the *L. nivalis* survey years in BBNP ranged from 92–533 blooming plants. Published data suggest that population size of *L. nivalis* is correlated with the number of *Agave* blooms in Mexico. The variation in numbers of *Leptonycteris* and *Agave* blooms in BBNP however, were not significantly correlated.

Phylogeography of the European Free-tailed Bat in the Western Palearctic

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The European free-tail bat *Tadarida teniotis* is one the most northerly distributed member of the Molossidae yet almost nothing is known about its population history and genetic structure. The importance of unraveling complex historical events that may explain current species distribution patterns is paramount for guiding conservation. Here we combined results from the analysis of two mtDNA fragments and nuclear DNA with species distribution modeling to determine *Tadarida teniotis* glacial refugia and postglacial colonization routes. For mtDNA we sequenced fragments of cytochrome *b* and the hypervariable domain (HVII) of D-loop, while for nuclear DNA we genotyped a set 14 microsatellites. Overall 150 samples covering the west Palearctic range of the species and a few from the Far East were used for DNA analysis. For modeling purposes we used a maximum entropy modeling technique to calculate bioclimatic models for the present and projected them to the last glacial maximum (LGM; 23 000–18 000 years BP). We used two different general circulation models (GCM) for this latter period, the Community Climate System Model (CCSM) and the Model for Interdisciplinary Research on Climate (MIROC). Microsatellites showed very high allelic diversity within the species range but no population structure was detected across European and North Africa. Palaeodistribution models predicted that suitable climatic conditions probably existed during LGM in southern Europe and North Africa. Our early results suggesting a panmictic population across a wide area highlight the need for international policies for conservation management of this taxon.

Hemoparasites in *Molossus rufus* E. Geoffroy, 1805, in Urban Shelters in the South of Brazil

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Bats can be the host of several species of hemoparasites and can be a group of interest for public health since several species are adapted to live in cities, increasing its proximity to human beings. Due to the scarce literature on hemoparasites in chiropters, this work had the objective of investigating the occurrence of infectious agents in bats of the *Molossus rufus* species in the south of Brazil. The research was carried out in urban areas and in rural properties located near Atlantic Forest areas, between October 2010 and September 2011. All the captures

occurred in the attics of residences. The collects were done monthly, during a period of four nights, with the help of mist nets. About 10µL of blood was taken from the propatagial vein to prepare the smear. The slides were prepared according to the Giemsa-staining method and analyzed in an optic microscope. During the research, 165 specimens of *M. rufus* were captured. The optic microscopy revealed the presence of *Plasmodium* sp. in six specimens and *Babesia* sp. in four of them. The infection in the *M. rufus* by these agents could have happened through an insect bite or orally since this kind of bat is an insectivore. An important aspect is that the chiropters flying ability helps with the dissemination of the parasites. The data obtained indicated the presence of potentially pathogenic microorganisms. Therefore, it is necessary to have more studies focused on the parasites species and the potential risk of infection for humans.

Carving up the Night Skies: Differences in the Shape and Use of Teeth in Early Bats Reflect Resource Partitioning

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Archaic Eocene bats are known from both Northern and Southern Hemispheres, with well-sampled early Eocene deposits in Eurasia showing relatively high bat species diversity. Some taxa, e.g. from the Green River Formation, USA and Messel, Germany, are known from articulated but partially crushed skulls and skeletons; others by three-dimensionally preserved but fragmentary craniodental and postcranial remains. All are represented by teeth, and microCT and 3D reconstruction software have recently enabled analysis of dentitions previously not easily studied (e.g. *Icaronycteris index* Jepsen, 1966 and *Archaeonycteris trigonodon* Revilliod, 1917). We surveyed conspicuous dental differences among early bats, including dentary depth and length, condylar and angular height, relative toothrow area, distribution and emphasis of tooth types, individual tooth area and height, premolar loss and/or molarization, transverse and longitudinal blade development, and cusp, style, cingular and conule position and development. Apart from the information these dental features provide for phylogenetic studies, they indicate dietary diversity among early Eocene bats and resource partitioning of night-flying insect resources. In the dentitions of some large early bat taxa, thegotic faceting overprinted on teeth whose cutting blades have been worn by mastication of hard prey is evident. Because all mammals must thegose their dentitions to sharpen dental blades dulled by use and/or to reshape components of the dentition (e.g. canines) for use as more effective weapons, thegotic facettes distinct from masticatory facets can also reveal behavioral differences between species.

Habitat Use of Aerial Insectivorous Bats in Urban Small Parks of San José, Costa Rica

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Although in recent years bat research in cities has increased, there is little data concerning the effects of development and the ability of small parks to maintain community structure. The aim of this study was to evaluate habitat use by aerial insectivorous bats in small parks in a highly urbanized area. We expected more activity in the parks than in places without vegetation. Three sessions of acoustic monitoring were conducted in 3 different parks. Each site and its control were sampled for 3 nights, between 18:00 h and 19:30 h. A total of 143 recordings were performed (122 in parks, 21 in controls). The most common species was *M. rufus*, followed by *N. laticaudatus* / *T. brasiliensis*, *Eumops* sp., *M. molossus* and *A. jamaisencis*. The relative activity was statistically higher in parks than in controls. There was no significant difference in activity between parks. The results are consistent with previous research where the general trend of urbanization has been reduced species richness and increased other opportunistic; however parks tend to be sites of greatest abundance and activity than those sites without vegetation within the urban landscape. Although small parks are not capable of replacing the natural conditions, its presence in cities are important to keep the remnant bat diversity. It is necessary to continue with studies that allow us to make decisions to reduce the impact of urban development on biodiversity.

Latitudinal Patterns of Higher-Taxon Richness of New World Bats and the Diversification of the Noctilionoidea

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The tropical niche conservatism hypothesis (TNCH) has been proposed to explain the high species richness in Neotropical vertebrates. Under the hypothesis, most clades have a tropical origin and fail to disperse to extratropical areas; whereas clades of temperate origin tend to occur also in the tropics, thus contributing to the diversity there. Here we examine the patterns in the diversification of the Noctilionoidea in the context of the TNCH by analyzing the latitudinal gradient of diversity of the nine New World bat families. The gradient of species richness shows a pattern consistent with the TNCH, but the gradient for higher-taxon richness reveals subtler patterns: Higher than expected species-to-genus ratios both at the southern and northern extremes of the continent; a low ratio in Central America and Mexico, but not in the corresponding latitudes in South America; a symmetrical Rapoport pattern for genera (more genera with small ranges near the equator); but a highly asymmetrical pattern for species (with an over-representation of restricted species in the extreme south); a rather uniform distribution of endemic species; but a higher than expected number of endemic genera in North America but not in South America. In general, results support the TNCH, particularly for the Noctilionoidea, but also reveal the effect of the geological history of the area. Our data support the idea that some of the clades traditionally considered of strict South American origin might in fact have originated in North America prior to the Great American Biotic Interchange.

The Revolutionary Foraging Niche of the Barbastelle Bat

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Barbastelle bats (*Barbastella barbastellus* and *B. leucomelas*) belong to the long-eared bats (Plecotinae) but have a unique head and face morphology, probably related to an unusual foraging niche. Long-eared bats generally use passive listening to detect prey and faint broad-band echolocation calls mainly for spatial orientation. Nevertheless, adaptive plasticity within the group is shown by the spotted bat *Euderma maculatum*, which uses loud, low-frequency (audible) echolocation calls. In general, long-eared bats, including *E. maculatum*, frequently feed on moths, a prey type usually difficult to capture for species using high-intensity echolocation calls. Indeed, many moths escape bat predation thanks to their ultrasound-sensitive ears by which they detect echolocation calls of approaching bats. Barbastelles feed almost exclusively on moths, and indeed seem more specialized on this prey type than any other European bat. This has been explained by a «stealth strategy» – echolocation calls are weak enough to alert the prey only when the bat is so close that anti-predatory reactions are no longer effective. Here, we propose that a further special, possibly unique and complementary, adaptation in the foraging technique exists. Based on previous findings (diet analyses, description of echolocation calls and field observations of foraging bats) and the above rationale, we experimentally analysed the prey detection technique of *B. barbastellus* in captivity. Results suggest that barbastelles listen to the fluttering noise emitted by flying moths to locate and capture them. This behaviour has not previously been described for bats, but may occur in other species, notably those with convergent head morphology.

The Australasian Bat Society: our Current Challenges and Future Vision

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The Australasian Bat Society is a professional scientific society comprising around 300 members mainly in Australia and New Zealand, representing research scientists in universities and government, students, wildlife rehabilitators, environmental consultants and members of the public with a general interest in bats. We aim to promote the conservation of all populations of all species of bats in Australasia, and our activities extend from grass roots advocacy to scientific research, and the development of standards and the provision of conservation advice at State and Federal Government level in Australia. Recent events have seen us make public comment either directly or together with the efforts of a coalition of other environmental groups. These events include concerted efforts by

business interests to weaken Australian environmental laws, and to reintroduce shooting and encourage dispersals as apparent control measures for flying-foxes. Despite some negative feelings about bats in the public domain, our Bat Nights are very successful in engaging with local communities and there is much interest and participation. Our greatest challenge at present is organising the information we have within our society to produce fact sheets, media statements, position statements on certain thorny topics and standards documents so that we can readily respond to the media and public enquiry with sensible and balanced information based on the scientific literature and our collective specialist experience. The new initiatives by Bat Conservation International to increase exchange between bat societies and networks is something that the ABS is keen to take part in.

From Predator-Prey Relationships to Resource Partitioning among Insectivorous Bats Revealed by Molecular Tools

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The plasticity in the foraging behaviour of bats balances the expectations based on rigid ecomorphological models and, arguably, prey abundance seems to be the likely explanatory factor of the flexibility in bat's foraging decisions. Moths are among the most consumed prey of insectivorous bats. It is a formidable food resource that not only might vary due to environmental features, but also is constrained by its life cycle. The adult phase may last only for several weeks whereas the tight link of the larval stage to particular host-plants may give way to a continuous input into the ecosystem due to the consecutive renewal of these plants. Therefore, we expect an ongoing adjustment of the foraging behavior of bats in response to this continuous variation in their staple food resource. These project, funded by the Spanish Ministry of Economy and Competitiveness, aims to deepen our understanding on the foraging ecology of insectivorous bats, with especial regard to moth specialists, focusing mainly in the predator-prey relationships through the seasonal/local changes in prey abundance. In order to do that we will rely on the most recent technological improvements in molecular ecology, which may allow us to identify the bats' prey at species level and semi-quantitatively, to achieve the following objectives: 1) to assess the effect of mismatching foraging habitats and source prey habitats in the characterization of bat requirements; 2) to determine the contribution of bats to the control of pest moths; 3) to enlighten the resource partition mechanism between sibling bat species.

Sustainable Winds: a View on Wind Energy Development and Bats in Mexico

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Wind energy is one of the most important sources for present and future energy world-wide, while being mild to the environment. However, although there have been studies focused on evaluating the actual impact occurring on wild animals, mostly birds and bats, few reports have mentioned the policies for site choosing and wind farms design. The joint effort between our institutions, including NGOs dealing with wildlife conservation, and the Mexico's National Commission on Biodiversity, have initiated the discussion for evaluating the current state-of-the-art about wind energy fields and environmental impacts, as well as proposing steps to consider when a new site is to be chosen. An initial workshop was organized with academic, governmental, and private sectors being represented. Several concerns were identified including both social and environmental issues. The social impact is a delicate issue requiring participants from other agencies with social focus and was set aside. As for the environment, besides the specific faunal problems mainly concerned with birds and bats, the habitat change and landscape modifications were raised as major problems, as well as thee accumulative or synergistic effects from all of those issues. Some activities were proposed to raise awareness in the public, like the assessment of monitoring programs to standardize those to collect the required data to develop conservation proposals, site key environmental elements identification, to build databases with the data on the biodiversity in the regions where major fields are set up, and geographic databases for allowing regional analyses highly windy regions and conservation priorities.

Temporal Variations in the Structure of a Neotropical Dry Forest Bat Assemblage

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Understanding the temporal dynamics of bat assemblages at the local level can inform human actions where they immediately impact bat populations. Such data are also necessary for meta-analyses of the extent of temporal variations for different bat faunas and of their underlying causes. Currently, those comparisons are limited by the scarcity of multi-year studies of bat assemblages. This study explored the stability of the bat fauna over an eight-year period in the Taboga Reserve, a 700 ha dry forest remnant in Costa Rica. The small size of this reserve within an agricultural landscape, combined with its proximity to a potential source habitat, provided conditions that could result in high temporal turnover in the bat fauna. To test this prediction, I analyzed temporal trends in species richness (using analytical rarefaction methods) and composition (rank abundance and species turnover) from biennial surveys of the bat fauna sampled with ground-level mist nets: four surveys (7-8 samples per survey) during dry season and one extensive survey (25 samples) overlapping dry season and early wet season. Twenty-five species were captured (N= 821 bats, inventory completeness 74 – 98%), 13 of which were abundant (≥ 1% of captures). Species richness in dry season surveys ($\overline{S}_{Est}$ = 18.2 $\pm$ 2.9) showed no directional trend over the eight years. Biennial turnover for the 13 abundant species ($\overline{t}$ = 5$\pm$ 1.96%) was lower than their seasonal turnover (13%) and the structure of rank abundance curves were indicative of overall temporal stability in the bat assemblage, possibly favoured by the availability of roosts.

Species Composition and Residency Status of Bats on a Small Island in Lake Huron

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Concepts of island biogeography are useful in studying habitat requirements, understanding dispersal abilities, and informing management decisions regarding spacing and size of conserved habitats. However, few studies of this nature exist for temperate bat species in North America. We investigated bat use of Charity Island, which is located in Saginaw Bay of Lake Huron, the third largest freshwater lake in the world. Although small (90 ha, 12 km from shore), the island has diverse foraging areas including forested corridors, a pond, and open shoreline. Bats would only be expected to commute from the mainland across the open water if they could do so with relative ease, the island offered sufficient foraging opportunities, but was limited in roost availability. We predicted that migratory tree bats with high aspect-ratio wings, such as *Lasiurus borealis* and *L. cinereus*, would be more likely to be commuters and that weaker-flying species, such as *Eptesicus fuscus*, would be the most likely residents. To determine the species composition of the island, we conducted mist netting and passive acoustic monitoring in June and July 2013. We radio tracked bats to determine if they were commuters or residents. We expect to find nightly species composition of the island to be skewed in favor of high-aspect-ratio bats as compared to the mainland, which would indicate willingness to commute longer distances to forage. Additionally, the presence of resident species would indicate that this small island provides the minimum summer habitat requirements for these species.

Cave Environment Influence on the Microbial Symbionts of Four Bat Species

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Bats are a critical component of ecosystems across the globe and are found in a wide variety of environments including man-made structures, caves, and tree roosts. The microbial communities that exist in these habitats can be very diverse and may play a role in the development of the symbiont microbiome of the animal hosts. The influence of environment on the skin-associated microbes of hosts is an under-explored area of research, particularly in wildlife. The aim of this study was to survey the skin microbial populations of four common bat species. Bats and their hibernacula were sampled using a sterile skin swabbing technique in two states within the White Nose Syndrome (WNS) epidemic area. Samples were sequenced with an Illumina Hi-Seq at the University of Colorado-Boulder targeting the 16S rRNA gene, and the microbial community was analyzed with the QIIME bioinformatics pipeline. Cave site is the strongest predictor of the composition of microbes living on bat skin, indicating that the environment has a strong influence on the microbes that colonize bats. Secondarily, there is also a

strong influence of host species identity on shaping the skin microbial communities and bat skin communities are significantly different than the cave surface. These results suggest that it will be important to consider the hibernacula environment of the bat as we progress towards understanding how the WNS pathogen interacts with the host skin community and begin to develop microbial profiling tools for predicting disease risk.

Bat Assemblage Responses to Different Landscape Elements: the Case of Palenque, Chiapas, Mexico

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We evaluated and compared bat species richness among Palenque landscape elements (LE), in Chiapas, Mexico. Palenque Landscape is composed by the tropical evergreen forest within the Palenque National Park (PNP), isolated vegetation fragments, live fences, riparian corridors and induced grasslands. We captured bats for a single night in 129 sites, and we generated cumulative species curves by the rarefaction method. To determine if species richness differed between LE, we performed a Kruskal-Wallis ANOVA. Finally we estimated a dendrogram using the UPGMA method based on the Jaccard´s Similarity Coefficient to explore bat species composition among LE. We recorded 52 species, 16 of which were new records for the area. Rarefaction curves showed that riparian corridors had more species than other LE, but ANOVA indicated that only induced grassland has significant less species ($H=38.78$, $P<0.0001$). The dendrogram showed two clusters, one group contains only the induced grasslands (IJ= 0.27) and the other included the rest of the LE. Within the second group, the PNP (IJ= 0.549) was the least similar, followed by the riparian corridor (Ij= 0.618). Live fences and the isolated vegetation fragments are the most similar LE according to bat composition. Our results indicate that riparian corridors and live fences are key landscape elements for the bat assemblage in Palenque. Its permanence results necessary to guarantee the 42% of the Mexican bats continued presence. We suggest that Palenque region should be considered a priority area for bats conservation in Mexico.

Bat Activities and Bat Fatalities at Different Wind Farms in Northwest Germany

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Northwest Germany is characterized as a flat and relatively open, highly agricultural-used landcape. It is also known for strong winds since it is situated on the coast of the North Sea. This led to a high density of wind farms. We compiled the results of post-construction studies from (at the present, April 2013) 9 wind facilities both at the coast and more inland. The data are part of the evaluation of mitigation meassurements performed by different consulting agencies. In most cases a carcass search with carcass removal trail and search effiency control was conducted. In most of the projects, we recorded the bat activity at the height of the turbine nacelle with Anabat SD1 and SD2 detectors (Titley Electronics, Australia) with one exception, where an Avisoft-System (Avisoft Bioacoustics, Germany) was installed. We compared bat activity and fatality with distance to the coast, structure richness, wind turbine measurements, and assessed whether there was a correlation between bat activity and fatality. Because the sites were situated in different geographical regions, we emphasize differences between wind facility sites. To identify the driving factors of bat activity and bat fatality, we performed a general linear model analysis (GLM). Because the main threatened species in our investigation is *Pipistrellus nathusii* (Nathusius´s bat) we mainly concentrated on this species. Compared to other investigations, we found no clear correlation between bat activity (which is in general comparativly low) and fatality.

Assessing the Impact of Wind Energy Development on Bats

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As concerns over rising costs and long-term environmental impacts from the use of fossil fuels grow, wind energy has become an important sector of the electrical power industry. However, large numbers of bats are killed at utility-scale wind energy facilities and these fatalities raise concerns about cumulative impacts of proposed wind energy development on bat populations. We reviewed bat fatality data from 122 post-construction fatality studies from 73 wind facilities across the U.S. and Canada from 2000-2011. To elucidate regional patterns, we divided the

area into 12 sub-regions. Only five of these sub-regions had fatality data. Fatalities are greatest in the Northeast deciduous forest and Midwest deciduous forest-agricultural regions and lowest in the great basin/southwest region. We estimate that between 650,104 – 1,308,378 bats have been killed in the U.S. and Canada from 2000-2011. Fatalities of 21 species have been found, some of which are already endangered. The majority of fatalities are migratory tree-bats: hoary bats (*Lasiurus cinereus*; 38%), eastern red bats (*L. borealis*; 22%) and silver-haired bats (*Lasionycteris noctivagans*; 18%), although these percentages vary by region and site. For example, little brown bats (*Myotis lucifugus*) make up 60% of fatalities at some sites, but only 6% of fatalities across all regions. Although wind-related fatalities are skewed towards migratory tree-bats, the cumulative impact of turbine-related fatalities for bats, especially cave-hibernating bats, is substantial in light of massive fatalities from white-nose syndrome. Thus, there is an urgent need to mitigate bat fatalities and conserve populations in a proactive and science-based manner.

Simplifying a Wing: Diversity and Functional Consequences of Reducing Joints in Bat Wings

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Bat wings, like the skeletons of other mammalian limbs, contain many joints within the digits. These joints collectively affect dynamic 3D wing shape, thereby affecting the amount of aerodynamic force a wing can generate. Bats are a speciose group, and show substantial variation in the number of wing joints. Additionally, some bat species have joints with extensor but not flexor muscles. While numerous studies have examined the diversity in number of joints and presence of muscles, musculoskeletal variation in the digits has not been interpreted in phylogenetic, functional, or ecological contexts. To provide this context, we quantify the number of joints and the presence/absence of muscles for 44 bat species, and map them phylogenetically. We show that, relative to the ancestral state, joints and muscles were lost and regained multiple times in many lineages and on different digits. Comparison of species with contrasting feeding ecologies demonstrates that those that feed primarily on non-mobile food (e.g. fruit) have fewer fully active joints than species that catch mobile prey (e.g. insects). We hypothesize a functional tradeoff between energetic savings and maneuverability. Having fewer joints reduces the mass of the wing, thereby reducing the energetic requirements of flapping flight. The presence of more joints increases the spectrum of possible 3D wing shapes, potentially enhancing the range and fine control of aerodynamic force production and maneuverability.

Coding of Spatial Frequency in Bat Biosonar

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In visual neural processing, organisms extract both temporal and spatial frequency, the latter of which is used to distinguish abrupt spatial changes such as edges, as well as more global information about an object's shape. Echolocating animals possess the unique ability to perceive their environment via the auditory analyses of the echoes of self-generated sounds. However, it is unclear whether echolocating bats also extract spatial-frequency information to do so. We hypothesize that echolocating bats can indeed analyze spatial frequencies and specifically, they apply a high-pass filter in order to find (high-spatial-frequency) prey items before a (low-spatial-frequency) background. We address this question using a two-alternative, forced-choice design in *Phyllostomus discolor*. We test whether bats are able to discriminate target discs, patterned with sinusoidal spherical waves of differing spatial frequency and modulation depth, from a flat reference disc. Additionally, the bats' echolocation calls and flight path are recorded to elucidate any behavioural adaptations the bats might use in order to solve the task. We expect the results of this experiment to reveal whether bats are capable of processing spatial frequency and to what threshold this can be done by *P. discolor*. This is the first step to help us understand whether bats are able to code spatial frequencies with an auditory system whose sensory epithelium is, unlike in vision, not arranged along spatial dimensions.

Ecological Correlates of Coronavirus Dynamics in West African Bats

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Bats are important reservoir hosts to a number of emerging viruses, including SARS-coronavirus (CoV), Hendra and Nipah viruses, as well as Ebola and Marburg viruses. These pathogens can cause problems for public health, animal industries, and wildlife conservation. To minimize the risk of future epidemics, knowledge about the reservoir hosts is required. We need to understand how ecological factors may influence disease dynamics and drive host-switching and emergence. While numerous studies have aimed at discovery of novel infectious diseases in bat populations, little research has examined the role of host ecology on pathogen dynamics and diversity. We investigated the influence of host phenology and demography on the dynamics and diversity of CoVs in West African cave-dwelling bats. We screened 7,000 bat faecal samples from 15 species, collected regularly over two years at ten bat colonies in Ghana, for CoVs. Four CoV lineages were quantitatively detected using highly sensitive strain-specific real time RT-PCR assays. Here, we report on results on host demographic, phenological and seasonal influences on infection dynamics. Preliminary findings suggest that CoVs were preferentially carried by juvenile bats and lactating females, corresponding to seasonal spikes in virus amplification once per year linked to bat reproductive cycles. These data may imply the potential of host colonies as settings conducive to host-switching events. In sub-Saharan Africa, where bat-human contact is relatively high, these kinds of ecological insights to the study of emerging diseases are crucial to inform decisions about management, conservation and mitigating potential threats to human public health.

Fruit Secondary Compounds Mediate the Retention Time of Seeds in the Guts of *Carollia perspicillata*

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Plants often recruit frugivorous animals to transport their seeds, however gut passage can have varying effects on plant fitness depending on both the physical and chemical treatment of the seed and the specific site of deposition. In particular, the gut retention time (GRT) of seeds is likely to be a key factor in seed dispersal effectiveness. One way in which plants can mediate the effects of gut passage on fitness is by producing fruit secondary compounds that influence GRT. Using frugivorous bats (*Carollia perspicillata*: Phyllostomidae) and Neotropical plants in the genus *Piper* (*P. colonense*, *P. peltatum*, *P. reticulatum*, *P. sancti-felicis*, and *P. silvivagum*), we investigated the role of fruit amide-alkaloids (piperine, piplartine and whole fruit amide extracts from *P. reticulatum*) in mediating gut retention time. Piplartine and *P. reticulatum* amide extracts decreased GRT, while piperine had no effect. In addition, GRT had species-specific influences on the germination success of seeds raised in laboratory conditions. *Piper* amides have primarily been studied in the context of their defensive role against herbivores and pathogens, but may also play a key role in mediating seed dispersal interactions.

Changes in Roosting Behaviour of Hibernating *Myotis lucifugus* Inoculated with *Geomyces destructans*

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Pathogens and parasites can change the behaviour of hosts and, in the case of white-nose syndrome (WNS), understanding changes in behaviour of bats infected with *Geomyces destructans* (*Gd*) could be important for management. Infection with *Gd* appears to cause reduced clustering behaviour in some of the affected species which leads to two possible hypotheses: 1) Bats cluster less because it improves individual survival (e.g., by reducing energetic costs or affecting local microclimate to slow fungal growth; or 2) Bats cluster less to reduce pathogen transmission. The first hypothesis predicts that individual bats, which cluster less, should exhibit reduced severity of clinical signs and increased survival. We evaluated this prediction by examining video recordings of captive, hibernating little brown bats. Bats were outfitted with temperature and humidity controlled incubators for the winter. Their behaviours were recorded by motion-activated cameras during periodic arousals from torpor. After several

months in hibernation, wing tissue samples were obtained from infected and control bats and scored to provide a measure of disease severity. The roosting positions of each individual were recorded after each arousal throughout the duration of the study for each individual. Our results indicate that bats infected with *Gd* reduce clustering but we found no evidence of a relationship between reduced clustering by individuals and severity of disease. Thus we found no support for the hypothesis that behavioural changes of infected bats provide a survival benefit. Altered clustering could, therefore, reflect a behavioural mechanism to reduce pathogen transmission, similar to behaviours that occur in other wildlife diseases. Further studies of wild and captive bats are needed to understand the role of behaviour in transmission of *Gd.*

Life-history Traits of Bat Species at Risk from White-nose Syndrome and Histopathologic Fndings in Multiple European Bat Species

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Despite pan-European distribution of *Geomyces destructans*, mass mortality has not been observed in hibernating bats in Europe. Dermatohistopathology, however, revealed fungal infection with cupping erosions and skin invasion diagnostic for white-nose syndrome (WNS) in a *Myotis myotis* specimen hibernating in the Moravian Karst, Czech Republic and eight bat species have already been reported positive for the WNS fungus in Europe. The objective of this study was to examine life-history traits of European bat species reported positive for *G. destructans* and identify other bat species at risk. To do so, we explored life-history traits linked with hibernation to group bat species with similar characteristics, and proposed a model of species-specific potential for infection. Then, we verified the prediction model by screening species with unknown infection status in Czech hibernacula**.** Over two hundred specimens of 14 bat species were monitored for the WNS and its causative agent *G. destructans* in the Czech Republic in spring 2012 and 2013. Sampling procedures employed to screen bats for WNS and *G. destructans* included punch biopsy of WNS-suspected skin lesions, skin swabs for fungal culture and polymerase chain reaction, and histopathologic examination of skin samples. We provide evidence on multiple species positive for the WNS diagnostic features on histopathology. Importantly, the broadening spectrum of affected species may have implications for the current knowledge on the epidemiology of this fungal disease.

Community Structure of Aerial Insectivorous Bats of External Areas of Barro Colorado Island Monument, Panamá

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Aerial insectivorous bats are almost half of the community of neotropical species. They contribute to pests control and herbivory reduction. They use echolocation to find their prey. Through acoustic sampling we assessed the structure of aerial insectivorous bats in four microhabitats (upper and lower forest edge and upper and lower open space) in external areas of Barro Colorado Monument. Seven sites were chosen for sampling, each was visited four times, and bat recordings were made for 4 consecutive hours. We found differences in the structure of the communities foraging in different microhabitats, and a tendency of certain species to be associated with certain microhabitats. Species with preference for the forest edge showed sharper echolocation calls of short duration, short pulse intervals and a combination of components of FM (frequency modulation) and QCF (quasi-constant frequency) (e.g. *Saccopteryx bilineata*). Species that showed a preference for open space have echolocation calls with lower frequency, long duration, long pulse intervals QCF components combined with FM (e.g. *Noctilio leporinus*). Differences between both cases are due to the foraging strategy, where some bats prefer the upper and other the lower parts of the space. This result provides important information to the knowledge of resource partitioning in aerial insectivorous bat communities. It also shows that the use of acoustic techniques is essential to raise awareness about this bat group and improve conservation strategies that include these species and the habitats they use.

It is Time to Stop Counting Bat Fatalities per Wind Turbine

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Bats of various species are killed at many wind facilities around the world. There are also data and estimates that suggest that this is having, or is likely to have, an effect on the stability of populations of at least some species. In response, some jurisdictions have instituted fatality thresholds that trigger mitigation actions. These are always based on the number of bats killed per turbine and are set based on prevailing fatality rates, or some apparently arbitrary number. Using the analogy of wildlife management, I argue that basing management of bat populations on fatalities/turbine ignores cumulative effects, population boundaries, and the increasing number of turbines. Despite the fact that all previous studies have measured the potential impact of wind turbines in terms of fatalities per turbine, or per megawatt, I suggest this needs to be abandoned in favour of fatality density (number per area), or regional cumulative estimates and thresholds, and that thresholds need to change as the number of turbines in a region increases. It is the total number of bats killed per population that is important for effective management. This will require an understanding of population boundaries and sizes, basic information that we currently lack.

The State of the UK's Bats: What Have We Learnt from the National Bat Monitoring Programme?

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Assessing change in species populations is an essential tool for bat conservation. As bats are important as bioindicators, effective monitoring of their populations also makes an important contribution to our understanding of the wider impacts of environmental change on biodiversity. The UK's National Bat Monitoring Programme (NBMP) was established in 1996 to assess the status and underpin the conservation of the UK's bat species through its contribution to government reporting on population trends and biodiversity indicators. It is a citizen science programme with surveys designed for volunteers to gather data using simple standardised methods across large numbers of sites. The NBMP uses three main survey methods to monitor bat populations: counts at summer maternity roosts, counts at winter hibernation sites and bat detector surveys in the field. A Generalised Additive Model framework is used to determine population trends over time. There is now sufficient coverage to estimate population trends for 10 species (or species groups), and 8 of these are surveyed by more than one method. All 10 species or species groups show either stable or increasing population trends from at least one survey in the 15 year period from 1997 to 2011. The direction of trends from different survey methods do not correspond for all species, however, highlighting the importance of using more than one survey method in an integrated approach to bat monitoring. We showcase some of the results and lessons learned from one of the best known citizen science surveillance programmes for bats.

Modeling Species Distributions Among Peripheral Populations In North Dakota

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Understanding the biotic and abiotic factors that drive the distribution of a species, especially among peripheral populations, is of fundamental importance for many conservation issues. Novel environments near the edge of a species distribution are often different and more challenging than those at the center of the distribution (Brown 1984). Peripheral populations can be of great importance, as selection pressures may have shaped these populations differently from other central areas of the distribution (Garcia-Romos and Kirkpatrick 1997). Unfortunately, distribution maps are often too simplistic, lacking information on peripheral and "island" populations that are outside of the continuous distribution. Such studies are especially important given the predicted impacts of global climate change on species distributions. We conducted a survey throughout North Dakota to assess the current distribution of bats, with emphasis on seven species whose distributions intersect the geographic boundaries of the state. We found 11 bats species resident during the summer months in North Dakota, including documentation of 2 species that were significantly outside their current IUCN distributions. Using maximum-entropy modeling, which allows for predictive modeling of a species distribution using environmental variables of known presence sites, we developed multiple habitat probability maps that provide much greater detail about the location of bat "hotspots" throughout the state. Also, maximum-entropy modeling can provide insight into what ecological factors

drive the range distributions of bats in the northern plains of the United States. These maps will be of use to state managers as they develop and employ a state-wide conservation action plan.

Key Areas for Bat Conservation in Latin America and the Caribbean (AICOM's and SICOM's)

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Latin America harbors a vast diversity of ecosystems, several of them currently considered as biodiversity hotspots, with high number of species and endemism's. Since its creation, and today including the joint efforts of 19 countries in the region, the Latin American Bat Conservation Network (RELCOM) has been worried for the conservation of the bats of the region and, in order to diminish the extinction of species and their related ecosystem services, has stimulated the recognition of sites containing threatened species, as a good measure of conservation. We promoted the creation in the region of a network of Key Areas for Bat Conservation in Latinamerica and the Caribbean, each area named as AICOM or SICOM, to include Areas and Sites, respectively, to serve as conservation units. Until now, and since the beginning of the project in 2011, we have recognized, or are in the process of recognition, 18 AICOMs and nine SICOMs, for seven countries of South America and the Caribbean (Argentina, Bolivia, Bonaire, Cuba, Ecuador, Paraguay and Venezuela). These areas include 105 species, and its recognition by RELCOM represents a tool that can be used for legal actions on behalf of the conservation of the sites and the species. We believe that increasing the number of areas recognized by RELCOM will be responsible for a wide and efficient network of conservation sites in Latin America and the Caribbean.

Reproductive Biology and Seasonal Dynamics of Spatial Activity of *Rousettus aegyptiacus* in the Eastern Mediterranean

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Reproductive cycle of *Rousettus aegyptiacus* has been intensively studied in the years 2005 –2012. We analyzed the data from two regions corresponding to two types of environment (biomes): the zone of continuous distribution in the Levant (Turkey, Cyprus, Lebanon, Jordan – 1285 individuals, 429 adult females) and an isolated population of *R. aegyptiacus* in the Dakhla Oasis, Egypt (2315 individuals,529 females). Seasonal dynamics of reproduction in both regions showed similar patterns. Females gave birth during most of the year except in winter months. In both regions, the timing of reproduction had peaks in April – May and August – September, the spring peak was more pronounced. This pattern comports with a seasonal polyestry, a typical reproductive strategy of bats in tropical regions. With this exception, however, polyestry is unknown in bats from temperate regions. In the same areas 240 individuals (43 bats in Cyprus, 131 in Egypt and 66 in Turkey) were followed using the automated radiotracking system, BAARA, manual tracking, and GPS transponders (in total 230,000 fixis). In Egypt and Turkey the vast majority of tracked individuals preferred foraging grounds close to major roosts (as well as preference for their own individually specific feeding sites), while in Cyprus bats visited food sources 20 km from roosts. Low spatial activity was correlated with limited capacity of food resources and regular use of individually specific foraging grounds. While areas with diverse and rich food resources, local spatial activity increased significantly.

Automatic Echolocation Call Identification in Europe vs. the Neotropics: More Species Does Not Mean More Difficult

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The development of long duration and high sampling rate unattended recordings has drastically increased our sampling efficiency. However, the use of such data is limited by the amount of time necessary for the analysis, often much greater than the time spent in the field. To circumvent this problem, we developed a new automatic identification tool, named SonoChiro© based on random forest classification, accurate -noise filtering and an intensive learning process. Model fits were progressively improved when compared to more than 10 million calls of

34 European and 80 Neotropical species. We then were able to use these experiences in two very different contexts to compare error rates on both continents and to investigate levels of similarity in echolocation calls within and between species. Standardizing training level, results showed a lower error rate in Neotropics despite higher species richness. Neotropical species also differ from European species by having higher dissimilarity between species and by a lower intraspecific variability. Thus, there is both (i) a more intensive acoustic niche differentiation between species and (ii) a larger number of available ecological niches. These two mechanisms induce much less overlap between species in echolocation characteristics and explains why automatic identification of Neotropical bats is relatively accurate .

Evidence for Ecologically Mediated Perception of Species Specific Signatures in Echolocation Calls of the same Peak Frequency

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Rhinolophus capensis uses peak echolocation frequencies which range from 75 kHz at one end of its coastal distribution in South Africa to 85 kHz at the other end. We tested whether peak frequency was the only acoustic parameter used to discriminate between conspecifics and other species. In habituation-dishabituation playback experiments we exposed 75-kHz and 85-kHz *R. capensis* individuals to a set of acoustic test stimuli each consisting of echolocation calls of the same peak frequency namely *R. capensis* calling at 85 kHz and another species, *R. damarensis*, calling also at 85 kHz. The two test groups differed in their behavioural responses to the test stimuli. The 85-kHz group discriminated between calls from conspecifics (85 kHz) and calls from *R. damarensis* (85 kHz) despite both stimuli having the same peak frequency. This indicates that other components besides peak frequency may contain species specific signatures. In contrast, the 75-kHz test group did not discriminate 85-kHz *R. capensis* from 85-kHz *R. damarensis.* This group is isolated from other *R. capensis* populations but co-occurs with *R. damarensis* and, in its habitat, 85-kHz calls likely represent another species. Furthermore, the 85-kHz *R. capensis* co-occurs with *R. clivosus*, the juveniles of which use similar echolocation frequencies of about 88 kHz and it has to regularly use other acoustic cues to avoid making recognition errors. We discuss our findings in the context of a multilayer recognition system which is required in the presence of other species using similar frequencies.

The North American Bat Conservation Alliance: Finding Our New Direction

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Although the bat conservation network in North America was one of the first to formalize its relationships, our coordinated efforts have varied in structure and effectiveness over the years. Canada, Mexico and the US all have dedicated biologists and local networks (regions or states) operating effectively to respond to localized priorities. However, the international network between these three countries has been inactive for many years. The early coordinated North American network faltered for a number of reasons, but we are currently launching an effort to revitalize this network and establish clear priorities and goals to address bat conservation challenges that warrant our combined attention. We are working under a new draft charter, developed during a 2008 meeting in Tucson, Arizona, and are taking steps to develop a functioning team with working objectives, key deliverables, and a specific mandate. Independent of an overarching network, several important collaborations are moving forward including the development of a North American bat monitoring effort and a multinational response to White-nose Syndrome. While these efforts will continue, we believe a coordinated and effective North American Bat Conservation Alliance would add value by enhancing cooperation and consideration of the full suite of concerns, threats and issues facing bats in North America. The alliance would help to establish continental bat conservation priorities and encourage efforts to address priorities that are not already being considered. It could also help elevate bat conservation in other existing conservation partnerships between our three countries and generate support and funding for critical projects.

Shifts in Physiological and Behavioral Mechanisms Let Bats Balance the Need to Feed and the Urge to Breed

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Bats use behavioral (change in activity patterns or in ingested energy) and physiological (torpor, metabolic compensation, and/or variability in digestive efficiency), mutually nonexclusive mechanisms to balance their energy budget. As small and actively flying mammals, bats have a high energy demand relative to body mass; therefore, balancing mechanisms should be pronounced in this group. Since the energy budgets of bats exhibit seasonal changes, the combination and use of different mechanisms could vary during times of high and low energy demand. Using a combination of flow-through respirometry, temperature telemetry and behavioral observations in free-flying bats, we found that male *Myotis daubentonii* exhibited marked variation in the relative importance of these different mechanisms during their period of seasonal activity in response to extrinsic (ambient temperature, insect abundance) and intrinsic (reproduction, body condition) factors. Cold ambient temperatures in spring facilitated long and frequent daily torpor bouts, whereas in early summer increased energy intake was the dominant factor in energy balancing. Intake was further increased in late summer, when insect abundance was highest, and daily torpor bouts were shorter and less frequent than in early summer. In autumn, males used metabolic compensation to reduce their resting metabolic rate in addition to daily torpor. Metabolic compensation might be one of the mechanisms that allow males to maintain high body temperature during the day while decreasing the need for foraging time at night, thus maximizing their opportunities to mate.

Bat-friendly Operation Algorithms: Reducing Bat Fatalities at Wind Turbines in Central Europe

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We developed 'bat-friendly' operational algorithms to reduce bat collision risk at wind turbines in Central Europe. The method we propose includes standardized data acquisition and analysis, risk assessment, and calculation of cut-in wind speeds that differ with the turbine-specific level of bat activity, month and time of night. During times of high collision risk, rotors are stopped to avoid bat fatalities. Bat-friendly algorithms were run in an experimental set-up at 16 wind turbines at 8 sites (2 turbines each) in 4 different geographical regions in Germany and at 2 turbines at one site in France. The two turbines within each site were operated with and without algorithms in alternating one-week intervals from July to September 2012. All turbines in the experiment were equipped with at least 2 of 3 different acoustic detectors at the nacelle (Anabat SD1, Avisoft USG, and Batcorder). Acoustic detectors sampled acoustic bat activity continuously during the night. Additionally, the area under the turbines was searched for animal fatalities each day during the experiment. Based on the fatality data we will draw conclusions on the effectiveness of algorithms (loss in revenue per reduction in bat fatality) and on the total cost of their implementation. We will compare the number of bat fatalities predicted for the specific operational algorithm to the number of carcasses found after correcting for search biases. Finally, and most importantly we will develop guidelines and practical examples for the quantification and mitigation of bat fatalities using bat-friendly operation of wind turbines in Central Europe.

Site-specific Wind Turbine Curtailment Has its Advantages

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As wind energy is a rapidly growing industry, there is increasing pressure on developers to minimize the impacts on bats. With large numbers of bat fatalities reported at wind facilities globally, robust predictive models are needed to provide insights into when and where particular species or group of individuals are most vulnerable to wind-turbine collisions. Bat activity is highest during periods of relatively low-wind speeds, and recent research demonstrates that raising the cut-in speeds at which turbines generate electricity can effectively reduce bat-turbine collisions. We analyzed fatality and weather data from a north-central Texas wind facility in 2009 and 2010, and found that a combination of wind speed and direction best predicted bat fatality. From our findings, we developed a

curtailment strategy to test against the wind speed-only strategy that has been implemented at other facilities. Thus, in 2011 and 2012, 30 wind turbines at our facility were included in a curtailment experiment: 10 were controls with 3 m/s cut-in speeds, 10 had 5 m/s cut-in speeds, and 10 had cut-in speeds that varied from 3 to 6.5 m/s depending on wind direction. A severe drought in 2011 reduced fatalities 10 to 20 times below previous years, and subsequently we found no difference among treatments. Nevertheless, in 2012 both curtailment strategies reduced fatality by ~50% compared to controls, but our site-specific strategy reduced fatalities by a further ~50%. These findings should be used to develop clearer guidelines for operating procedures that may lead to more effective curtailment strategies.

Plasticity in Thermoregulatory Behavior May Provide the Endangered *Myotis sodalis* a Buffer Against Climate Change

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Due to climate change, the endangered Indiana bat (*Myotis sodalis*) is predicted to be extirpated from its core distribution within the next decade. However, the Indiana bat may be able to adapt to climate change through plasticity in thermoregulatory behavior. We hypothesize that Indiana bats are flexible in use of torpor and selection of roost microclimates in response to weather conditions and climate. During previous work in central Indiana, USA, we observed that Indiana bats move between a variety of types of summer roosts. Additionally, for Indiana bats in the Southeast, use of torpor coincides with changes in air temperature. We will investigate the flexibility of thermoregulatory behaviors simultaneously within a population of Indiana bats located in central Indiana during the summers of 2013-2015. Using skin-temperature-sensitive radio transmitters, we will determine the daily body temperatures of adult female Indiana bats and track them to their roosts, where we will record roost characteristics. We will also employ temperature data loggers and ambient-temperature transmitters to record internal roost temperatures. We will record local climate conditions using weather stations distributed throughout the landscape. We will conduct mixed linear models to determine if roost characteristics and behavior, climate, and weather conditions affect use of torpor. With logistic regression models, we will determine if weather conditions and climate affect bats' selection of roosts. Our analyses should provide additional insights into the effects of climate change on Indiana bats and may provide further evidence of phenotypic plasticity's ability to buffer these effects in vertebrates.

Changes in Winter Activity of Bats in the Great Smoky Mountains National Park, Tennessee, Due to White-nose Syndrome

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The White-nose syndrome (WNS) epizootic, characterized by the psychrophilic fungus *Geomyces destructans* (Gd), has caused unprecedented mortality of hibernating bats throughout the Northeastern United States. Gd was first recorded in the Great Smoky Mountains National Park (GSMNP) during winter 2009/2010 and bats were confirmed WNS positive in winter 2011/2012. By January 2013, Park rangers began receiving numerous reports regarding daytime activity of bats within the Park, including contact with a Park visitor. The goal of this research is to evaluate possible behavioral changes of bats during winter hibernation following progression of WNS. We hypothesize that WNS affected caves in southern latitudes may experience delayed mortality due to warmer ambient temperatures during hibernation. Using ultrasonic detectors and temperature data we have established that bats in GSMNP are active throughout the winter. Bat calls were recorded during each acoustic survey night (140 sample nights) regardless of low nightly temperatures. By year three of WNS confirmation, we see a significant increase in activity levels during two of the coldest months of the year (January: t-ratio -4.36, $p < 0.000$ and March: t-ratio 2.7, $p < 0.011$), suggesting a time lag in mortality due to WNS when compared to affected regions in the Northeast. Although we have documented this trend in GSMNP, we have yet to see a precipitous change in winter activity levels of bats at other caves in Tennessee.

Reproductive Biology of the Female Bat, *Artibeus lituratus* (Olfers, 1818) (Phyllostomidae): a Histomorphological Approach

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Few studies of neotropical bats address the reproductive biology using histomorphology as a methodological approach in population. This paper describes the histomorphology of the reproductive system of *Artibeus lituratus* females, at the population level. The population was studied during the second semester of 2008, in Belén de Umbría (Risaralda – Colombia). We obtained 25 reproductive tracts of *A.lituratus*, which were processed histochemically with Hematoxylin-Eosin, Masson's Trichrome and PAS. The results were compared with reproductive information collected in the field. We found an anatomical and histological organization similar to that of humans. In *A. lituratus* the oviduct is a tubular and rolled up organ, composed by three-tissue layers: serosa, muscularis, and mucosa through the light. The uterus is simple, tubular, and pear-shaped. It is histologically composed by parametrium, external, myometrium and endometrium into the light, with a changing glandular organization, depending on the ovarian cycle phase. We observed higher levels of ovarian folliculogenesis in one of the ovaries, suggesting ovarian alternation. There were 15 pregnant females, in which we found four embryos (E13, E17, E19) and eleven early implantations (E6 to E9). Gestation probably started in July and births occurred between September-October. The evidence also suggests that the subsequent implantations are due to postpartum oestrus. We report that 50% of the pregnant females were not detected by traditional methods, evidencing the inaccuracy of such techniques and a possible underestimation of some demographic parameters. The population was stable and the reproduction period occurred during the fructification season.

Seeing in the Dark--an Analysis of Bat Flight through Stereographic Infrared Videography

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We have used stereographic infrared videography to record Brazilian free-tailed bats and Cave Myotis in California, Massachusetts, New Mexico, and Texas, and analyze their flight paths. This required the development of a collection of procedures for field work and video analysis. We present guidelines of camera setup and calibration procedures in the field. We then discuss our methods for processing the recorded videos, which can be divided into three categories. First, the parameters are computed that describe the geometry of the scene by manually annotating points in the scene, on a calibration device, and on the animals. Computer vision techniques are then applied to estimate the flight paths of the bats. These include detection of individual bats in each camera view, reconstruction of their positions in three-dimensional space, and tracking. Finally, flight behavior can be analyzed based on the estimated paths.

Circum-Mediterranean Phylogeography of a Bat Coupled with Past Environmental Niche Modelling: a New Paradigm for the Recolonization of Europe?

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The isolation of populations in the Iberian, the Italian and the Balkan peninsulas during the ice ages define four main paradigms that explain the distribution of intraspecific genetic diversity in Europe, though not without exceptions. In this study we investigated the phylogeography of a wide-spread bat species, the bent-winged bat,

Miniopterus schreibersii around the Mediterranean basin and the Caucasus. Samples were collected from 28 new locations in 14 countries, and combined with previous data from four countries. We also undertook an environmental niche modeling (ENM) analysis, for predicting the current and past continental distribution of the species during the last glacial maximum (LGM). The genetics results indicate that populations of *M. schreibersii* in Europe went extinct and the continent was repopulated from Anatolia after the end of the LGM. The data show signatures of a gradual geographic expansion, as well as philopatric distributions of individual populations. In the Maghrebian region of North Africa, there is evidence for the presence of a new *Miniopterus* species (*Miniopterus maghrebensis*) occurring sympatrically with the nominotypic form, which we describe here for the first time. However, the fossil record in Iberia and the ENM results indicate continuous presence of *Miniopterus* in this peninsula that most probably was related to the Mahgrebian lineage during the LGM, but did not persist after the LGM. Combined with similar results from previous studies, we define a new paradigm that involves the recolonization of all of Europe from Anatolia. The study shows how genetics and ENM approaches can complement each other in providing a more detailed picture of intraspecific evolution of species.

Bats Across Biomes: Bat Response to Flooding Frequency Across a Large Semi-arid Floodplain System

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Australia's Murray-Darling basin is among the world's most threatened river systems, and also one of the largest semi-arid drainage basins at over 1 million square kilometres. Floodplain ecosystems within the basin are rapidly being lost due to increasing land clearing and water extraction for agricultural irrigation. Due to the interconnected nature of the basin's freshwater systems the management of the region's water and natural resources require knowledge of broad ecological processes and organisms. Bats play a key role in both aquatic and terrestrial foodwebs, yet ecologists currently have a very poor understanding of how bat communities respond to floodplain dynamics. To provide guidance for future conservation strategies in the region, we conducted a large-scale survey of bat activity in the Murray-Darling basin, with the aim of determining the importance of floodplain habitats for bats. We used systematic acoustic surveys during 2011 to measure overall bat activity, foraging activity, species richness and community composition for 7 habitat types within 7 large freshwater wetland systems. Habitat types were selected to represent a flooding frequency gradient and a range of vegetation structures. Overall, 140,000 Anabat files were recorded from 195 sampling nights. Preliminary analyses indicate that overall activity, foraging activity and species richness was higher in frequently flooded treed habitats. Within open habitats, overall activity was similar between agricultural and open wetland habitats, but foraging activity was higher over open wetland. These results indicate that bat communities respond to flooding frequency at the landscape scale, with important implications for floodplain natural resource management.

Bats of the Cordillera del Cóndor in Ecuador with the Discovery of a New Species of *Sturnira*

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An evaluation of the diversity, abundance and conservation status of bats was conducted in two localities at the Cordillera del Cóndor, southeastern Ecuador. The study area was in the Nangaritza River Basin, specifically in the The Tepuyes Conservation Area. The localities chosen for the field work were: Miazi Alto (among 1 256 and 1 430 meters) and in the Tepuyes forest (among 1 200 and 1 850 meters). We registered 18 species belonging only to the family Phyllostomidae. We captured 93 specimens; the most abundant species was *Dermanura glauca*. From the 18 species, only eight were shared by the two localities. Four species are within any category of threat (22.2% of the total reported). Additionally, we reviewed previous studies in the area. With this data, we present a complete list of bat species that have been recorded in the Cordillera del Cóndor. As a noteworthy record, we registered a new species corresponding to genus *Sturnira*, subgenus *Corvira*. Seven specimens collected from the new form of *Sturnira* were examined and in addition 19 specimens of *S. bidens* (n = 15) and *S. nana* (n = 4) were included for morphometric comparisons. For the molecular analyses, the complete cytochrome-b (1140 bp) was amplified by polymerase chain reactions. Phylogenetic analyses were performed using Maximum parsimony (MP), Maximum likelihood (ML) and Bayesian inference (BI). Species differentiation was supported by a Multivariate analysis of variance (MANOVA) test (Wilks' $\lambda = 0.008$, $F8, 42 = 53.1$, $P = 0.001$).

Singing Isn't Just for the Birds

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Birdsong has served as the primary model for studying the evolution, ecology and neural basis of complex vocal behavior. Birdsong is also a prominent model for human speech because of its complexity and flexibility- it has variable syntax, hierarchical organization and is vocally learned. Most mammals, on the other hand produce rather simple monosyllabic vocalizations that lack the hierarchical organization and flexibility of birdsong. This key behavioral distinction has been attributed to the general absence of a neural substrate supporting vocal plasticity in mammals that is present in both songbirds and humans. Cetaceans and bats may be exceptional since both groups have evolved a suite of neural specializations to support echolocation. They are the only two groups of mammals that demonstrate vocal learning, juvenile babbling, and regional dialects. Recent research has shown that some bat species sing like birds, producing elaborate songs that vary with social context. Using two species as models, *Saccopteryx bilineata* and *Tadarida brasiliensis*, remarkable similarities are found between bird and bat songs. These parallels suggest significant evolutionary convergence of production modes, neurobiological mechanisms, and ecological selection pressures between bird and bat songs. Future research on the neurobiology and evolution of vocal complexity in bats, especially those that "sing like birds", would greatly augment our current avian models of vocal behavior and human speech.

Phytophagous Bats Response to Local and Landscape Characteristics in Fragmented Tropical Semi-deciduous Forest in Mexico

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Fragmentation reduces the amount of forest cover available for wildlife at the landscape level, but also has negative effects on patch quality at the local level. The simultaneous analysis of local and landscape attributes is important when we evaluate the use of remnant habitats by bats in fragmented landscapes. In Yucatan, Mexico we analyzed how seven parameters of vegetation structure (local level) and eight landscape attributes influenced the phytophagous bats abundance in two landscapes with different matrices: a) pasture and b) tropical semi-deciduous forest (TSDF). Four sampling sites were located in forest fragments in a pasture matrix and four sites in large tracts of continuous TSDF. In each type of matrix sampling was performed in two sites with a cenote (water filled sink-holes) and two without cenote to evaluate the local differences between vegetation surrounding cenotes (more and larger trees of species eaten by bats), and vegetation without them. Phytophagous bat abundance was negatively correlated with percentage of forest cover and mean proximity index of the TSDF matrix and positively correlated with the edge density, patch density and landscape heterogeneity of the pasture matrix. Bat abundance was positively correlated with plant richness and basal area of edible tree species. In the agricultural landscapes of Yucatan, the amount and spatial distribution of forest remnants are not the only important variables affecting how bats respond to fragmentation, patch quality (local level) and high heterogeneity of land cover types (landscape level) have also a crucial effect on phytophagous bats abundance in fragmented landscapes.

Echolocation in Non-echolocating bats

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Since the early days of research on echolocation, the widely held view is that old world fruit bats (Pteropodidae) do not use echolocation and rely on highly sensitive night vision. The only exception was the genus *Rousettu*s whose members use a "strange" form of clicking echolocation. The non-echolocation dogma was also the basis for dozens of studies attempting to explain the evolution of echolocation. Here, we challenge this dogma.We conducted a study on the possible use of echolocation in Pteropodidae and found that all genera we tested (*Eonycteris*, *Cynopterus* and *Macroglossus*) do in fact produce short high frequency click-like sounds that are probably used for echolocation. All bats dramatically increased (4 folds) the number of clicks per time unit in darkness compared to a light condition. While emitting these clicks, bats were able to orient in a completely dark room ($<10^{-4}$ lux), avoiding 1 cm diameter wires and landing on a feeding platform. Moreover, several individuals

whose eyes were covered produced even more clicks and were still able to perform these tasks. We are currently investigating the sound production mechanism and comparing the clicks to those of the better studied Rousettus-genus. We are convinced that more bats from the Pteropodidae family produce echolocation clicks. The use of echolocation by bats formerly believed to be non-echolocators may completely revise our understanding of the evolution of echolocation and of the difficulty of evolving such a trait.

Bats without Bad Teeth – Low Percentage of Dental Caries in the Neotropical Frugivorous Bat *Artibeus jamaicensis*

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Dental caries is a widespread disease which affects humans as well as many other mammals. The Jamaican Fruit Bat *Artibeus jamaicensis* (Chiroptera: Phyllostomidae) shows remarkably low prevalence of dental caries despite a diet composed exclusively from sugar-rich fruits. To find explanations we conducted an interdisciplinary study including ecological, microbiological, dental, and microscopic techniques. Bats were captured on Barro Colorado Island (Panama). Only seven out of 434 captured *A. jamaicensis* were affected by dental caries. Dental inspections and staining revealed very low incidence of dental plaque. Only 0.9 % of all surveyed surfaces showed dental plaque, notoriously less than in humans. However, a genetic survey of 16S rDNA fragments via 454 - Pyrosequencing sampled from the bats´ oral cavity revealed a range of plaque-forming and potentially cariogenic bacteria, largely overlapping with those from humans. The presence of potentially cariogenic bacteria indicates that there are no substances in the saliva of bats inhibiting bacterial growth. Teeth were compared to human teeth in using advanced microscopic techniques. Bat teeth showed a distinct surface structure in the micrometre and nanometre scale comparable to self-cleaning surfaces. The enamel layer was remarkably thin and the hydroxyapatite crystals were tightly packed. The enamel layer represented only 20 % of the total hard tissue and lacked pores. Hence bat teeth architecture differed remarkably from that of human teeth. Our results suggest that the lower caries incidence in *A. jamaicensis* may be related to the particular surface texture of bat teeth, despite the presence of various potential cariogenic bacteria.

Effects of Bats on Pecan Nut Casebearer Moths and Nut Damage in Pecan Agroecosystems in Texas

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In our research we've found that pecan orchards serve as attractive habitat for bats in central Texas and that five species of bats prey upon pecan nut casebearer (PNC) moths, which are devastating pests of pecans. However, there is significant spatial and seasonal variation in both bat and PNC activity, and it is unknown if predation on PNC by bats translates to quantifiable downstream effects. To evaluate the impact of bats, it is necessary to establish links between the presence of bats, abundance of PNC and degree of larval damage to pecans. In this study, we used the natural heterogeneity of bat activity within pecan orchards to evaluate these relationships. If bats have significant impacts on pecan production through PNC suppression, we expected to observe lower larval damage in areas of high bat activity. Overall bat and foraging activity were monitored with Anabat detectors distributed throughout pecan orchards. Crop load, PNC abundance, and larval damage were measured in 30m radius plots around each detector. Relationships between variables were analyzed with multiple regression models in R. Larval damage ranged from 2.8 to 64.3% and preliminary results show a trend toward a negative relationship between feeding activity and larval damage, as predicted. Interestingly, the strength of the relationship depends upon the metric of bat activity (e.g. foraging versus search calls) and the dates included in the analysis, illustrating the importance of understanding the nature and timing of predator-prey interactions and the complexities of analyzing these types of interactions.

Immunohistochemical Characterization of Merkel Cells in Facial Projections and Vibrissae Follicles of *Artibeus jamaicensis*

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Phyllostomid bats have unique morphological facial features, including patterns of glabrous facial verrucae that lack typical, integumentary, sensory end-organs, but are well-endowed with Merkel cells and free nerve endings (neurites or *Haarscheibe*). Routine paraffin histology, immunohistochemical staining, and immunofluorescence were utilized to elucidate the nature of Merkel cells found in the epidermal rete pegs of facial verrucae and vibrissae hair follicles of *Artibeus jamaicensis*. We found an abundance of dermal afferent nerves branching widely as they approach the epidermal-dermal junction. Many axons terminated at the rete pegs forming a delicate meshwork of nerves suggesting the presence of Merkel cell-neurite complexes. Other nerves penetrate the epidermis terminating within various epidermal strata as free-nerve endings and some epidermal nerves have terminal enlargements. Vibrissal follicular Merkel cells were found in the outer root sheath, with some populations being innervated. Merkel cells in root sheaths and verrucae responded variably to antibodies. Most notable was positive immunoreactivity (IR) for Serotonin (5-HT), Vasoactive Intestinal Peptide (VIP), Neuron Specific Enolase (NSE), Calbindin D-28K (CALB1, and Protein Gene Product 9.5 (PGP 9.5) in Merkel cells of vibrissae hairs, while IR for NSE, PGP9.5, CALB1, and Synaptophysin (SYP) was found in epidermal rete pegs and associated nerves. These findings suggest multiple Merkel cell populations with diverse functional attributes.

Temperate Forests, Forestry, and Bats

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Over the past two decades there has been increased research focus on the biology of temperate insect eating bats living in natural environments. The incentive for this stems from the need to address questions about the impacts of human disturbance e.g., forest harvesting, on wildlife in general. For bats, the shift from studying maternity colonies in buildings to animals in trees coupled with the improvements in telemetry and acoustic sampling have enabled comparative studies of ecology, behaviour and physiology. Aside from the direct negative effects that tree removal has on bats, research over the past two decades has increased our understanding of how bats use forests, leading to changes in management regimes. Data on social behaviour (e.g., fission fusion) illustrate how a focus on conserving single roost trees will not suffice because groups roost in areas of forest and use multiple trees. Data on selection of specific roosts suggest general characters can be used to predict roost type across a variety of landscapes for a variety of species. Although research on foraging ecology in natural ecosystems has lagged behind studies of roost use, we do know that activity is concentrated along hard edges created by forest harvesting. Thus, while considerable progress has been made leading to recommendations which enhance our abilities to conserve bats in ecosystems where forest harvesting occurs, still to be determined are reliable means of assessing forest quality for bats and how to generate these areas over the long time frames needed.

Feathered Echolocation: Oilbird Biosonar in the Wild

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Following the discovery of echolocation in bats and, later, in whales, few searches for additional echolocators have been successful. Biosonar has been documented in some shrews and tenrecs and in blind humans. The only known non-mammalian echolocators are birds, specifically within the swiftlets (Apodidae, Collocalinii), which occur across the Indo-Pacific region, and in Oilbirds (Steatornis caripensis, Caprimulgiformes) in South America. Work on echolocaton of Oilbirds predates 1990 and includes a single field study. There are notable discrepancies in descriptions of the parameters of Oilbird echolocation signals regarding signal duration, frequency content and, accordingly, detection capabilities. We revisit bird echolocation with descriptions of echolocation signals recorded with multi-microphone arrays in the field in Trinidad in 2012. Benefiting from the technological advances and computational techniques developed over the last decades in the study of bat echolocation, our aim was to resolve previous conflicting descriptions of Oilbird biosonar signals. Our data indicate that Oilbird echolocation signals recorded in the field are consistent, and somewhat different in structure than signals described from captive birds. Oilbirds emit sound bursts each comprising several click-type signals, which vary in number per

burst. We discuss whether these individual clicks or sub-components of the overall burst each constitute a functional, informative unit or whether this design serves a different function or reflects a mechanical constraint on sound production.

Torpor Patterns of Hibernating Gray Bats: Implications for WNS

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White nose syndrome (WNS) has resulted in the death of over 5 million hibernating bats across 7 species since it was first discovered in 2006. While the exact cause of mortality is unknown, WNS infected little brown bats (*Myotis lucifugus*) arouse more frequently than uninfected bats. While gray bats (*M. grisescens*) have been shown to be infected with WNS, for unknown reasons, extreme mortality events have not yet been observed. Factors such as hibernation behavior are being proposed as possible explanations. To investigate the hibernation ecology of gray bats, we attached temperature sensitive radio transmitters onto 58 female gray bats across 4 hibernacula and recorded body temperature at approximately 15 minute intervals for over 90 days. Preliminary analysis of temperture data shows hibernation temperatures of between 10 and 15°C. Torpor bout lengths varied substantially between individuals (range: 6.36-16.56 days). Or results indicate similarity in torpor bout lengths between gray and little brown bats. Additionally, as gray bats are hibernating at temperatures in which *Geomyces destructans* (the fungus that causes WNS) grows faster, lack of impacts of WNS-induced mortality cannot be explained through differences in hibernation ecology.

What Proportion of the Bats that Occur at the Entrance of Caves and Abandoned Mines Hibernate There?

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In the late summer and early fall in temperate areas, large numbers of bats congregate at the entrances of caves and abandoned mines which are used during the winter as hibernacula. There are several hypotheses to explain these swarms including courtship and mating, and information transfer about potential hibernating sites or migration routes. It is known that some bats that visit a site during swarming do not necessarily hibernate at that same site, although some certainly do. Characterization of the proportion of bats that occur at the entrance of underground sites during the spring and also during the fall swarming period that eventually hibernate there is not well known and could provide insight into the movement dynamics, site fidelity and population structure of temperate hibernating species. Thus, our objective was to compare the proportion of bats (males and females) that were tagged during spring emergence and fall swarming that actually hibernate inside the mine. At an abandoned gold mine at Rawdon, NS, Canada, we trapped and PIT-tagged 338 *M. lucifugus* and 224 *M. septentrionalis* during emergence in the spring or swarming in the fall. We have actively searched for PIT- tagged bats during each of 1-3 winter counts inside the mine from 2008-2012 where we expect that we were able to count and scan >90% of the ≈1200 bats present (pre-WNS). We have 660 individual relocation records of tagged bats during hibernation. Generally, bats that were tagged in the spring were more likely to be recaptured at the site during hibernation, *M. lucifugus* were more likely to be recaptured during hibernation than *M. septentrionalis* and, for both species, males were more likely to be recaptured than females.

Use of Avicennia marina Mangrove Forests by Microbats in South-east Queensland, Australia

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Previous studies have found mangroves to be an important habitat for many microbat species in Australia, Borneo and Brazil. In south-east Queensland *Avicennia marina* mangroves occupy an area of 533km^2 and can grow up to 25m tall, forming large open forests. The aim of this study was to critically determine how microbats use three structurally distinct mangrove forests in south-east Queensland. Four harp traps and three passive Anabat detectors were used (over 2011/2012) to assess microbat abundance and activity over four consecutive nights in each forest type over four experimental blocks. Microbat abundance and activity were compared between open (both old growth

and mature) and closed (regrowth) *A. marina* forests, and between old growth and mature forests. Stem density, canopy height, DBH and relative hollow abundance were significantly higher in old growth, followed by mature, then regrowth forests ($p = <0.001$), confirming the characteristics of these forests. Mean relative abundance and activity of microbats were higher in open *A. marina* forest than closed forest ($p = 0.0288$ and 0.0057 respectively), but there was no significant difference between old growth and mature forest. It was concluded that open *A. marina* forests may be important habitat for microbats in south-east Queensland, and the management of mangroves should be considered for microbat conservation.

Demographic and Genetic Estimators of Effective Population Size Suggest High Male Reproductive Skew in Spix's Disk-winged Bat

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Comparison of demographic and genetic estimates of effective population size, N_e, can provide insight regarding variance in reproductive success, a major factor determining N_e within populations. Such comparison can also provide inference regarding mating system when patterns of mate choice are unknown or difficult to observe directly. We used demographic and genetic methods to estimate N_e for two populations of Spix's disk-winged bat, *Thyroptera tricolor*, in southern Costa Rica and draw inference regarding the mating system, which is currently undescribed. We parameterized a simplified demographic model of N_e for overlapping generations using four years of mark-recapture and microsatellite data from two populations. Adult population size, or genetic neighborhood size, was estimated by regressing genetic distance among roosting groups ($F_{ST}/1 - F_{ST}$) and pairwise ln(distance) among home ranges. Survival rate and generation time estimates were obtained from previous mark-recapture studies demonstrating Type 1 survivorship. Genetic estimates of N_e were generated using a linkage disequilibrium, single-sample method implemented in the program LDNE. Demographic estimates of N_e were larger (2.3–3.1-fold) than genetic estimates for both populations when variance in breeding success was minimized. Sensitivity analysis indicated discrepancies between estimators could be resolved by parameterizing the demographic model to include strong skew in male reproductive success (~10% of males breeding). Further, maximum-likelihood estimates of relatedness indicate high occurrence of paternal half-siblings within annual cohorts, despite females having only a single pup each year. These results suggest the presence of a highly polygynous mating system in this species.

Total Testicular Regression in the Tropical Vespertilionid Bat *Eptesicus furinalis* (Chiroptera: Vespertilionidae)

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Bats from temperate zones are generally seasonal breeders. By other side, bats from tropics have their reproductive patterns diversified according to the habitat where they belong. Studies on reproduction of *Eptesicus furinalis* are scarce or nonexistent, so the aim of this work was to investigated its reproduction in the northwest of São Paulo State, Brazil (49W22´45" 20S49´11"). Twelve sexually mature specimens, collected at different dates during the year, were submitted to standard histological procedures and analyzed. The analysis indicated the presence of a pattern of total testicular regression, very similar to that observed in *Myotis nigricans* and in temperate bats that hibernates, with four distinct periods throughout the year: active, regressing, regressed and recrudescence. In active period, the testicular morphology presented the typical organization of mammals, with the seminiferous epithelium doted of three types of spermatogonia: the dark type A (A_d), the pale type A (A_p) and type B; and seven steps on spermatid differentiation (spermiogenesis). In regressing period, the amount of cells in meiotic division (spermatocytes) decreases dramatically and the observation of elongated spermatids attached directly to the basal compartment, with the absence of spermatocytes, was frequent. The regressed period was characterized by the presence of only Sertoli cells and spermatogonia within the seminiferous epithelium and, the recrudescence period, by the reactivation of the spermatogenesis, where the meiotic and differentiation processes were restarted. This pattern of reproduction seems to be related to the fact that tropical species of *Eptesicus* are probably derived from hibernating species of temperate zones.

Eonycteris spelaea is the Major Pollinator of Durian and *Parkia* in Southern Thailand: Economic Valuation of Pollination Service

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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 (*Durio zibethinus)* and two species of *Parkia,* and to identify their pollinators. The floral biology and pollination ecology was determined in eight semi-wild trees of durian, 28 trees of *P. speciosa,* and four of *P. timoriana*. All are mostly or completely self-incompatible. 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. *Eonycteris spelaea* visited flowering plants continuously from dusk until after midnight. Several other fruit bat species also contributed to pollination success. Nocturnal and diurnal insects (moths,giant honey bees, and stingless bees) also frequently visited flowers. Bats visited durian and *Parkia* flowers at the rate of 26.1-112 visits per inflorescence per night. The pollination services offered by fruit bats to these plants were estimated to be worth 137 million US dollars annually in southern Thailand. Protection of fruit bat populations and their roosts is vital for the continued production of these fruit crops.

Assessing Factors that Influence Bias in Mathematical Models Used to Estimate Bat Fatality Rates Associated with Wind Turbines

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The rapid growth in wind-energy installations and associated turbine-related fatalities has generated concern for the impact on bat populations. Estimating the number of fatalities is integral to determining the cumulative impact on affected species. The most commonly applied fatality estimators have fundamental assumptions that are routinely violated in wind-turbine data, namely uniform population sizes that maintain a constant death rate. We assess the robustness of models to violation of these assumptions by deriving new mathematical models that remove at least one assumption of earlier estimators. In comparison to a null model (i.e., the simple-uniform model), we evaluate (1) conditions that perturb the steady-state process and (2) populations with non-uniform fatalities (i.e., migratory species). Using the simple-uniform model to estimate fatalities can result in errors ranging from –100.0 to 65.7%. In general, migratory events exert minimal error except in atypical situations of short migrations relative to the search interval. However, searcher-induced perturbations that disrupt the steady-state process of carcass death and subsequent removal by scavengers/decay can have a major influence on estimated fatality rates. Additionally, we provide means of correcting bias inherent in the null model and suggest that our migration models may have other applications, such as revealing migratory patterns from carcass counts. Examples illustrating the application of the models are given, as well as conditions in which each is appropriately applied. The diversity of our developed models and the ability for parameters to vary between searches provide broad applicability to a range of wind-farm conditions and study designs.

Assessing Migratory Patterns of Hoary Bats from Wind Farm Fatalities Using Stable-Hydrogen Isotopes

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Bat fatalities associated with wind-energy development have generated concern for population sustainability of affected species. Hoary bats are among the most susceptible species and part of the difficulty in determining fatality risks is our limited knowledge of bat migration. We used carcasses of fall migrants collected at a wind-energy installation to assess migratory patterns based on hydrogen-isotope ratios (δD) of fur and cross-sectioned claw samples. Data suggest male hoary bats do not molt at location of summer residency given that $\delta D_{claw\ root}$ was significantly more depleted than δD_{fur}, a pattern not found in females. Using claw samples, we concluded that represented localities of summer residency extended from the central United States into northern Canada (δD from -43.6‰ to -153.0‰). It remains uncertain whether location of wintering grounds can be detected from claw-tip samples, but $\delta D_{claw\ tip}$ for most specimens was indicative of localities from the southern United States or Mexico (δD

from -22.3‰ to -103.6‰). The difference between the $\delta D_{claw\ root}$ and $\delta D_{claw\ tip}$ within the same individual significantly increased as location of summer residency moved northward, indicating a differential migration occurs with some individuals migrating greater distances than others. However, these differences were not explained by sex as there was no difference in latitudinal distributions of males and females. Individuals migrating from more northern latitudes also arrived at the study site later than individuals from lower latitudes. Our study highlights the utility of wind farm fatalities to better understand migratory patterns and, in turn, provides insight into population structure.

State Reproductive and Estrus Cycle of Bats in a Forest Seco, Parque Natural Santa Rosa, Costa Rica

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Many tropical bats are able to reproduce continuously regardless of the season, while species of bats from temperate areas usually reproduce once a year. Bats have the ability to adjust the periods of spermatogenesis, oogenesis, intercourse and fertilization to the seasons that guarantee the survival and growth of its progeny. In this study, we determine if a short drought during the rainy season in a dry forest affected the reproductive cycles of different species of female bats. We used mist nets to capture females over a period of four nights. We determined the female reproductive stage visually and performed vaginal smears to know their estrous cycle phase. We captured a total of 21 females distributed in six species; where 71.4% did not present an active reproductive status and 28.7% had an active reproductive status (pregnant or lactating). However, for the estrous cycle we found 42.8% of females with proestrus and estrus, and 57.1% without male´s acceptance. Despite observations of females without evident reproductive activity, many females were presenting estrous cycles during the drought. Consequently, this indicates that species in this study are not being affected by a drought and might show high adaptability to drastic environmental conditions. However, it is important to compare this study during the rainy season to know if changes in reproductive dynamics occur.

Spatio-Temporal Variation in Pollination Systems of the Organ Pipe Cactus: Specialists vs. Generalists

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It has been proposed that the pollination system of chiropterophilous columnar cacti in Mexico shows latitudinal differentiation. The current hypothesis states that most columnar cacti in tropical areas depend heavily on nectar-feeding bats for their reproduction (specialists), while species from extratropical areas are pollinated by a diverse assemblage of species (generalists). To test this hypothesis, we examined the effects of the pollinator guild and its variation in time and space on the reproductive success of a widespread species. During two years, we recorded the temporal variation in pollinator assemblages and their effect on fruit and seed production in three widely separated populations of *Stenocereus thurberi* in NW Mexico. Using exclusion experiments we assessed variation in reproductive success and pollinator efficiency. We found significant differences among sites in the timing, type and relative efficiency of pollinators. Contrary to the hypothesis of a N-S gradient of specialization, in the northern and central populations the reproductive success depended almost exclusively on bat pollination. In the southern population, bats were usually absent , and generalist pollinators were always common. In the northern and central sites, the similarity between natural and manual cross-pollination treatments indicated no pollen limitation, but in the southern site a strong pollen limitation was found at the end of the season, because of the temporal differences in bat abundance and/or their timing of arrival. The large variation among populations in the pollinator guild, and in the reproductive success in *S. thurberi* suggests that local processes can greatly affect the evolution of specialized pollination systems. The migration pattern of bats is more complex than a simple N-S trend. The temporal variation in the timing of arrival, and the intensity of pollinator activity, could lead to a bet hedging strategy based on the unpredictable availability of pollinators in some populations.

Observable and Acoustic Behavior at Indiana Bat Day Roost Sites

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Understanding social behavior is essential to understanding any species, especially those that form large social groups such as bat maternity colonies. The study of acoustic and observable behavioral components could lead to the development of diagnostic tools for identifying social activity at bat roost sites (i.e., mother-to-young interaction, checking behavior, and duress). Since 1997, Indiana State University has monitored a population of endangered Indiana bats (*Myotis sodalis*) near the Indianapolis Airport; this on-going project lends itself to behavioral studies due to large colony size and high fidelity shown to roosts within and between years. Though >135 roosts have been documented, each year the bats return to a small subset of primary roosts and to 5 more permanent bat boxes that were installed in the mid-1990s. The fidelity shown by this population leads to predictability of maternity colony locations, allowing for repeated and longer sampling periods. In summer 2012, we will collect data at multiple types of known roost locations; we will deploy visual and acoustic equipment simultaneously. We will analyze the effects of time, colony size, and roost site type (i.e., primary, secondary, and bat boxes) on frequency of various social behaviors. Preliminary data on Indiana bats suggests that behavior varies with roost type (e.g., maternity or solo male roost) and time (e.g., stage of maternity season). This study will give insight into types and temporal patterns of behavior at roost sites and enable comparison of various observational methods for the study of social behavior.

First Record of *Molossus aztecus* (Molossidae) in the Brazilian Amazon

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The current diversity of species of the genus *Molossus* in South America is provisional and a taxonomic review is needed, especially of the small species, such as *Molossus aztecus*. In Brazil there is only one record of its occurrence, at two towns (Lavras and Viçosa) of Minas Gerais State, Southeastern region. Little is known about the biology, ecology and behavior of this insectivorous bat. The present study is the second record of *M. aztecus* for Brazil and the first for the Northern region (Brazilian Amazon). On May 2012, six adult females were mist netted around the building in a periurban area of Tucuruí town, Southeastern region of Pará State. On August 2012, four sessions of night activities (18:00-21:00h) were performed with a total of 12 h of observation. The bats emerged from four points of the building´s roof and we observed an average of 290 bats/night emerging from them. Two evident peak periods of bat emergence were observed, one around 18h30min and another around 19h32min. The two peak periods of bats returning to roost were observed around 19h07min and 19h55min. This night activity of *M. aztecus* is similar to known foraging behavior of other molossid species and seems to be synchronized with the insect abundance at early nights. *Molossus aztecus* must have a wider geographic distribution in Brazil and one of the main obstacles for its register is its morphological similarity with *Molossus molossus*, a species more common, more studied and with a wider distribution in all Latin America.

Hematological Findings of *Artibeus jamaicensis* Bats in Different Ecosystems with Different Degrees of Perturbation

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Bats are prone to various viral and parasite infections, many of which are readily transmitted to humans directly or by means of a vector. The growth of human populations and the perturbation of the habitats in which bats and humans coexist exacerbate the probability of spreading zoonotic diseases. Little is known about the hematological values of Mexican bats and its correlation between habitat perturbation and the presence of viruses and parasites. For this reason we conducted a survey of the hematological values of *Artibeus jamaicensis* as a marker of immunological state in two distinct ecosystems: urban-perturbed and rural-conserved areas. A total of 90 bats were captured 50 from urban areas in the state of Morelos and 40 from rural areas in the state of Campeche. Bats were euthanized and the blood samples were obtained by cardiac puncture for complete blood counts, sera and

organs were used for a parallel work. Average obtained in urban areas was 3.69E +03 (SD 2.37E+03) leukocytes/uL, and 3.53E+03 (SD 8.15E+02) leukocytes/uL in rural areas, however standard deviation was lower than the one obtained in urban areas. We also observed the presence of hemoparasites in both states, in Campeche the prevalence was 22-30%. In Morelos the prevalence was 7.5%. These data is contrary of what we expected as the bats in the rural-conserved area present more variability in their hematological

Behavioral Syndromes of the Nectarivorous Bat Species (Phyllostomidae: Glossophaginae): *Glossophaga soricina, G. leachii, Leptonycteris yerbabuenae* and *Choeronycteris mexicana*

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The nectarivorous bat species *Choeronycteris mexicana* and *Leptonycteris yerbabuenae* have been described as migrants specialized in sub-humid ecosystems and to feed primarily from cacti and agave flowers. In opposition, *Glossophaga soricina* and *G. leachii* are resident species and are generalists in habitat use and feeding habits. All the named species overlap in space, time and feeding resources along their distribution. The main goals of this study were to compare behavioral syndromes between generalists and specialists species. Experiments were performed in an electronically automated experimental space. For the trials, captive (from Germany) and wild individuals (from two Guatemalan locations) were used. Nine different models of a priori behavioral syndrome structures were tested through a Structural Equation Modeling analysis. A general domain proactivity-reactivity was found, although differences between the studied groups were observed. Three correlation models were statistically significant in all the studied groups, but when the behavioral syndromes described by these models were analyzed throw factors, only the specialist groups shared a common factor (captives and wilds). Factors were also found in the generalist groups but there were not common factors shared by the three groups. The existence of factors suggests common mechanisms correlating different behaviors. The behavioral syndromes present in the specialist species, as other morphological and physiological adaptations seem to have converged independently in both species towards cactophily as to travel long distances. For the resident *Glossophaga* species, having flexible behavioral syndromes governed by different mechanisms would allow closer populations to cope with different environments.

Role of *Artibeus jamaicensis* and *Brachyphylla cavernarum* in the Dispersal of Endangered *Sthalia monosperma* (Leguminosae) in Puerto Rico

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We gathered data on food choice experiments of the Phyllostomid bats *Artibeus jamaicensis* and *Brachyphylla cavernarum,* as related to the endangered tree *Stahlia monosperma*. The distribution of *S. monosperma*, an endangered tree for which no dispersal vector is known, is restricted to a few locations around the island of Puerto Rico and eastern Hispaniola, Greater Antilles. 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. We released bats in a flight cage, where they were presented with two food choices, with the purpose of assessing their role in the dispersal of *S. monosperma.* Our preliminary results reveal that when *S.monosperma* were presented, bats will feed on the fruits. *B. cavernarum* will select and carry fruits of *S. monosperma* occasionally, while *A. jamaicensis* explored the plates briefly before moving to the other choice offered, or consumed the fruits in the plate without carrying them. We examined ten the caves where phyllostomid bats roost. There was no evidence of *S.monosperma* inside or outside of the selected caves that prove the removal of the seed. 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, although it should be noted that these fruits appear to be at the bottom of the dietary preferences of bats.

Ectoparasites of Bats in Tropical Dry Forest Fragments in Two Types of Livestock Systems from Colombia

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The management type of livestock systems (eg traditional vs. silvopastoral) offers different living conditions for parasites and their hosts, both because of environmental conditions such as the availability of

resources. The remnants of tropical dry forest immersed in silvopastoral farming systems maintain greater diversity compared to a traditional ranching system, which is a more disturbed and simplified environment for wildlife. We assessed whether it was possible to identify differences between bats' ectoparasitism present in tropical dry forest remnants embedded in livestock handling systems (BMS) and silvopastoral systems (SS) in the Córdoba department of Colombia. Sampling was carried out from August 2011 to January 2012 in two farms SC and two farms SS. 251 bats were collected using mist nets, which were sacrificed directly on the net and stored in plastic bags for later review, using the laboratory stereoscope. Mites were preserved in Hoyer solution, diptera in alcohol. The most abundant family was Phyllostomidae bats. Mites were found in Chirodiscidae, Spinturnicidae Macronyssidae families. Diptera where found in Streblidae and Nycteribiidae families. More monoxenous ectoparasites were found in areas corresponding to the silvopastoral system (11) than in the conventional system (7) for both mites and flies. The specificity was higher in the silvopastoral system than in the conventional one. There were no differences between systems related to host sex or parasite abundance. The type of extensive livestock management (silpastoral and conventional) was not indifferent to both the host species and their associated ectoparasites.

Separately Measuring Cutaneous and Pulmonary Gas Exchange and Water Loss of Hibernating Bats

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The "dehydration hypothesis" postulates the causative fungal agent (*Geomyces destructans; Gd*) of White-nose syndrome (WNS) damages the wings in such a way as to disrupt water balance, which is a crucial challenge for bats. Unfortunately, due to methodological limitations, past studies have only speculated about gas exchange and water loss across even healthy wings. To test the dehydration hypothesis and further elucidate the pathogenesis of WNS we must understand physiological processes during hibernation. To this end, I tested various respirometry chambers to investigate which design best allowed me to separate cutaneous and pulmonary gas exchange and water loss of hibernating bats. Measurements were obtained using three chamber designs: masks, body chambers, and wing chambers. Masks were secured over rostrums with bands. Body chambers involved placing bats in a small cylindrical chamber with their heads protruding out through a fitted opening. This design separates pulmonary exchange (and the minute cutaneous exchange from the head) from the rest of the body. Wing chambers were made out of malleable plastic, flexible enough to allow bats to fold their wings. The body chamber was the most successful design for separately measuring pulmonary and cutaneous respiration. Now relative contributions of pulmonary and cutaneous water loss and changes due to WNS-associated wing damage can be estimated. Not only will this chamber design allow us to expand our understanding of the physiological complexities of hibernation, but also the WNS epidemic. Moreover, this study advances our ability to study hibernation as a whole and is applicable across disciplines.

Conservation Importance for the Bats of Cusuco National Park, Honduras

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Cusuco National Park (CNP) is a protected area of the Merendon Mountain range on the Northwest region of Honduras. Its geographical location and geological formation has developed different types of habitats of ecologically important for bats, allowing a diversity and richness of species previously unknown. Deforestation, agriculture and cattle rising are some of the threats that affect the diversity and species richness. Since 2003, the British organization Operation Wallacea (Opwall) has been working in the country to develop a monitoring program in biological conservation and research of bats in the buffer and core zone. One of the major objectives of the project is to measure the diversity and richness of species of bats in the buffer and core zone within the park through an intensive annual monitoring of 8 to 9 weeks of work during the summer season. With the help of more than 15 international experts and the volunteer program offered by Opwall, bat teams get to study the bats in different types of habitats in different altitudinal stratum using mist nets and genetics. So far, CNP presents the greatest number of species reported for a single area of study in Honduras with a number of more than 50 species of bats from 5 different families, increasing the official list of species of bats for the country, and more than 10 published bat related articles. CNP is one of our priority areas for the conservation of bats for the Bat Conservation Program in Honduras (BCPH or PCMH in Spanish).

Chiropoxvirus: Updates on a Novel Bat Pathogen

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A wildlife hospital and rehabilitation center in northwestern United States received several big brown bats with necrosuppurative osteomyelitis in multiple joints. Wing and joint tissues were positive by PCR for poxvirus. Phylogenetic comparison showed that this virus shares its most recent common ancestor with *Cotia virus*, a poxvirus isolated from sentinel mice placed outside of Sao Paulo Brazil in 1965. The genetic distance between these isolates supports the establishment of *Chiropoxvirus* as new genus of *Poxviridae*. Further lab and field studies will investigate potential ecological and host overlap between these viruses.

Does Reciprocity Explain Food Sharing in Common Vampire Bats?

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According to the reciprocity hypothesis, regurgitated food sharing in common vampire bats (*Desmodus rotundus*) represents a social investment: bats feed roost-mates to ensure reciprocal sharing. If so, direct benefits of long-term social bonds exceed the indirect fitness benefits of helping relatives. Alternatively, however, reciprocal patterns might merely reflect symmetrical relatedness cues; mistakenly feeding some non-relatives might simply be less costly than mistakenly allowing some close relatives to starve. I will describe evidence for and against these interpretations from past and ongoing work involving 35 vampire bats tested in the presence and absence of cage wall barriers. Although relatedness and association independently predicted food sharing in the wild, when association was held constant in captivity, stable food-sharing networks were predicted by reciprocal sharing ($p<0.0002$) and allogrooming ($p<0.0002$), but not relatedness ($p=0.16$). Several observations also suggest positive interactions between relatedness and reciprocal help. The symmetry of reciprocal sharing significantly increased with pairwise relatedness ($p=0.028$), the only bats that have passed food across cage walls have been close kin that also reciprocate, and new mothers secured donations with greater ease after their pups became reliable adult reciprocators. My findings illustrate that (1) physical contact is not necessary for food sharing in vampire bats, but cooperation experiments that prevent physical contact can significantly alter natural behavior (2) long-term cooperative social bonds can span the conceptual divide between direct and indirect fitness benefits, and (3) to disentangle these benefits one must directly test cognitive mechanisms of partner enforcement (experiments which are currently ongoing).

Tracheal Calcification in Birds, Bats, Shrews, and Mice

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Post-natal calcification in the respiratory tract has been associated with mechanical stress imposed by muscles. Respiratory tract calcification is extensive in birds and is suggested to have evolved in response to stresses from vocalization/signing. Little is known about tracheal calcification in bats and how this might relate to flight and/or echolocation. Bats and birds synchronize respiration with wing-stroke to economize flight, resulting in compressive forces imposed by flight muscles on the respiratory tract. We hypothesized that tracheal and primary bronchi calcification will occur in echolocating *Artibeus jamaicensis* but not in nonecholocating *Syconycteris australis* and *Pteropus rodricensis*. We also compare tracheal and bronchial calcification between bats and shrews (*Sorex vagrans*) known to use sonar and the house mouse (*Mus musculus*), not known to produce sonar, to assess phylogenetic aspects. Tracheae were dissected from *A. jamaicensis* (N=4, 1-4 years old), *S. australis* (N=2), *P. rodricensis* (N=1), *S. vagrans* (N=6) (all of unknown age), and *M. musculus* (N=3, 4 months old) and cleared and stained with alcian blue and alizarin red. Tracheae and primary bronchi of *A. jamaicensis* and *P. rodricensis* were heavily calcified. *S. australis* tracheae showed heavy calcification with traces of calcification present in the bronchi. Tracheal calcification was present in some *S. vagrans* (N=3) but not in the bronchi. No calcification was detectable in mouse respiratory tracts. These preliminary data suggest calcification is not solely due to vocalization or solely flight mechanics. More data are needed from a wider range of mammals to assess the role that age possibly plays.

Seed Dispersal by *Sturnira lillium* and *Artibeus jamaicensis* in Freshwater Wetlands of Veracruz, Mexico

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Frugivorous bats are keystone species in the regeneration of neotropical forests. In order to determine which bat species contributed most to the regeneration of vegetation in wetlands of Veracruz, Mexico, we compared the abundance of *Sturnira lilium* and *Artibeus jamaicensis* in pasturelands and fragments of forested wetlands. We also compared the number of seeds and species richness of plants dispersed by these bat species. Using mist nets, we captured 641 bats, of which 407 were *A. jamaicensis* and 234 were *S. lilium*. We also collected 161 feces containing seeds, 72 belonged to *Sturnira* and 89 to *Artibeus*. The abundance of *A. jamaicensis* was similar between vegetation types, while *S. lilium* was more abundant in forest fragments than in pasturelands. Neither *Artibeus* nor *Sturnira* showed differences in the species richness of plants they dispersed among vegetation types. However, *A. jamaicensis* dispersed more seeds in pasturelands, contrasting with *Sturnira*, which dispersed more seeds in the forest fragments. The diet of *A. jamaicensis* was dominated by *Ficus* spp. while the *Sturnira*'s diet was composed of Piperaceae and Solanaceae. Our results suggest that in wetlands, *A. jamaicensis* is more tolerant than *Sturnira* to changes in land-use, probably due to the type of management that farmers make of their lands, usually preserving trees for shadow of cattle and eliminating shrubs and herbaceous plants, which provide food to *Sturnira*. Therefore, human management can influence in the bat species that forage in modified landscapes, in turn influencing in the plants involved in the regeneration process of wetlands.

Effectiveness of the Multi-Spatial Scale Approach to Forest Management -- a Tasmanian Case Study on Bats

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The management of forest habitat outside of formal reserves (the matrix) plays a crucial role in biodiversity conservation, yet we know very little about the effectiveness of different management approaches and how these vary in different landscapes. Using Tasmania's hollow-using bats as a case study, we investigated the effectiveness of the multi-spatial scale approach to forest management at providing suitable habitat, from which bats can recolonise harvested areas and thus maintain populations in timber production landscapes. Bat call surveys and radio-tracking revealed that no single forest retention measure was preferred by all bats and that the effectiveness of forest retention measures varied between landscapes. In landscapes where mature forest was rare or lost, small patches (<1ha) and large strips (50ha) were used more extensively by bats than in landscapes where mature forest was more abundant. Not all species formed maternal colonies in such patches and strips, instead preferring large patches (>350ha) to breed. All species, however, did select roost areas with the highest availability of hollow-bearing trees. These findings provide support for the multi-spatial scale approach to forest management rather than the 'one-size fits all' approach because no one forest retention measure is likely to cater for the habitat requirements of all bats. Forest management strategies should include the retention of mature forest in a mosaic of small and large patches and strips. In addition, the type, amount and spatial arrangement of mature forest (containing hollows) in the landscape should be considered when retaining mature forest in production forests.

Seasonal and Reproductive Effects of Flight Membrane Wound Healing in Captive Big Brown Bats

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Research on bat flight membranes has revealed several physiological functions essential to bat survival and conservation; however, injuries to the flight membranes of bats are commonly seen in the wild. In many cases such injuries heal completely, although little is known about wound healing during times of energy restrictions and high demand (e.g. hibernation and reproduction). Because wound healing is an energy-dependent process, it is expected to vary across seasons and reproductive status. We used an 8 mm diameter circular biopsy tool to punch the wing membranes of individuals in a captive research colony of big brown bats, *Eptesicus fuscus*, and compared differences in healing rates between summer and winter seasons, and between reproductive (lactating) and non-reproductive (non-lactating) females. We also compared the Body Condition Index (BCI=mass/forearm length) of

biopsy and control bats to infer if wing damages results in faster depletion of fat reserves and/or slower healing rates as a function of reproductive stage. Preliminary results indicate the wing membranes heal rather quickly regardless of season. Moreover, so far we have not observed differences in BCI scores between membrane biopsy and control groups. This study provides bat researchers with important baseline data that can be used to assess the health status of bat populations and to develop strategies important for bat conservation given the threat of white-nose syndrome to bats.

Acoustic Sampling of Bat Activity in a Fragmented Landscape in Nicaragua

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Tropical dry forests supply important ecological and economic benefits. However, threats to forests in Central America such as resource extraction and conversion to other uses (e.g., agriculture) often result in a fragmented landscape. We acoustically surveyed bats on the 200,000-ha Paso del Istmo of southwestern Nicaragua. This isthmus, between the Pacific Ocean and Lake Nicaragua, is considered an important passageway for wildlife. Our objective was to increase knowledge of bats and determine impacts of forest fragmentation on bats. We deployed Anabat SD1 or SD2 detectors at 103 sites that represented a range of forest fragmentation levels. We characterized the landscape into 4 cover classes: closed-canopy forest, open-canopy forest, crops, pasture. The FRAGSTATS intersection of forest area (% forest from 0-25%, 25-50, 50-75, 75-100) and patch density (low, medium, high) guided selection of study sites; we equally sampled 9 combinations of forest area and patch density on the landscape. We excluded areas on the Pacific coast as plant communities (e.g., mangroves, *Rhizopora* spp.) differed from interior-isthmus forest types. We surveyed sites between January and May 2012 to determine a relative activity index (AI) for each site for all bats, feeding buzzes, and for bats identifiable to species using recorded calls (e.g., *Pternotous davyi*, *Saccopteryx bilineata*). We collected ~300,000 files and compared AI per site to fragmentation indices using FRAGSTATS. Activity levels, species, and impacts of fragmentation will be reported. In our companion study, captures of bats revealed that large, mature forest patches maintained a more diverse bat assemblage.

Roosts Amplify Social Calls in Spix's Disc-winged Bat

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Many animals exploit the acoustic properties of their shelters to amplify social calls. Bats spend most of their time in roosts, and often depend on acoustic communication for locating roosts and roost mates; despite their importance, the role of roosts for amplifying sounds in bats remains unknown. In this study we addressed this question in Spix's disc-winged bat (*Thyroptera tricolor*), a small insectivore that roosts within the developing tubular leaves of several plants. *Thyroptera tricolor* uses two social calls to locate roosts and group mates: "inquiry calls" are produced in flight, while "response calls" are produced within the roost in response to inquiry calls. Inquiry calls allow group members to maintain contact during flight, while response calls allow flying bats to locate roosts and group members. In playback trials, we assessed whether tubular leaves amplify incoming inquiry calls and outgoing response calls. We also determined if roosts modified the acoustic properties of social calls, reducing signal fidelity. Our results show that inquiry and response calls are significantly amplified by tubular leaves. However, outgoing response calls were only amplified at peak frequencies above 60 kHz, whereas incoming inquiry calls were consistently amplified regardless of frequency of the broadcast call. We also found that the acoustic properties of most inquiry calls changed as they entered the leaf, whereas acoustic properties of outgoing response calls changed only for the few calls emitted above 65 kHz. This study shows that roosts may be an important component of social communication among disc-winged bats.

Ectoparasite Survey of Vampire Bats from Cueva de Los Riscos, Jalpan, Querétaro, México

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The Vampire bats *Desmodus rotundus* and *Diphylla ecaudata* are mainly distributed in the neotropics, and both are found especially in caves, and represent two small mammal parasites of mammals and avian species respectively. These bats have had some research focuses, because of their role of reservoir and transmission of some pathogens. However, there are a few records on their ectoparasitic fauna. Following this assumption, we have started with the study of their ectoparasitic fauna of both Vampire bats at the limestone cave Los Riscos, at the State of Queretaro, where we found a permanent colony of Vampire Bat and Hairy-legged Vampire Bat. The field collections of ectoparasites were done during two years (2006 - 2008). We obtained 55 bats [*D. rotundus* (20); *D. ecaudata* (35)] and a total of 2305 ectoparasites, including Acarines with seven species and Streblid flies with five species. We found small differences in ectoparasitic prevalence, mean abundance and diversity between two species. Parasite prevalence was 100% for Acarines in both Vampire species and 85 and 100% for Streblids in *D. rotundus* and *D. ecaudata*, respectively. Mean abundance was 23.65 and 33.68 for Acarines/hosts, and 9.75 and 13 for Streblids/hosts, *D. rotundus* and *D.* ecaudata, respectively. Financial assistance was provided by the Dirección General de Asuntos del Personal Académico, Universidad Nacional Autónoma de México, Grant IN221906 and IN219113 to J.B.M-M.

Bats and Their Shelters in Guarulhos, Southeastern Brazil

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In spite of urban expansion in the city of Guarulhos (1,222,000 habs), several forest fragments still remain, mostly in the north and northeastern municipality. Although many faunal inventories have been conducted in southeastern Brazil, in Guarulhos these are scarce.The present study provides a record of the bat fauna and roosts from Guarulhos, State of São Paulo, Brazil . Capture sessions were carried out between February and November of 2011, using mist nets across trails, around and above streams and lakes, near built areas and at possible day roosts. We recorded 17 bat species belonging to Phyllostomidae (13 spp.), Vespertilionidae (3) and Molossidae (1). *Sturnira lilium* (73), *Artibeus fimbriatus* (69), and *A. lituratus* (59) were the most numerous corresponding to 57.8% of all captures. An abandoned house was used as shelter by groups of *Desmodus rotundus* (N=3), *Diphylla ecaudata* (3), *Carollia perspicillata* (7), and *Anoura caudifer* (9). Inside that house, *D. rotundus* and *D. ecaudata* harbored in one of the rooms, while *C. perspicillata* and *A. caudifer* were roosting in another. Two glossophaginae bats (*A. caudifer* and *G. soricina*) were found in an empty historic mansion. A groundwater tunnel underneath a trail served as shelter for some bats, such as *D. rotundus, C. perspicillata*, and *G. soricina*. Although forest fragments of Guarulhos could offer natural day roosts, bats were observed harboring only in man-made shelters.

Persistence Versus Extinction: Are Disease Dynamics of White-nose Syndrome Changing?

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The emergence of the novel pathogen, *Geomyces destructans* (Gd), which causes the disease White-nose syndrome (WNS) in bats, has driven dramatic population declines in North America and is predicted to cause the local extinction of several bat species. However, after severe initial declines in New York, the oldest infected hibernacula now seem to be exhibiting changes in disease dynamics leading to apparent population stabilization for *Myotis lucifugus*. We present prevalence and infection intensity data using swab sampling and real-time PCR for localities where populations are suspected to be stabilizing and compare these to localities experiencing continued decline. We propose potential mechanisms that would lead to stabilization for some populations. Understanding persistence versus extinction processes is critical for determining long-term impacts of WNS, and informing conservation decisions for species and localities that continue to be pushed towards local extinction.

Roost Occupation, Evening Emergence, and Diet of *Myotis myotis* at the Northernmost Edge of its Distribution

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Greater mouse-eared bat *Myotis myotis* belongs to the most common, cave-dwelling vespertilionid species of southern Europe, however frequency of its occurrence decreases towards north. Contrary to its Mediterranean core range, in northern Poland the species is strictly synanthropic, forming nursery colonies exclusively in large building lofts. We studied seasonal dynamics of roost occupation, patterns of evening emergence and diet of *M. myotis* from the world's northernmost breeding colony of that species in church loft in Wejherowo (Polish Baltic Sea Coast, 54°36'N). Bats occupied roost since April until the end of October. During the study period, colony consisted of maximum 33 individuals (18 adults and 15 juveniles). Air temperature inside the roost varied between 8.4 ^{o}C and 24,3^{o}C (mean=17.2 ^{o}C) while relative humidity between 33% and 72% (mean=55%), both parameters were siginificantly correlated with ambient temperature and humidity. Bats started emergence from roost at 59 min. after sunset, while mean duration of emergence was about 54 min and revealed prolongation after obtaining the ability to fly by juveniles. Dynamics of emergence was affected by air temperature and rain. The main prey of *M. myotis* from the studied colony were carabid beetles Carabidae (frequency of occurrence, FO=94.8%). We revealed very high, previously unnoticed share of carabid larvae (FO=19.3%) in species' diet. Frequency of occurrence of the remaining taxa (Staphylinidae, Scarabaeidae, Diptera, Lepidoptera, Chilopoda, Arachnida) was much lower and revealed seasonal variation, suggesting opportunistic tendencies of *M. myotis* to utilization of food resources. The species, considered typical ground gleaner, appeared to prey on both epigeic and airborne arthropods.

Pollinator Specialization in Flower-visiting Bats

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Flower-visiting bats may exhibit several different types of specializations related to chiropterophily**.** Flower-visiting bats can exhibit dietary specialization and rely almost completely on a diet of nectar/pollen. Some are morphologically specialized, with anatomical adaptations for efficient exploitation of flowers. Flower-visiting bats may also display pollinator specialization and visit only a limited number of different plant species. I hypothesize that dietary and morphological specialization in bat pollinators will equate to pollinator specialization. I used microscopic analysis of guano to determine the number of plant species visited by five species (*Monophyllus redmani, Phyllonycteris poeyi, Erophylla sezekorni, Brachyphylla nana* and *Artibeus jamaicensis*) at sites in Cuba. I examined degree of specialization during one foraging bout and one season. These species exhibited varying degrees of morphological and dietary specialization ranging from very specialized to very generalized. I expect to find that the bats showing high degrees of morphological and dietary specialization also will exhibit higher degrees of pollinator specialization and visit fewer plant species per night, and overall within a season.

Looking Backward: a Molecular and Morphological Reconstruction of an Ancient Bat Ecosystem

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Bat communities provide unique ecosystem functions, particularly in tropical regions where insectivores, nectarivores and frugivores live sympatrically and interact with thousands of plant an animal species. Understanding these interactions in contemporary communities is challenging. Measuring them through time, particularly thousands of years, is extremely difficult. Molecular methodologies have changed our view of bat food webs providing species-level analysis through rapid sequencing protocols. We have used these to analyze competitive and mutualistic interactions in dozens of species and revealed novel predator and prey adaptations, and functional redundancy in seed dispersal. Here we perform first reconstructions of an ancient bat ecosystem. We extracted vertical core samples through undisturbed/isolated guano deposits in a Jamaican cave system which currently hosts insectivorous, pollinating and frugivorous bats. We performed a pollen profile through these layers and targeted

DNA extractions at regular intervals. We amplified the COI gene (standard insect barcode) and the trnL region for plant identification. We carbon dated the layers to generate a timescale. We recovered complete pollen profiles and successfully identified insect and plant DNA from all layers. Insect DNA, though degraded, corresponds to groups not native to caves but frequently found in insectivorous diets (e.g. Trichoptera, Lepidoptera, Ephemeroptera). Recovered plant DNA commonly corresponded to Solanaceae, whose species are bat dispersed. Carbon dating placed the oldest core layers at >4000 years BP. Our results provide extensive evidence that these caves have housed a stable/diverse community of bats including insectivores, frugivores and pollinators for at least four millennia and highlight their importance to conservation.

Social Learning Within and Across Species: Information Transfer in Mouse-Eared Bats

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Social learning describes information transfer between individuals (typically of the same species) by means of observation or direct interaction. Social learning in bats has been documented in a variety of contexts, and bats have proven to be valuable model systems for better understanding social learning and its mechanisms. Not only do bats live, and sometimes hunt, in large groups, such groups often comprise several species. Bats are thus well suited for investigating possible inter-specific information transfer. However, it has yet to be convincingly demonstrated that social learning occurs across species boundaries in bats. Furthermore, it is not fully understood what level of interaction between demonstrators and students is necessary for social learning. We address these questions by comparing the efficiency of two levels of interaction in intraspecific learning, and by investigating the occurrence of interspecific learning in sympatric bat species. We show that intraspecific social learning exists in the greater mouse-eared bat (*Myotis myotis*), and that direct interaction with a demonstrator enhances information transfer. Demonstrator-bats learned to identify food using an associated light cue and passed this information on to their students. In our paradigm, strict observational learning - without direct interaction - does not appear to be as efficient for information transfer as does direct interaction. Additionally, we did find some evidence for interspecific information transfer from *M. myotis* to *Myotis oxygnathus*. Our study adds to our understanding of learning and information transfer in wild-living animals.

Intergeneric Variation in the Baculum and Glans Penis of *Eumops glaucinus* and *Molossus rufus* (Chiroptera: Molossidae)

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Bats provide important models for studying diversity of form and function. Between the highly variable primary sex traits in male of some species of Chiroptera are the glans penis and the baculum (os penis). The size and shape of the baculum varies among species, and its variability even between closely related species has been considered a useful trait in taxonomy. Eumops glaucinus and Molossus rufus are species belonging to two different genera of molossid bats, whose taxonomic relationships are controversial. Despite its worldwide distribution, detailed information about the taxa are still insufficient for the interpretations and formulations of the evolutionary relationships among them. Because this our aim was to compare the glans penis and the morphology of the baculum in these two species. After cutting the penis of specimens they were diaphanized and analyzed under stereoscopic. In E. glaucinus the baculum has approximately 0.62 mm in length, it is curved in about two-thirds of its length when viewed laterally, and narrower in the apical portion than in the basis. The glans penis has around 1.53 mm, lacks epidermal projections and in ventral surface has a furrow in level of urinary meatus. In M. rufus the baculum is lower, with about 0.34 mm in length, shaft-shaped with rounded ends, narrowing in the midline. The glans is larger, has spine-shaped epidermal projections and an evident furrow at level of the urinary meatus. The present results reinforce the intergeneric differences for these features in these taxa of Molossidae.

The Bat-Moth Arms Race

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The intimate details regarding the coevolution of bats and moths have been elucidated over the past 50 years. The bat-moth story began with the evolution of bat sonar, an exquisite ultrasonic system for tracking prey through the night sky. Moths countered with ears tuned to the high frequency of bat echolocation and with evasive action through directed turns, loops, spirals, drops and power dives. Tiger moth (Lepidoptera: Erebidae, Arctiini) produce anti-bat sounds. In some species the sounds advertise moth toxicity, in others they mimic the sounds of toxic species, and in still others they jam the sonar signals of the bats. We have recently taken our laboratory studies of tiger moth anti-bat sounds back into the field where we use high-speed videography and high frequency microphone arrays to document the bat-moth arms race in 3D.

The Evolution of Skeletal Architecture in the Achievement of Powered Flight

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Bats face a host of locomotor challenges not encountered by terrestrial mammals. Compared to terrestrial taxa, bat wing elements display decreased cross-sectional bone areas, an adaptation that likely increases bone compliance to accommodate the high bending strains that result from powered flight. Unfortunately, little is known of the evolutionary origins of their bone architecture. Based on micro-CT scans, this study compares cross-section area of the midshaft of fore- and hindlimb elements in bats and other small mammals. We studied extant bats (n=30), the Eocene fossil bats *Icaronycteris index*, *Hassianycteris messelensis*, and *Palaeochiropteryx tupaiodon*, wild-caught and laboratory rodents (*Mus*, *Peromyscus*), and some extant insectivores. Compared to terrestrial taxa, the bones of bats displayed relatively thinner cortices in the radius and metacarpals, but not in other limb elements. All fossil bats displayed cortical thickness values within the ranges documented in extant bats. Ancestral character state reconstructions, using modern phylogenies and rodents as an outgroup, show that bat forelimb bone thicknesses display little homoplasy in the radius and metacarpals, and that the megabat *Cynopterus* has unusually thick cortices. Presence of a thin-bone phenotype in only certain elements of the forelimb, and its absence in the hindlimb, suggests that cortical thinning may act to decrease wing bone mass and to increase proportional resistance to bending forces. Therefore, selection to increase bending resistance was probably already driving skeletal morphologies at the base of Chiroptera. Ongoing analyses of additional fossils and extant bone microanatomy and paleohistology may reveal additional insights into the skeletal evolution of bats.

Bats without Borders --The Distribution and Conservation of Cave-dwelling Bats in Southern Africa

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Southern Africa is a subcontinent rich in bat fauna, but limited distribution data hinders ecological and conservation research. Climate change and extensive land use change are recognised as major threats to bats globally; yet, despite bats being a major taxonomic group in southern Africa we are unable to measure biodiversity change and consequently cannot implement any proactive measures to counter any declines. The overall aim of this project is to determine the distribution of focal cave-dwelling bat species. As a group, cave-dwelling bats are considered to be at higher risk from human impacts, due to their dependency on and 'visibility' in caves. We used Maximum entropy modelling (Maxent) to model habitat suitability in order to determine which ecogeographical variables influence/limit their distributions. Maxent uses presence-only occurrence data, which is particularly important when absence data is hard to obtain. Predictive maps were generated for focal species, using recently validated museum specimen data, and a suite of environmental predictor variables (including geological, physical and climatic data from southern Africa). Relevant variables predicting suitable habitat over this large subcontinent were species-specific, but in general water availability (both temporary and intermittent), seasonal precipitation, vegetation and distance to karst (caves/limestone areas) were the most important factors associated with distribution

patterns. This study illustrates how predictive modelling can be used as an important conservation tool to direct field work and inform conservation priority areas for research and monitoring of poorly studied species relatively quickly and at low cost.

Sonar Jamming in the Field: Advancements in the Study of Bat-Insect Interactions

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Advancements in imaging and 3-d calibration technologies have recently allowed for a new level of analysis of bat-insect interactions occurring in the natural environment. These technologies allow for capturing predatory events over ever-increasing volumes (500-1000 m^3) with the ability to reconstruct bat and insect flight trajectories in 3-D. We give two examples of studies on bats and sonar-jamming arctiine moths enabled by these new technologies. The first examines the effectiveness of sonar-jamming and flight evasion defenses by comparing attacks on clicking moths with attacks on silenced moths. Clicking moths escaped bats ten times more often than silenced moths, making sonar-jamming the most effective defense against bats ever documented. The second study combines laboratory and field experiments to document the acoustic cues available to insects while being attacked by bats, and the cues that an arctiine moth (*Bertholdia trigona*) uses to initiate defensive responses. Our results indicate that through echolocation call intensities and pulse intervals, bats provide insects telltale signs that they have been targeted for attack. *Bertholdia trigona* uses these specific cues to initiate defensive clicking, and to differentiate legitimate bat attacks from false threats where a bat is attacking another nearby insect. These studies help demonstrate what is possible with a new generation of imaging technologies suitable for field-recording of bats and insects.

Ectophylla alba: a Charismatic Tool for Environmental Education and Communication Using Bats

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Humans have always admired and protected the thing that gives us some direct benefit and that seems nice and pleasant. On the other hand, we have always feared what we do not know or understand. From this perspective the bats are in trouble, most people consider them ugly, dirty and dangerous. This bad reputation has led bats to critical conservation problems. The Bat Conservation Program of Costa Rica in conjunction with Tirimbina Biological Reserve developed an environmental education material based on years of research with *Ectophylla alba*. When you show a picture of this species most people are surprised that something that cute is really a bat. This material consists of an activity book and a storybook that aims to promote the conservation of bats by protecting their roosts and the diffusion of knowledge about bats. We have done workshops with around 500 children and 300 adults in Costa Rica. The results of these workshops show very positive results in both knowledge and sensitivity through questionnaires and drawings before and after the workshops. This material is currently used on environmental education in different countries as part of the Conservation Strategy of Central American bats.

A Plant Perspective: What Happens when Bats Modify Me as their Roost?

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There are 22 species of bats that use modified leaves as their roosts with different architectures, using at least 77 species of plants. One of the types of tent is "Conical" in *Potalia turbinata* (Gentianaceae), bats cut on the petiole at the base of the leaves to fold them from a 45^o to 70^o angle. We predict that this modification will have a negative effect on flower production of the plant due to the drastically changed angle and the decreased area exposed for photosynthesis. We worked at Tirimbina Biological Reserve in Sarapiqui, Costa Rica. We took phenology data from 135 plants in an area of 7.3 hectares, once a month during two years and 8 months. We found that the plants that aren't modified as tents produce an average of 63 $\pm$ 49 flowers (N=68) and the ones that are modified as conical tents for more than 9 months produce 43 $\pm$ 17 flowers (N=17). This is the third research that measures the effect on the modification on plants by bats and it is the first one that measures the effect on the reproductive success on plants.

Do Frugivorous Bats Use Shade Coffee Plantations for Roosts and Foraging Sites? The Case of *Sturnira ludovici*

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Shade coffee plantations are considered important habitats for biodiversity conservation. In these systems, frugivorous bat richness is equal or even higher to that in forest. However, whether these plantations are a reliable source of shelter and food to frugivorous bats is largely unknown. To answer this question we captured a total of 24 individuals of *Sturnira ludovici*, half in cloud forest (CF) and half in shade coffee plantations (SCP). Each bat was fitted with a radio transmitter to locate their roosts and feeding areas. Twenty roosts were located in cavities belonging to 11 different tree species. Roosts located in CF differed significantly (P <0.05) from SCP in smaller crown area, a higher percentage of understory cover, and greater richness and density of neighboring plants. Both home ranges and core use areas were smaller on average in SCP than in CF, but these trends were not statistically significant. The distances traveled by bats were generally longer and more variable in SCP. The distance between capture sites and foraging sites was significantly longer in SCP ($\overline{X}$=802.5m) compared to CF ($\overline{X}$=177.7 m, F = 8.57, P = 0.008). Although *S. ludovici* does use roosts and foraging sites in SCP, it is important to note that the maintenance of this species largely depends on the preservation of forest remnants in modified landscapes, where roosts and fruits are constantly and in abundance.

Space-use of *Mystacina tuberculata* in Relation to its Pollination of the Woodrose

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The lesser short-tailed bat (*Mystacina tuberculata*) is New Zealand's only native mammalian pollinator and the only fully temperate bat-pollinator globally. Although the bat's unique status as a pollinator is widely recognised, there has been little research exploring its pollination services; the short-tailed bat has a specialised pollination relationship with the fully-parasitic angiosperm the woodrose (*Dactylanthus taylorii*). The exploration of this relationship is important because like the short-tailed bat, the woodrose is endemic and endangered. It is also the only groundflowering plant in the world to be pollinated by a bat. The aim of this study was to examine the spatial ecology of the short-tailed bat with respect to its pollination of the woodrose. Radio telemetry and spatial logistic regression was used to explore changes in the bat's space-use with the onset of flowering in the woodrose. A preliminary investigation into the bat's potential for long distance pollen transport was also conducted using a pollen analogue. The findings show that short-tailed bats do alter their space-use to visit localised aggregations of the woodrose when it is in flower and that transfer of pollen does occur between spatially isolated woodrose populations. These findings build on the limited knowledge of the foraging behaviour of the short-tailed bat and their interactions with the woodrose. Ultimately, more informed decisions can be made to aid the conservation of these two endangered and unique species.

Heart Rates of Subtropical Blossom Bats (Pteropodidae) During Torpor

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'Fruit bats' (Pteropodidae) were previously thought to be exclusively homeothermic. However, recent reports have identified several small species capable of using periods of torpor to balance their energy costs. Torpor in these megabats is limited to daily torpor, unlike many insectivorous bats which hibernate and express multiday torpor. The few studies conducted on torpor physiology in megabats focused solely on thermal energetics, whereas cardiac physiology has received little attention. We aimed to quantify cardiac physiology during torpor for blossom bats (*Syconycteris australis*) in comparison to hibernating insectivorous long-eared bats (*Nyctophilus gouldi*). We investigated heart rate (HR), metabolic rate (MR), and subcutaneous temperature (T_{sub}) simultaneously, at rest and during torpor at a range of ambient temperatures (T_a). At rest (T_a = 10-12°C), HR of normothermic bats was 515bpm (*Sa*), and 510bpm (*Ng*); during torpor (T_{sub} ~15°C) HR fell to a minimum of 62bpm (*Sa*), 17bpm (*Ng*). HR and MR both at rest (r^2= 0.71 *Sa* and 0.64 *Ng*) and during torpor were strongly correlated (r^2= 0.98 *Sa* and 0.84 *Ng*). Although the thermal response of cardiac function of torpid *S. australis* was similar to that of hibernating *N. gouldi*, the slope of the relationship between HR and MR differed greatly. Our study provides the first quantitative data of

HR as a function of temperature for a 'fruit bat' during torpor. It demonstrates a clear difference of the relationship between HR and MR in daily heterotherms and hibernators even though they are from the same mammalian order.

Full Night On-board GPS Tracking and Audio Monitoring of Echolocating Bats

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Tracking animals in the wild is a challenging task. Tracking bats is even more demanding due to their small size and high speeds of movement. To overcome these difficulties we have developed a miniature device that includes a Global Positioning System (GPS) and an ultrasonic microphone. Since echolocating bats emit sounds in order to perceive their environment it is possible to infer their activity by recording their vocalizations. Ultrasonic recording also enables monitoring the presence of conspecifics. Our method thus allows full-night tracking of bats while monitoring their behavior. We used the device to track *Rhinopoma mycrophylum* bats, a social echolocating bat species that is common in northern Israel during the summer. These first full-night recordings of the echolocation of a single bat enable us to probe fundamental questions such as what determines pulse repetition rate and how the presence of conspecifics influences the emission parameters of an individual. Our main interest, however, is to determine the factors influencing foraging success and foraging planning. Preliminary analysis revealed many details on the ecology of these bats such as the duration of their foraging, the distances covered and the number of insects attacked per night. We found a large variability in foraging characteristics and are now analyzing how the: (1) strategy of movement, (2) presence of conspecifics and the (3) past success influence foraging success and future behavior. We expect that further development of this method will open a new window into the cryptic world of echolocating bats.

Mid-Cenozoic Emballonurids in Subtropical North America: Demise of an Archaic Lineage and the Origin of Neotropical Diclidurines

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The entire Paleogene-Neogene fossil record of the pantropical Emballonuridae in the western hemisphere consists of two molars of *Diclidurus* and a canine of indeterminate genus from the middle Miocene La Venta fauna, Colombia. New finds of emballonurids from several local faunas in Florida, USA, of Oligocene and Miocene age greatly enhance this record. The fossils appear to represent two different lineages of Emballonuridae. A new genus with two new species from two Oligocene local faunas, I-75 and Brooksville 2, represents an archaic lineage. These bats are dentally more derived than Taphozoinae (eastern hemisphere Eocene emballonurids and recent taphozoines), and are possibly related to Emballonurini. A single M1 from the earliest Miocene Buda local fauna may represent a third new species in, and is the last known appearance of, the same clade. A second new genus and species from the early Miocene Thomas Farm local fauna is more derived than the Oligocene taxa and appears to represent a Diclidurini. This taxon is similar to *Saccopteryx* and comprises the oldest known Diclidurini. The presence of these taxa in extreme southeastern and peninsular North America suggests that the evolution of the diclidurin clade occurred in tropical North America in the late Oligocene or early Miocene. These bats subsequently dispersed to South America presumably about the same time as did noctilionoids based on other fossils including speonycterids and new finds from Panama.

Clustering, Energetics, and Phenology of Hibernation in a Cold-Temperate Climate

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Hibernation consists of energy-saving torpor bouts (controlled reductions in body temperature (T_b)), which are interrupted by periodic arousals to normothermic T_b, presumably to correct physiological imbalances that occur during torpor. Arousals account for the majority of hibernation energy expenditure and arousal timing varies among individuals. Many hibernating bats are unusual among hibernators in their tendency to cluster in large numbers during hibernation and this could influence torpor arousal cycles, energetics and emergence timing. We tested the hypothesis that clustering is a strategy for energy conservation which also influences torpor bout duration and emergence timing. We predicted that bats with the smallest fat reserves at capture in early winter would be most likely to cluster and use the longest torpor bouts but would emerge earliest in the spring once conditions warmed

enough to support flying insects. We used temperature telemetry to quantify the frequency and duration of torpor bouts and arousals, infrared camera traps to record the tendency of individuals to cluster and cluster size, and passive transponders (PIT tags) to determine emergence timing of free-ranging bats hibernating in central Manitoba, Canada. We outfitted 7 adult females, 11 young-of-the-year females, and 28 adult males from two caves. This study will add to our understanding of hibernation behaviour and help determine links between clustering, energetics, and hibernation phenology.

The Structure and Function of Hibernating *Myotis myotis*'s Constitutive Immune System: Are Eurasian Bats Special?

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Mammalian hibernation consists of prolonged periods of reduced basic metabolic rate and body temperature, which are interrupted by intermissions of arousal when most of the physiological functions are temporarily restored. Hibernation affects as well the immune system, and it has been hypothesized that arousals may activate the dormant immunity to combat accumulated pathogens. Despite a plethora of studies on hibernating rodents and insectivores, we know virtually nothing about the immunocompetence of hibernating bats. We collected blood from greater mouse-eared bats (*Myotis myotis*) in order to compare the structure (white blood cell counts) and the functionality (bacterial killing capacity of the blood) of the pre-hibernating, hibernating and aroused individuals' constitutive immune system. In accordance with studies on non-Chiropterans, hibernating bats showed reduced numbers of total leukocytes, both agranulocytes being affected. After arousal, the numbers of these cells were restored, while the number of neutrophils was not affected as their values remain similar for all three physiological conditions. When compared with euthermic conspecies, hibernating individuals had the lowest bacterial killing capacity, although their immune system function at both 37°C and 9°C. The constitutive immune function is reduced during torpor, but contrary to all animal species studied so far, hibernation of greater mouse-eared bats has no influence on circulating neutrophils indicating a continuous preparedness of the immune system against pathogens. Further comparative studies are needed to test whether this is a general pattern among hibernating bats and if dissimilarities occur, to explain the apparent continental differences in susceptibility to colonization with *Geomyces destructans*.

Lying through Your Teeth: Non-independence and Convergence Mislead Morphological Phylogenetics of Phyllostomids

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Morphological characters are indispensable for understanding the pattern, process, and tempo of evolution. If phylogenetic characters are independent and free of systematic biases, then combining as many different kinds of characters as are available will result in the best-supported phylogenetic hypotheses. Since morphological characters are subject to natural selection for function and arise from the expression of developmental pathways, they may accumulate strong ahistorical signal and non-independence that amplifies those signals. We use new dental and multi-locus genetic data to quantify saturation and similarity in morphological characters, and introduce two likelihood-based approaches to identify strongly conflicting characters and integrate morphological and molecular data. We use these new methods to analyze the phylogeny of incomplete Miocene fossils in the radiation of Phyllostomidae (New World Leaf-nosed Bats). Morphological data were saturated and showed higher rates of change higher than most molecular substitution rates. The average dental character encoded variation much more self-similar when compared to the average molecular character. Saturation and high rates of change indicate ahistorical signal in the morphological data, and extensive similarity suggests characters are non-independent and biases are amplified. To integrate the morphological data into tree building, we used statistical molecular scaffolds and combined phylogenetic analyses excluding a small subset of strongly conflicting dental characters. The Miocene nectar-feeding †*Palynephyllum* nests within the crown nectar-feeding South American subfamily Lonchophyllinae, while †*Notonycteris* is sister to the extant carnivorous *Vampyrum*. These relationships indicate older divergences than hitherto suspected, with implications for the timing of radiation in the highly ecologically diverse Phyllostomidae.

Rabies Virus Monitoring in Bats from Area of Influence of a Hydroelectric Power Plant in Jirau, Rondônia, Brazil

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In Rondônia State, Brazil, a hydroelectric power plant is being built at Jirau. The implementation of huge enterprises such as the hydroeletric demands a series of alterations in the environment that can destroy artificial and natural shelters for bats. Several studies have found an association between environmental changes and outbreaks of rabies. Monitoring Jirau´s bat population was made over a period of three years. In this period 4.387 bats were captured (mist net or active search), 3.852 of them were ringed, 535 bats and 486 were sent for rabies diagnosis and rabies antibodies dosage (Direct Fluorescence and Simplified Fluorescence Inhibition Microtest). All bats were negative to rabies. The prevalence of antibodies was 15.4% (0% in the first campaign, 2.8%, 6.4%, 19.2%, 14.8% and 36.3% in the subsequent campaigns). The results of serology showed a progressive increase for every subsequent campaign. As the first campaign was performed before the demolition of the houses and vegetation suppression, these results may reflect stress and perturbation to the populations of bats (e.g. forced migration for new shelters and foraging areas, competition for space and food with established populations). When statistically analyzed using Kruskal-Wallis and Dunn tests confirmed that there is significant difference in the results observed in the first campaign and subsequent campaigns. The increase of rabies virus circulation among these bat populations indicate a potential risk of rabies outbreak that should be monitored.

Structure and Diversity of Pyllostomid Bat Assemblages on Riparian Zones in a Human Modified Tropical Landscape

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Tropical forests around the world have been lost, mainly because of agricultural activities. Landowners usually maintain the vegetation along riparian zones during the establishment of pastures. In human dominated landscapes, linear elements such as riparian vegetation help to maintain the diversity of bats. However, information about the role of riparian zones as a reservoir of bat species in human dominated tropical landscapes is lacking. The aim of this study was to assess the influence of riparian vegetation on the phyllostomid bat assemblage in an agricultural landscape. In a rainforest Southeast Mexico, bats were mist-netted at ground level in 12 sites: three riparian sites in mature forest, three riparian sites in pastures, three sites in continuous forest away from riparian vegetation and three sites in open pastures. In total 1752 phyllostomids representing 28 species were captured. Sternodermatinae was the most speciose and abundant subfamily and was present in all sites. Riparian mature forest and riparian vegetation in pasture sites have the greatest species richness and shared 60% of species. Riparian pastures hold 75% of all species identified. Open pastures sites have the lowest richness and abundance of bats and also have no Phyllostominae species. The absence of Phyllostominae species in open pastures was likely the result of their sensitivity to the decrease in resource availability (food, roost). Our findings support the hypothesis that the maintenance of riparian corridors in a fragmented landscape can be compatible with agricultural practices and bat biodiversity conservation.

Ecological Niche and the Evolution of Social Foraging

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Much of the past research on sociality in bats has focused on temperate species, many of which are only seasonally social, if they spend any time in social groups. The primary explanations for bat sociality, with a few exceptions, have then focused on collective roosting for the gain of thermoregulatory benefits of females from the temperate zones. In contrast, many of the more numerous tropical and sub-tropical bat species are social year-round often in long-term stable groups. It is these tropical species that show the greatest diversity in social and mating organization, and research comparing tropical and temperate species can test how and why sociality has evolved in bats, in the absence of confounding effects of seasonal disruptive events such as hibernation or migration. At least one major driver of sociality has been crystalizing from this comparative approach: energetic limitation, dependence

on ephemeral food resources, and correlated information transfer among roost members. We review how these energetic limitations relate to the unpredictability of shareable food patches in time and space and how the benefits of increased foraging efficiency through social foraging, information transfer, and eavesdropping may outweigh the costs of living in a group.

MHC Class II *DRB* Gene Diversity of *Artibeus jamaicensis* in Mexico

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The major histocompatibility complex (MHC) encodes a group of closely linked genes that play a central role in the vertebrate immune system. These genes translate surface glycoproteins membrane antigen presenting which interact with the T cells to generate the appropriate immune response. Most natural mammal populations studied possess high levels of diversity within the MHC. We examined genetic variation at the MHC class II exon 2 of *DRB* gen in fifteen populations of *Artibeus jamaicensis* in Mexico. The Jamaican fruit-eating bat (*A. jamaicensis*) is one of the most abundant and widely distributed species in tropical Mexico, with a broad potential to determine immunological assets by its population wealth. Using PCR amplifications, cloning and sequencing, we assessed the individual DRB allelic diversity. Sequences from 193 individuals were analyzed; we obtained eight sequences of 216pb per individual. We found 130 variable sites and 163 haplotypes were identified (haplotype diversity 0.9789 $\pm$ 0.0022). From three to five alleles were discovered in each individual, suggesting gene duplications (40% of individuals presented duplication). No deletion or insertions were detected, suggesting these are functional alleles. The rate of non-synonymous substitutions (0.7359) was greater than the rate of synonymous substitutions (0.2501) providing evidence for positive selection acting above the evolutionary history of the species in shaping MHC diversity. We conclude high haplotype diversity in wild populations of *Artibeus jamaicensis*, with large standards of gene duplication, and suggesting functional genes that translate MHC into immunological response.

Indecent Exposure: Was Non-target Mass-mortality of New Zealand Lesser Short-tailed Bats Caused by Primary or Secondary Poisoning?

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The use of toxic baits to control introduced mammals is essential for wildlife conservation in New Zealand, but also involves risks to non-target species, including the New Zealand lesser short-tailed bat (*Mystacina tuberculata*). Due to its terrestrial foraging behaviour and broad diet this species has been considered at risk of primary or secondary poisoning. In 2009, 115 lesser short-tailed bat deaths were observed during a rodent control operation using baits containing the anticoagulant diphacinone in Pureora Forest Park, New Zealand. Necropsy examination confirmed diphacinone poisoning. This was the first recorded non-target mass-mortality of this species. Reducing the risk of further such events occurring requires determining the route of exposure of bats to diphacinone. We therefore used infra-red cameras to record whether lesser short-tailed bats consumed similar non-toxic bait in captive and wild settings, and to record whether bait was consumed by arthropods likely to be consumed by bats. Ten captive bats were observed at two feeding stations containing the non-toxic bait and their normal captive diet for 264 ten minute periods over 12 nights, and no bat consumed the non-toxic bait. No free-living bat visited non-toxic baits during 252 h recorded over 35 nights at 12 sites in Pureora. Arthropods visited non-toxic baits at all 12 wild sites, and were recorded in 45% of ten minute periods sampled. We conclude that bats are more at risk through secondary ingestion of toxins via arthropod consumption than through direct ingestion.

From Research to Education, an Openness to the Community

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Over many years, our research group has been investigating on bats, but it was recently that we have become aware of the importance of expanding this knowledge to reach the community, if the goal is the conservation of bats. It is for this reason that in 2007, we decided to create the PCMA (Program for Conservation of Bats in Argentina) which although carries out researches, their primary goal is to provide education. Bats are a group of very special mammals that besides receiving threats, like any wild animal, has one of the most important

threats to the conservation of any species: "ignorance". Despite all the benefits to the environment and humans, they still produce negative reactions in people. Throughout all these years, the PCMA has made strong campaigns attempting to reverse this situation, working in educational institutions through lectures and activities, in order to inform to people that bats are beneficial and to clarify about the myths and legends that have been woven around them. Brochures have been produced as well as stories and educational material. There has been a strong spread through the media and through workshops at different levels of education and to the community in general. All these activities have allowed the PCMA carry the message about the bats and their benefits, thus advancing an important step toward its conservation.

Wing Area Variation from Measurements of Bats in a Tropical Dry Forest at Nancie Biological Station, Guanacaste

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Habitat type and foraging behavior are factors that promote wing morphology diversification in chiroptera, and this is related to flight energetic and biomechanic. We evaluated wing area relation in bats of dense and less dense undergrowth in a dry tropical forest at Nancite Biological Station, Guanacaste. We installed four mist nets during four consecutive nights in clear and dense undergrowth. The nets were open between 18:00 and 24:00 h. Wing area was calculated for each individual measuring fingers length: three, four and five, and area width between fingers: three-four and four-five using triangle formula (b*h)/2. Percentage of vegetative cover was calculated for each undergrowth type. We used a T test for independent samples to determine differences between wing area in clear and dense undergrowth. A total of 21 individuals were captured for dense undergrowth and 24 for clear undergrowth. No differences between wing area and undergrowth type was found, although there was a general pattern in which individuals with greater wing area were found in less dense undergrowth and individuals with lower wing area were found in dense undergrowth.

Long-term Memory of an Associative Learning Task in the Fringe-lipped Bat

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Long-term memories may be adaptive for animals that consume diverse and potentially rarely encountered prey items. The Neotropical bat *Trachops cirrhosus* hunts a variety of vertebrate and insect prey by eavesdropping on their mating signals. Prey mating signals are diverse and may be heard infrequently in the case of seasonally breeding prey species. One way to maximize foraging efficiency is to remember the calls of previously encountered prey for an extended period of time. To investigate the long-term memory capabilities of *T. cirrhosus*, wild-caught individuals were trained to retrieve a food reward from a speaker broadcasting an artificial auditory stimulus (cell phone ringtone), and were then released into the wild. Over a year later we recaptured a subset of these individuals and quantified their behavioral responses to the trained stimulus as well as two control stimuli: a different ringtone and a static tone. We also quantified the responses of naïve bats to the same suite of stimuli. We found that 1) the experimental bats flew to speakers broadcasting their learned stimulus, even after over a year without reinforcement, and 2) experimental bats generalized stimuli broadcast in the experimental context, as demonstrated by higher responses to the control stimuli than the naïve bats. Our study shows that bats can retain memories for an associative learning task for long periods of time without reinforcement. We propose that this capability may enable wild bats to maintain recognition of rarely encountered prey species.

Rates of Evolution in the Cranial and Postcranial Skeletons of Phyllostomid Bats

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The movement of lineages into new adaptive zones and subsequent differentiation are often accompanied by changes in morphology. Vertebrate morphologists typically turn to feeding systems for evidence of adaptation to new ecological niches. Previous analyses of phyllostomid bats found significantly lower rates of cranial evolution among the morphologically distinct subfamily Stenodermatinae, suggesting stabilizing selection following the early

filling of multiple feeding niches for which the family Phyllostomidae is well known. In contrast, the evolution of the locomotor system within phyllostomids has received little attention. Locomotor and feeding systems are integrally related, and both their rates of evolution and the possibility that they display multiple fitness optima have received little attention. We analyzed the rates of evolution and correlations between the traits in the locomotor and feeding systems by combining new phylogenies with series of measurements from species representing all phyllostomid subfamilies. Comparison of a series of evolutionary models across a large sample of phylogenies revealed multiple morphological optima in both systems, as well as correlation between skull shape and locomotor traits. The multiple optima recovered, linked in each case to trophic differentiation from and insectivorous ancestor, imply that selective pressures associated with niche partitioning have shaped the cranial and postcranial morphology of phyllostomid bats. Rates of morphological evolution were high at the base of the phylogeny, with much lower rates within each of the differentiated ecotypes. We conclude that the invasion of a new adaptive zone resulted in rapid evolution and was followed by stabilizing selection in both morphological systems.

Individual and Group Signatures in Territorial Songs of Male Greater Sac-winged Bats

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Acoustic territorial displays are common among birds but comparatively rare among mammals. The greater sac-winged bat *Saccopteryx bilineata*, an insectivorous Neotropical bat, is exceptionally vocal and known for its elaborate territorial displays. Male *S. bilineata* are often philopatric and establish small territories in their birth colony in which females can roost during the day. Territories of several males can be found in the same colony. Each harem male defends a territory of up to $2m^2$ of vertical surface in the day-roost against other males with complex territorial songs that are learned through vocal imitation. We studied social influences on male vocal activity and the occurrence of vocal signatures in territorial songs of 27 male *S. bilineata* from 12 different-sized colonies in Panama. Male vocal activity was significantly correlated with both the number of harem females and territorial neighbours as well as the overall colony size, indicating that males utter more territorial songs with increasing male-male competition. Territorial songs are multi-syllabic vocalizations with low-frequency buzz syllables being most prominent. We found statistical evidence for a pronounced individual signature encoded in the buzz syllables of territorial songs that could facilitate individual recognition among rivalling neighbours. Additionally, we found a vocal group signature in territorial songs, suggesting that young males may learn territorial songs from more than one tutor male. Male *S. bilineata* appear to cooperatively defend their colony against male intruders, making a group signature in territorial songs potentially advantageous.

How About the Conflict Between Wind Turbines in Temperate Forests and Strict Forest-dwelling Bats?

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The installation of wind turbines in Germany is continuing at full pace, but suitable, conflict-free sites are scarce. Therefore, the planning and building of turbines increasingly shifts to forests, which are otherwise mainly used for forestry. However, these sites could be important habitats for bats and wind turbines might lead to habitat loss due to construction and operation. European bats are strictly protected by law, and the EU is obliged to contribute to their conservation. Habitat-suitability models could be an essential aid in conservative wind turbine planning, however, model performance depends on the data quality. This study analyzed the accuracy and reliability of habitat-suitability models in forests and compares two data sets. The first model used climate, geographic, and land-use data that were low in detail and the second used detailed forest inventory data. To develop models roosting data of a strict forest-dwelling bat *Myotis bechsteinii* were used. We hypothesized that the model using low detailed data is sufficient in its performance to aid the assessment of species distribution, but that the visualization of actual species occurrence is more accurate in the high-detailed model. Models allowed very good spatial predictions of suitable habitats. However, the model using low-detailed data overestimated suitable habitat. The high-detailed model was better able to predict actual species occurrence and is, therefore, more appropriate for conservative wind turbine planning in forests.

New Approaches to the Analysis of Eocene Bat Teeth: Identifying Hidden Diversity in the Messel Bat Fauna

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The Grube Messel in Germany (middle Eocene) is a unique and spectacular locality for fossil bats. Messel bat specimens are remarkably abundant (>700 individuals known) and are typically represented by complete or nearly complete skeletons. The most common taxon by far of the four bat genera known from Messel is *Palaeochiropteryx*. This taxon is represented by the largest number of individuals and shows the most variability in body size and proportions. Recently, many exceptionally small specimens of *Palaeochiropteryx* have been found, suggesting the existence of at least one more "hidden" species besides the two already known (*P. tupaiodon* and *P. spiegeli*). Variation in dental morphology is a useful taxonomic indicator, however, until now it was not possible to easily examine teeth with conventional methods or to differentiate the two known species based on teeth because dentitions are often in occlusion or are hidden by the plate itself. We addressed this problem with the help of high-resolution micro-CT technology. CT scanning allows visualization of not only whole tooth surfaces but also their internal structures, which can be helpful for determining cusp homologies. Based on CT scans of Messel specimens of *Paleochiropteryx*, we have developed differential diagnoses for three species of *Palaeochiropteryx* based on dental structures. Until now it has been assumed that seven bat species existed at Messel, each filling a specific ecological role. The occurrence of an additional, small species of *Palaeochiropteryx* suggests that habitat utilization by Messel bats was more complex than previously thought.

Properties of a Bat Ensemble Vary with Scale and Habitat Variability across a Rainfall Gradient in Panamá

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Community properties (e.g., species richness, abundance) vary across spatial scales and are controlled by factors such as climate, habitat and species interactions. Usually, studies relate few properties to one factor in isolation and at one scale at a time. Hence, very few multi-scale studies in bat ecology have tested how multiple controlling factors simultaneously affect community properties at different scales. We ask whether climate, habitat structure, or insect resources at three spatial scales explain most of the variation in four community properties of a Neotropical insectivorous bat ensemble across a rainfall gradient in the Isthmus of Panama. Using climatological data, habitat surveys, and insect captures in a hierarchical sampling design we determined how much variation of the community properties was explained by the three factors employing two approaches for variance partitioning. Our results revealed that most of the variation in species richness, total abundance, and feeding activity occurred at the smallest spatial scale and was explained by habitat structure. In contrast, climate at large scales explained most of the variation in individual species' abundances. Although each species had an idiosyncratic response to the gradient, species richness peaked at intermediate levels of precipitation, whereas total abundance was very similar across sites, suggesting density compensation. Interestingly, idiosyncratic responses seem to be related to species' specific biomass; lighter species were more abundant at drier sites whereas heavier species showed the opposite trend. Overall, each community property responded in a different manner to the factor and scale under consideration.

Selection of Roosting Habitats by Male *Myotis* Bats in Balsam Fir-White Birch Forest

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Current lack of knowledge about bat roosting ecology within boreal forest stands limits our understanding on how these species may be affected by forest management practices. In balsam fir forests, Little Brown Bat (*Myotis lucifugus*) and Northern Long Eared bat (*Myotis septentrionalis*) seems to roost during summer under loose exfoliating bark of commercial timbers. The main objective of this project is to understand the factors involved in roost trees selection by male *Myotis* bats within managed boreal forests of Quebec, Canada. Fieldwork took place at the Montmorency research forest near Quebec City, from mid-June to mid-August. During 3 years, we captured 15 bats using mist nets located in various forest habitats. Radio transmitters were fitted on captured individuals to relocate them at their roosting trees during approximately 8 days after release. Selected trees by bats were compared to random trees, using variables such as Diameter at Breadth Height (DBH), tree height, tree degradation and

percentage of remaining bark. Surrounding forest habitat was also sampled and additional variables (such as size of canopy gaps, stand height and insolation) were derived using Light Detection And Ranging (LIDAR). I am currently analyzing LIDAR data that I shall present during the conference. Our actual results confirm that male *Myotis* bats selected snags with large diameter, mostly located in canopy gaps and within stands containing a higher proportion of snags nearby. Maintaining snags availability within balsam fir-white birch forest should be considered by silvicultural practices interested in promoting roosting habitat used by male *Myotis* bats.

From Social Environment to Physiological Adaptations: Insight of Male Reproductive Tactics in *Carollia perspicillata*

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Mating systems of bats are known to be very diverse. In many species, access to reproductive females is biased toward favored males. In *Carollia perspicillata*, females aggregate themselves at spots of interest. The control over these resources requires successfully guarding and protecting them against sneaking males. The energy investment for reproduction is therefore not similar for all males. Thus, physiological traits are expected to result from tactical allocation. In this project, we investigated three physiological aspects linked to the reproduction of male *C. perspicillata*. First, we analyzed the relation of social status with testosterone and cortisol circulating hormones. Using blood plasma hormone concentrations, we tested for divergences between harem and bachelor males. Second, following the predictions of sperm competition models, we searched for a greater investment of sperm resource per ejaculate in the bachelor males. Indeed, they are in a disfavored position and must invest more per copulation in order to fertilize a female. Sperm traits of motility and size of the ejaculate were again compared between males with different life-history traits. We obtained ejaculation in-vivo by performing an electro-stimulation. Finally, we monitored the allocation of two anti-oxidant molecules (vitamin E and glutathione) in the blood plasma. We also measured glutathione concentration in the sperm. The measures of oxidative damage in the sperm and plasma (lipid peroxidation and glutathione disulfide) revealed information about the general and targeted ability of the males to manage oxidative stress. Our project highlighted physiological adaptations of male reproduction to the social environment.

The Effects of Conspecifics on Echolocation in Bats

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Bats may face any number of challenges to their echolocation systems when flying with conspecifics. These may include jamming, interference, masking, echo ambiguity, and even the acoustic "clutter" created by echoes from the physical bodies of conspecifics. Whilst the Jamming Avoidance Response (JAR) is well documented in the electric fishes, the concept is not coherent when applied to echolocating bats. We investigated the effects of conspecifics on echolocation in *Myotis daubentonii* and *Rhinolophus capensis*. We used multi-microphone array systems to record bats flying alone and in pairs in indoor and outdoor flight rooms and also bats flying freely in the field. From these recordings we reconstructed flight paths and calculated call intensity, among other echolocation call parameters. Calls of *Myotis daubentonii* were shorter in overall duration and wider in bandwidth (steeper sweep rate and lower FM-min) when flying with conspecifics compared to when flying alone. In *Rhinolophus capensis* we found that the terminal FM sweep was longer and wider in bandwidth (same sweep rate, but decreased FM-min) when flying with conspecifics than when flying alone. Our findings show significant changes in the call parameters of two different bats, with very different echolocation systems, when flying with conspecifics.

Species Richness and Diversity of a West Indian Bat Assemblage in an Encroached Urban Forest

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We have obtained preliminary data on species richness and diversity in the Julio Enrique Monagas National Park, an urban forest located in the northern part of Puerto Rico. The research was conducted over a 12 month period. As part of the methodology we assembled mist nets, complemented by acoustic monitoring. To date, data

have been obtained on eight of the thirteen species living in Puerto Rico, that is, 62% of the species living in Puerto Rico are present in this urban forest. The nectar feeding *Monophyllus redmani* is the most abundant species so far. Diversity was high (H_s= 1.45), considering the insular nature of the assemblage and the fragmented nature of the ecosystem, and in comparison to results from previous studies such as research in the Hacienda Esperanza, a much less encroached habitat further west. Our results have important implications for management and conservation of biological diversity on tropical islands, and contribute to further development of a baseline against which the effect of urban encroachment can be compared.

Immune Responses in Hibernating Bats

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We are developing tools to better understand the immune physiology of bats and how it may differ from that of other mammals. Compared to other mammals, bats appear to have delayed or reduced immune responses to some pathogens that may allow them to be disease carriers. The state of immune suppression that accompanies torpor in hibernating bats renders them susceptible to the psychrophilic fungus, *Geomyces destructans*. The epizootic disease, white-nose syndrome (WNS) that results may be due, in part, to immune pathology that accompanies restoration of immune competence upon arousal from hibernation. In order to address whether immune responsiveness in hibernating bats is a contributing factor in WNS or in the ability of bats to serve as zoonotic disease carriers, we wish to establish the levels of normal immune function in bats and how they are affected by torpor. We have developed methods to measure levels of specific immune cells, cytokines, and antibodies within *Myotis lucifugus* and *Eptesicus fuscus*. We are comparing these molecular measures to classical ecoimmunological assays to determine which measures are correlated. We will also present our plans to develop gene expression assays to quantify and compare individual immune and metabolic mechanisms. Together, these methods should allow us to better understand the differences in immune physiologies between WNS-susceptible and WNS-resistant bat species and between bats and other mammals.

Mobile Transects Are More Effective at Detecting Bat Passes than Stationary Points in Low Bat Density Landscapes

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Numerous landscapes in North America have features that contribute to low bat densities, such as rare roost sites, clustered feeding areas, vegetation homogeneity, and climate patterns. Driving transects have been proposed as a method to collect large-scale data on bat presence and activity in low density habitats (e.g., grasslands, rangelands, deserts, croplands), as they can provide greater geographic coverage per night than stationary methods such as points counts. However, mobile sampling may under-represent activity at any given location along the transect. Our objective was to compare the efficiency of detecting bat passes between point counts and driving transects in a low bat density landscape (Lubbock County, TX). Three different survey methods were compared along the same 24 km route: a driving transect conducted at 24 km/h; a set of five, 10-minute point counts at permanent locations; and a set of point counts at locations randomized each survey night. Ten sets of the three survey methods were completed and data from each set was analyzed independently and pooled over the sets. A Pettersson D1000X time expansion detector was used to continuously sample the driven route and the point counts. Our data show that driving transects detect significantly more bat passes for the route than either of the point count methods. By maximizing the sampling area, driving transects effectively measure bat activity in an area with low bat densities without substantially increasing the sampling effort or cost, facilitating an increase in the scale of bat population and habitat studies.

Wind & Biodiversity: Solutions for Reducing the Impacts of Wind Farms on Bats and Birds

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Wind & Biodiversity is an R&D project that arises from the need of reconciling wind energy developments and biodiversity. When inadequately located and designed, wind farms can be responsible for negative impacts on

bats and birds. Because European Union Directives and regulations do not exclude the possibility of setting these projects inside Nature 2000 sites, promoters must assure that they do not compromise the conservation objectives of these areas. So, a fully understanding of the real impacts and the development of the best mitigation and offset measures are essential. The main goals of our project are 1) to understand the ecology and the dynamics of bird and bat populations; 2) to accurately quantify and also understand the reasons beyond bird and bat mortality; 3) to develop equipments and technology to mitigate bird and bat fatalities; 4) to develop, adapt and validate compensation measures to implement in wind farms with high mortality rates; and ultimately 5) to develop integrated and sustainable management solutions/services adapted to wind farms, according to its engineering, performance and ecological context. Up to now we obtained more knowledge on how bat and bird assemblages use wind farm areas, by using cutting-edge technologies (e.g. radar), and we developed mitigation/ compensation techniques and optimized methods to assess bat and bird fatalities. One of the main products of the project was the online platform Wildlife Fatality Estimator, which helps researchers and consultants to choose and apply methods and estimators, when estimating bird and bat fatality at wind farms.

Phylogeography of *Geomyces destructans* in North America and Europe

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Geomyces destructans is the fungus responsible for White-Nose Syndrome in bats. Prior to its discovery and description in the past several years this fungus was unknown to science. Detailed genetic work using microsatellites and genomic work with whole genome sequences on fungal isolates from bats and sediments in North America suggests a recent introduction and rapid spread across the eastern part of the continent. Using these same genetic and genomic approaches we have been searching for the likely source of *G. destructans* using isolates and swab samples collected from a variety of European sources. We describe the discovery of potential sources of *G. destructans* from Europe and the apparent introduction routes of this devastating pathogen.

Teachers Training and Community Work: Two Efficient Educational Strategies for Bat Conservation

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The PCMM has developed diverse educational strategies for bat conservation during 18 years already. Among all of them, the most successful ones are training future teachers and working for the conservation of priority caves hand in hand with the rural communities that are close to them. After 13 years of working with current and future basic education teachers from the Benemérita Escuela Nacional de Maestros (BENM), using a methodology that includes a training program and a supervised practice, we have proven that, once they join their workforce, they have incorporated the subject of bats and their conservation in their professional work, which creates a multiplying effect. Regarding community work, after eight continuous years in Grutas Xoxafi, we have proven that a strategy using short, medium, and long term goals and with activities designed for different groups (schools, authority figures, women, guides, etc.), is the best way to guarantee the cave-bat populations' conservation and to promote and note the participation of all the sectors of the communities, so everyone, humans as well as bats, has benefits. Currently, all the BENM groups visit Grutas Xoxafi. This action reinforces the conservation strategies' efficiency and the bond between the different bat conservation actors which are promoted by the PCMM.

Land Use Alters Bat Ectoparasitism by Changing Host Communities in Southern Costa Rica

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Bat flies are blood-feeding, often highly host-specific bat ectoparasites. Their host-parasite dynamics can be affected by numerous aspects of both host and bat fly ecology, including host roost duration, as well as anthropogenic disturbance. We examined the effect of anthropogenic land use change and host ecology on ectoparasitism of bats living in Coto Brus, Costa Rica, a mosaic of coffee fields and forest fragments. We caught 1195 bats representing 36 species, counted and collected their bat flies, calculated intensity (parasites per infested host) and prevalence (percent of hosts infested) of parasitism and identified bat flies to species (N=21 spp.).

Parasites were more prevalent on bats living in roosts of longer durations. Intensity did not vary between land use types, however, parasites were significantly less prevalent on bats caught in forest fragments adjacent to coffee than those caught in the nearby forest reserve. Individuals in these fragments were more likely to belong to species that had lower roost durations than bats in other land-use types. Intraspecific parasitism prevalence did not differ between land use types but both bat and bat fly species compositions differed significantly between land use types and were correlated with one another. These results indicate that small-scale land conversion does not affect parasitism dynamics within a given species but may affect overall parasitism dynamics through effects on host species communities, thereby changing parasite-mediated disease risk in bat communities.

The Impact of Oil Palm Plantations on Neotropical Bat Assemblages

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High global demand for palm oil has caused a steady increase of oil palm cultivation in Latin America over the past decades. Oil palm agriculture mainly comes at the expense of forests and leads to encroachment of plantations into natural ecosystems. This development calls for the evaluation of impacts on local biodiversity. Neotropical bats provide a variety of important ecosystem services and their enormous diversity comes with several specific roosting and foraging requirements. Modified habitat structure and consequently altered availability of resources in oil palm monocultures presumably leads to lower species richness and altered assemblage structure. Using mistnets and acoustic monitoring, we investigated the impact of oil palm plantations on Neotropical bats by comparing plantations to sites at the margins and interior of a lowland rainforest at the border of the Piedras Blancas National Park, Costa Rica. Based on captures, we found distinct assemblages and lower species richness in plantations in comparison to forested habitats. Species absent from plantations were predominantly animalivorous gleaners, a guild previously reported as disturbance sensitive. Relative abundances were highest in plantations, where captures were dominated by few species of canopy frugivores. Although oil palm plantations potentially represent stepping stones for matrix-tolerant species, they host an impoverished bat fauna and function as effective barrier for a big proportion of the natural species pool. Forest conversion in favor of oil palm cultivation can augment negative effects of forest fragmentation by decreasing landscape permeability and preventing the colonization of isolated fragments, consequently diminishing ecosystem services provided by bats.

Patterns of *Geomyces destructans* Infection across North America

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Transmission dynamics of *Geomyces destructans* in wild bats remain poorly understood. Determining prevalence, intensity of infection, and transmissibility among individuals in wild bat populations aids development of effective management strategies for controlling spread and mitigating impacts of WNS. We assessed prevalence of *Geomyces destructans* infection by swab sampling bats in 20 states across enzootic, epizootic, and leading edge regions in North America during the 2011-2012 and 2012-2103 winter seasons. Prevalence varies by species in highly impacted regions even within the same hibernacula and by region depending on time since WNS first detected. We also compare infection prevalence and intensity on bats to hibernacula wall substrates. By non-invasive swab sampling of multiple individuals at sites, we are able to provide early detection methods of presence of *G.destructans* before disease symptoms or mortality and visible infection are apparent. Our results are useful to track spread of *G. destructans* at a continental scale and determine factors associated with risk of arrival of *G. destructans*, disease progression, and impacts to populations.

Agriculture and Bats in the United Kingdom: Do Agri-environment Schemes Benefit Bats and their Insect Prey?

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Agricultural intensification is a major cause of biodiversity declines. Agri-environment schemes (AES) have been introduced in many countries as an attempt to counteract the negative effects of intensive agriculture by providing financial incentives for farmers to adopt environmentally-sensitive agricultural practices. We surveyed pairs of AES and conventionally-managed farms in central Scotland to assess the effectiveness of specific

prescriptions (field margins, hedgerows, species-rich grasslands and water margins) and the importance of the surrounding landscape for bats and nocturnal insects. Bat activity levels (mainly *Pipistrellus* spp.) and abundance of their insect prey (mainly Diptera and Trichoptera) were lower on farms participating in AES than on non-participating farms. In contrast, moth abundance and species richness were higher on farms participating in AES. AES field margins, species-rich grasslands and water margins (but not hedgerows) had higher moth abundance and/or species richness than their conventionally-managed counterparts. Fragmentation metrics related to woodland configuration were the most important landscape characteristics influencing bat activity levels. The extent of rough grassland and scrub within 500 m of the trapping site was the most important landscape predictor for nocturnal insect abundance and (moth) species richness. In summary, the implementation of the AES management prescriptions assessed in this study benefits moth populations (and could potentially benefit moth-eating bat species), but not Pipistrelle bats nor other bat species foraging on similar prey, which may respond more positively to a landscape-scale management approach focused on the creation and management of woodland.

Habitat Use by Aerial-hunting Insectivorous Bats in the Corredor Biológico Chichinautzin, México

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The Corredor Biológico Chichinautzin (COBIOCH) is a Protected Natural Area located in the northern part of the state of Morelos, with elevations ranges from 1,250 to 3,450 m, and spans eight vegetation types. Currently, very little information regarding bat fauna is available for the area. As part of an ongoing program to monitor bat populations in the COBIOCH, we determined habitat use by foraging bats by acoustic surveys in 5 habitat types within COBIOCH (Pine, aok-pine, oak, tropical deciduous forest and farmland). During October 2012 to March 2103, we recorded echolocation calls in 20 one-kilometer line transects using Echo Meter EM3 bat detector. We applied qualitative and quantitative analyses to identify time-expanded echolocation calls from free-flying bats. Thirteen species of insectivorous bats were identified corresponding to the families Molossidae, Vespertilionidae, Mormoopidae and Emballonuridae. Species in the genus *Myotis* were the most common and widespread species in the area, being generalists in using foraging habitat, while *Eumops* were the restricted, being recorded using only pine habitat. *Pteronotus parnellii* was a very common user of tropical deciduous forest and oak forest. Pine and oak woodlands, and tropical deciduous forest, were used extensively by eight aerial-hunting bat species, while pine-oak forest were used only by four species. These results provide some insight into actions for protecting bats in COBIOCH. Tropical deciduous, pine and oak habitats constitute an important target for bat conservation.

Predation on Birds by the Bird-like Noctule in Japan

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Recently, unexpected bird-eating behaviour has been reported for two large insectivorous temperate bat species. It is thought that those species capture migrating birds while flying at high altitude, although this has not been observed directly. One question raised by these unexpected findings is whether large aerial-hawking bats along the routes of migrating birds in other temperate regions also make use of this food resource. In this study, we analysed the diet of the birdlike noctule *Nyctalus aviator*, one of the largest aerial-hawking bats in Japan. We analysed 9,167 faecal pellets of the birdlike noctule collected from three day roosts in Japan. Bird feathers were found in pellets collected in spring (May and June) and autumn (mid-August to September), whereas no bird remains were found from the pellets in summer. Faecal pellets from October to December contained a large amount of bird remains (feathers and bones). Although there seemed to be inter-annual variability in the timing and the amount of bird predation, our results indicate that *N. aviator* consumed migrating birds in spring, autumn and early winter. Also, it is possible that prey species varied with geographical area, or with season, because bird bones were found in the droppings in early winter in only one locality. Given the great species diversity and wide distribution of bats, predation on migrating birds by large-sized insectivorous bats is likely more general along migration routes in

other temperate regions. Our results provide new perspectives on the ecological and evolutionary interactions between bats and birds.

An Automated Aerial Telemetry System for Tracking Bats

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Radiotelemetry and other methods of tracking (e.g., satellite tracking or GPS tags) have been used with great success to develop our understanding of bat movements, foraging habits, and migratory patterns. However, tracking bats is notoriously difficult – even with advanced equipment – and often prohibitively expensive. Thus, there exists a need to increase the reliability of data collected using telemetry techniques while controlling costs. Our goal over the past two years has been to adapt existing commercial unmanned aerial vehicles (UAVs) into a fully autonomous wildlife telemetry platform using inexpensive, modifiable electronics and open-source flight control software. Our resulting UAV system costs less than $500 and is capable of tracking a radio source for approximately two hours of continuous flight time. We are able to follow both stationary and moving targets, but we anticipate that tracking of moving targets will be more reliable given the limitations of the flight platform and onboard algorithms. While we do not expect to fully replace the human element of radiotelemetry, we anticipate that automated tracking UAVs will assist in locating roost trees in challenging terrain, reduce the cost of using aerial telemetry, and limit data gaps by ensuring more constant contact with the target. Future goals, UAV upgrades, and anticipated applications will also be discussed.

Public Outreach about Bats in Fairs and Holidays in Bolivia

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People's misconceptions is among the many threats bats have to face as it enhances the bad image of them and promotes negative attitudes, leading sometimes to extirpation of local and beneficial. Public outreach has becoming an important tool to change the image of bats and working with children has proved to be important. However, this activity does not involves the entire family. Here we describe and discuss an activity PCMB has to reach directly broader audiences. The main activity includes the "Bats Tent" that can be placed in fairs and public spaces attended with large crowds, and coordinated with several members and volunteers of the program. Activities in the Tent are organized for ages, and includes from games, sories printed on posters to exhibit ofstuffed specimens. Weare based in the hypothesis people changes their perception once exposed to bat information. We test this by designingclosed and open evaluations. Closed evaluations are based in scoring perception through tests based on comparing previous experiences with newly acquired information. Open tests were based in requesting filling out a book based on their given information. These methods were applied in 8 fairs in Cochabamba, Bolivia, to over 1500 people. More than 80% showed mostly interest in the explanations that involved showing specimens. This activity has proven to be very efficient in changing people's misconceptions and implies hard volunteer work. This has to be part of other public outreach activities within each programs' country.

Ecological Interactions between the Mexican Long-nosed Bat and the Morning Glory Tree in Central Mexico

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The Mexican long-nosed bat (*Leptonycteris nivalis*: Phyllostomidae) is a migratory and endangered species. El Diablo cave, the only known mating roost for this species, is located in Central Mexico, where the morning glory tree (*Ipomoea murucoides*: Convolvulaceae) is an important source of pollen and nectar for nectar-feeding species in the tropical deciduous forest. To investigate the strength of the relationship between the Mexican long-nosed bat and morning glory trees, we determined the bat's diet by analyzing pollen form bat's fur and performed pollination experiments to determine the role of bats as pollinators and the plant mating system. To investigate the role of morning glory tree as a source of energy for the bats we calculated bat energetic requirements, measured the energetic offer by the plant's nectar and estimated its carrying capacity. The plant was always present in the bat's diet. Although this plant is self-incompatible, fruit-set of plants pollinated by bats did not differ from those of plants pollinated by other agents. Each bat requires around 100 kJd^{-1} and each flower accumulates 1.32 kJ during the night.

In this atypical year, there was a mismatch between flowering and bat presence in El Diablo Cave, and therefore, carrying capacity was not determined by this plant. We do not discard the bat as a main pollinator, and the plant as the main energy source, when flowering and bats coincide as it happens in normal years.

Diversity and Abundance of Bats from Las Capillas, Jujuy Province, Argentina

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The forests of Northwestern Argentina are among the richest and most diverse in the country. For decades the human activities have affected large areas with a great negative impact on their flora and fauna. However our study site, Finca Las Capillas, have an excellent status of conservation, because for more than 50 years the access to humans activities has been restricted, diminishing the antropic effects on the wildlife. We present the results of 12 surveys developed between 1996 and 2012. Bats were collected with mist-nets placed inside vegetation, over ponds and close to water. Species accumulation curve was calculated with EstimateS program to determinate if the surveys were representative. Three estimators of species richness were used: Chao 1, Jackknife 1 and MMMeans. The Shannon and Simpson diversity indices were calculated to analyze and describe the diversity of the area. Twenty-four species were recorded, representing the four families of Argentina, of which 51% belongs to Phyllostomidae; the sample contains species of all trophic guilds, being the insectivores the most abundant. Several species represent the first record for Argentina, and are not known elsewhere in the country. The Shannon index was 3.37, high in comparison with other localities. It is fundamental that this area continues to be restricted to human use, a reason for which was recently declared as AICOM (Important Area for Conservation of Bats) with the support of the PCMA (Program for Bat Conservation in Argentina) and RELCOM (Latin-American Bat Conservation Network) as a first step for its protection.

What Scale for What Species to Investigate the Effect of Habitat on Bat Activity?

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Characteristics of habitat are determinant in explaining the acoustic activity of bats. Habitat type, fragmentation and anthropization are regularly considered in ecological studies. However, the spatial scale at which those characteristics are measured could influence significantly the results. This scale effect varies according to the taxon considered. According to their high mobility, bats have a large foraging range. The aim of this study is thus to determine which spatial scale matters for research on bat habitat. To do this, we investigated at which scale the correlation between acoustic activities of bats and habitat composition is the strongest. A French national bat monitoring program collected bats calls along road transects. A barycenter of each 200 meters transect (n_1=10000) was considered as one sampling point. For each point, every bat passes (n_2=40000) were identified to species, and an index of acoustic activity for nine common bat species was calculated. Based on Corine Landcover layer, habitat composition surrounding each point was analyzed along a gradient of spatial scale. We tested the effect of habitat composition on acoustic activity of different species, considering different spatial scale. Preliminary results allowed identifying the most pertinent spatial scale that has to be taken into account for each bats species. These results may imply new considerations for management plans of protected area, as areas centered on roosting sites, or for environmental impact assessment.

Postcranial Skeleton of Seven Genera of Bats of the Family Phyllostomidae from Northwestern Argentina: Description and Comparisons

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In Argentina, the phyllostomids are the second most diverse group of bats, represented by 19 species. Eleven of that species, belonging to four subfamilies, and representing five trophic guilds, are distributed in the northwestern the country, an area from where we describe and compare seven species and seven genera, based on 28 specimens collected and prepared as complete skeletons, and deposited at the Colección Mamíferos Lillo, Tucumán,

Argentina. Our objectives were to describe and compare the structure, size, shape and orientation of each element of the post-cranial skeleton of all the analyzed species. Differences were found in both, the axial and the appendicular skeleton. In the axial skeleton, the differences were observed in the neural arch, spinous process, and transverse process and foramen of the vertebrae. In the scapular and pelvic girdles, the differences were found in the sternum (e.g. lateral, posterior and ventral processes of manubrium), and pelvis (e.g. gluteal fossae, isquiatic tuberosity, ascending ramus of ischium) respectively. In the forelimbs and hindlimbs, the variations were observed in the proximal and distal epiphysis of humerus and radius and in the head, and greater and lesser trochanters of the femur and proximal epiphysis of the tibia. This set of characters brings important information to help in the understanding of the possible adaptations of the postcranial skeleton for each type of feeding habits, and in the future they could be use as complementary evidence for phylogenetic studies.

Hey Mom, What's for Dinner? Post-weaning Maternal Food Provisioning in a Bat with a Complex Hunting Strategy

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Adult animals of many taxa show extended parental care by transferring food to inexperienced offspring, thus providing nutritional and sometimes even informational benefits such as the acquisition of adult dietary preferences and foraging skills. In bats, post-weaning food provisioning is severely understudied, despite the taxon's diverse and complex foraging strategies. The Neotropical Common Big-eared Bat, *Micronycteris microtis,* preys on relatively large insects gleaned from vegetation, finding its silent and motionless prey by echolocation. The demands of this cognitively challenging hunting strategy make *M. microtis* a likely candidate for maternal post-weaning food provisioning. We studied five free-living mother-pup pairs in their night-roost using infra-red video recordings. Each mother exclusively fed her own pup and mother-pup recognition was mutual. Provisioned pups were volant and had started own hunting attempts. Weaned pups were provisioned for five subsequent months with a variety of different insects, reflecting the adult diet. Mothers transferred over 50% of their prey intakes to pups. Maternal prey transfers declined as pups matured, whereas the pups' self-hunted prey intakes increased. During prey transfers, aggressive behaviour between mothers and pups was scarce. We argue that post-weaning maternal food provisioning might yield two informational benefits for *M. microtis* pups: First, learning how to handle large and defensive prey is mandatory for inexperienced pups and could be practiced with prey items provided by their mothers. Second, acoustically characteristic echo images of prey items could be gained during mother-pup prey transfers, probably facilitating the successful acquisition of *M. microtis*' complex hunting strategy.

Bat Aestivation

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Mammalian torpor is often expressed in winter. Bats are known to use torpor also during summer (aestivation), but quantitative data on bat aestivation, especially from the field, have only recently become available. Generally, it is assumed that variables of torpor in summer largely reflect the higher temperatures experienced, with only minor or no seasonal physiological adjustments. However, data on bats show that temperature effects explain only some of the seasonally changed torpor patterns. In Australian long-eared bats, *Nyctophilus* spp., minimum metabolic rates during torpor (TMR) showed no significant seasonal changes. Further, the thermal response of the duration of torpor bouts in free-ranging subtropical *N. bifax*, although mean torpor bouts were ~8-fold longer in winter, was described by a single regression line for both seasons, suggesting that these seasonal changes were largely caused by temperature. In contrast, the minimum skin temperature - ambient temperature relationship of *N. bifax* differed significantly between summer and winter. Subtropical blossom bats, *Syconycteris australis*, express daily torpor in both seasons. However, under the same thermal conditions, torpor bout duration in summer was ~35% longer and minimum TMR was only ~60% of that in winter, demonstrating a physiological adjustment. Similarly, desert freetail bats, *Mormopterus* sp., at the same ambient temperature, remained torpid longer in summer than in winter, but, like in *Nyctophilus* spp., no seasonal differences in TMR were found. Our comparison shows that, in addition to seasonal changes in torpor patterns due to temperature, bat aestivation can involve substantial physiological acclimatisation.

Seasonal Variation in the Basal Rate of Metabolism of *Pipistrellus pipistrellus*: a Comparison with Other Small Mammals

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Basal metabolic rate (BMR) is the lowest metabolic rate of a normothermic endotherm. Being indicative of how fast the physiology of an endotherm is working, it is widely used in comparative analyses. It has also been shown to vary seasonally, but the extent of this phenotypic flexibility can be difficult to assess when concurrent variations in body mass occur. BMR was measured in 28 common pipistrelles (Vespertilionidae), including 14 "summer" (May-July) and 14 "autumn" (August-October) individuals, and the observed seasonal variation was compared with that of other bats and small terrestrial mammals (< 150 g). BMR was significantly influenced by season in pipistrelles (ANCOVA, $P < 0.05$) : it decreased between summer (8.0 ± 0.7 mL h^{-1}; 76% of expected) and autumn (7.2 ± 0.8 mL h^{-1}; 63% of expected), while body mass simultaneously increased (4.6 ± 0.4 g vs 5.2 ± 0.9 g). A comparison of these data with measurements previously obtained by the author on *Lasiurus seminolus* and *Nycticeius humeralis* already demonstrates the existence of some diversity in the seasonal variation of BMR among vespertilionid bats, and shows that accounting for concurrent variations in body mass is essential when assessing this flexibility. A comparative analysis among small mammals sets non tropical bats such as *P. pipistrellus* apart from most other small mammals, inasmuch as these bats downregulate their metabolic rate in fall concurrently with an increase in body mass, while the general trend among small mammals is rather a positive link between BMR and body mass variations.

Spring Arrival Sequence and Summer Activity of Bats at Schmeeckle Reserve and Kemp Wildlife Station, Wisconsin, U.S.A.

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Wisconsin currently has a healthy population of bats. However, cave-hibernating bats and migratory tree-dwelling bats are threatened by White Nose Syndrome (WNS) and wind farms in Wisconsin. White Nose Syndrome is due to a fast-growing fungal disease that arouses bats during hibernation causing the depletion of energy stores, exposure, and potentially death. The disease has spread quickly since its discovery in New York in 2006, threatening some species with extinction, and is expected to reach Wisconsin within two years. Migratory tree-dwelling bats are experiencing high mortality rates around rapidly growing wind farms throughout North America. Data were collected from acoustic detectors (Anabat) permanently mounted by the Wisconsin Department of Natural Resources (WDNR) at two sites in the state: Schmeeckle Reserve in Stevens Point and Kemp Wildlife Station on Lake Tomahawk in Woodruff. Echolocation calls were collected and analyzed from each site for April through August 2009–2012 to determine the spring arrival sequence and overall summer activity patterns of individual species. Analook software was used to identify individual species of bats and to record time and date of activity. *Myotis lucifugus, Eptesicus fuscus/Lasionycteris noctivagans,* and *Lasiurus borealis* are the most common species with variations in prevalence between the two sites. Little activity was detected in April with the majority of activity occurring in July and early August. This research project contributes to baseline distribution, migratory, and hibernation data being collected by the WDNR to further the understanding of threats to these ecologically and economically important resident bat populations.

New Neurons in Adult Brain of Some Microchiropteran Bats

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In the adult mammals new neurons are generated in two brain structures: subventricular zone (SVZ) of lateral ventricles and dentate gyrus (DG) of hippocampus. The only known exceptions are adult Sorex shrews that do not generate new cells in the DG. However, many important mammalian orders were not investigated in this respect. We decided to enlarge the list of mammalian species investigated for adult neurogenesis by some species of microbats. The bats were captured on permission of the Ministry of Environment of Armenia. After capture all bats were injected with bromodeoxyuridine (BrdU, 300 mg/kg). Seven to nine days later animals were perfused transcardially with 4% paraformaldehyde in narcosis. We used immunohistochemical double-labeling to characterize the phenotype of newly generated cells. Colocalization of BrdU with NeuN (marker of mature neurons),

glial fibrillary acidic protein (GFAP, astrocytic marker) and 2`,3`cyclic nucleotide phosphatase (CNP, oligodendrocytic marker) was examined using confocal microscope. We found that in both neurogenic regions the rate of neurogenesis was highest in *Rhinolophus ferrumequinum* and lowest in *Rh mehely*. Double-immunolabeling showed that in all neurogenic regions of the bats' brain the neuronal phenotype dominated among newly generated cells, while proportion of astrocytes was low. BrdU colocalized with CNP in only a few cells in the SVZ of Rh ferrumequinum. We suggest that the rate of neurogenesis in different species may depend on the bats' ecology.

Fossils, Development, and the Evolution of Bat Flight

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The transition to powered flight in bat ancestors involved evolutionary novelties with profound functional implications. Bat research in many fronts simultaneously provides a rich array of data that have the potential to reveal the evolution of flight. Here I attempt to integrate this knowledge in a comprehensive approach to understand the origin of bats. I investigated the evolution and development of some key organ systems using tools from gross Anatomy and Embryology, Paleontology, Phylogenetics, and molecular control of development. I integrated these diverse sources to formulate sequences of character change to the extent possible supported by developmental information. Anatomy of fossils revealed not only character states of Early Eocene bats, but also the developmental stage attained by key organ systems as compared with states of their descendants. These attributes were enhanced, reduced, lost or otherwise modified in specific ways suggestive of selection along the many lineages of modern bats. Coupling this with both molecular and macroscopic developmental data allowed to generate firm hypotheses on the evolution of wings and legs and their many fine adaptive functional details. These findings have broader implications when integrated with aerodynamic and paleoecological data. Evolution of the bat functional anatomy was found to compose a mosaic of embryonic retentions versus divergences from a basic mammalian developmental plan. Part of that evolutionary history can be readily traced with the aid of fossils. Changes in the pattern of expression of developmental genes may have allowed a rapid evolution of the functional anatomy.

Influence of Call Structure on the Jamming Avoidance Response (JAR) of Brazilian Free-tailed Bats

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Bats rely heavily on echolocation for orientation and prey detection, hence abiotic and biotic factors that interfere with echo reception are problematic. When flying in the presence of other bats, individuals have been shown to adjust their echolocation to avoid frequency overlap with the calls of nearby conspecifics, known as a jamming avoidance response (JAR). One aspect of JAR that has not been examined is how the spectral structure of the jamming signal (i.e. CF vs FM) impacts the jamming response. The objective of this research was to examine how the structural characteristics of an echolocation broadcast impacts JAR in free-flying Brazilian free-tailed bats, *Tadarida brasiliensis*. We created four echolocation playbacks that had the same minimum frequency and duration, but differed in call shape and frequency modulation (CF only, FM only, FM with short QCF section, FM with long QCF section). We examined the response of bats when: 1) flying in the presence of an unchanging broadcast (static stimulus), and 2) when the playback signal was abruptly switched as the bat approached the speaker (dynamic stimulus). Initial results reveal that bats exhibited JAR in the presence of the broadband playback signals, but not in the presence of the narrowband broadcasts. Further, the presence and/or duration of the terminal QCF section did not impact the observed jamming response. 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.

Threat Assessment and Conservation Prioritization of the Bats of El Salvador

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The Bat Conservation Program of El Salvador (BCPES or PCMES in Spanish) as part of the Central American Strategy for Bat Conservation applied the Method for Species Extinction Risk Assessment (MER in Spanish) for threat assessment to the bats of El Salvador, the smallest country in Central America. The method is

based in four evaluation categories: Distribution, Habitat, Vulnerability and Human impact. At the national level, nine out of 67 species were found to be threatened. Most threatened species are from the family Phyllostomidae (six species) and the other three are from the families Mormoopidae, Natalidae and Vespertilionidae. We used the number and distribution of threatened species and species richness for a complementarity analysis to identify Important Bat Conservation Areas (IBCA or AICOM in Spanish) in El Salvador. The area with the most threatened species (four of nine threatened bats) is El Trifinio – El Pital, where the threatened species occur in pine-oak and cloud forest. In addition, we determinate the principal threats for Salvadorian bat species which are: Habitat loss, misperception of bats (misinformation), control practices for vampires, indiscriminate use of toxic substances and eradication of bats living in buildings. Based on the risk assessment, the identification of IBCA and the determination of the principal threats, we developed a three years plan that includes investigation, education and conservation actions for the persistence of bats in the country. This plan will be upgraded at the end of the period with a long term strategy to fulfill our main objective.

Swarming and Hibernating Pipistrelle Bats: a Four-Year Capture-Recapture Study

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Autumnal swarming is well described for several *Myotis* species and is generally characterized by a strongly male-biased sex ratio. One hypothesis is that swarming is a mating behavior allowing gene flow between isolated colonies. Alternatively, these autumnal gatherings may be a social event where females "teach" juveniles where hibernaculums are. The mating system of pipistrelle bats (*Pipistrellus pipistrellus)* remains enigmatic. Here, we present a four years survey of a colony in an abandoned mine in Switzerland, frequented all year long and used both as a "swarming" site and as a hibernaculum. Bats were monthly captured from April to October the first three years and weekly the last year. Age, sex, weight and recapture data were collected during the study. Acoustic recordings were performed during one winter to assess activity during hibernation. Adult males regularly frequented the site during the capture period, with a slight peak in July and August. Adult females show a more marked peak of abundance in August, with a higher density than males. A peak of juveniles of both sexes is observed a few weeks after the female's peak. This pattern strongly differs from the one described for *Myotis* species. Our data suggest a particular social structure, where swarming differs from other species and where the presence of juveniles late in autumn might reflect a more complicated social structure than expected. The very low recapture rate and recaptures at distant sites suggests that individuals frequenting the site belong to a much bigger population.

Form and Function: Analysing Flight Trajectories for the Study of Behavioural Strategies

Holger Goerlitz
Max Planck Institute for Ornithology, Germany

Video and acoustic methods are increasingly employed to calculate the spatial positions of flying animals in the lab and field. Time-alignment and potential smoothing of the positions yields the flight trajectory, i.e., the three-dimensional movement of the animal in space. Analysing the form and shape of these trajectories informs us about the animal's behaviour and about the function of the flight for the animal's behaviour. This talk aims to present different methods to analyse flight trajectories and their form in relation to the animal's surrounding and to other flying animals to understand their behavioural functions. Flight trajectories can be analysed individually to estimate a range of descriptive parameters, such as speed and acceleration as derivatives of the positional information, or tortuosity, curvature and others to describe the shape. Next, by including directional information and placing the flight trajectories in relation to other fixed and moving objects, the relative distance, direction and orientation can be obtained, and their variation over time can be analysed. Multiple flight trajectories can be compared by extracting and comparing multi-dimensional patterns or by phylogenetic classification of the trajectories. Finally, to understand the function with respect to other behaviours and the environment, additional measurements are required. This includes call recordings, distance to external objects (including the trajectories of other animals) and environmental measures. Using flight trajectories of bats that are interacting with moths, with other bats and with loudspeaker playbacks, I will illustrate some of these approaches and refer to the upcoming talks within this symposium.

Potential Distribution of the Migratory Corridor of an Endangered Pollinating Bat in Mexico and USA

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The Mexican long-nosed bat (*Leptonycteris nivalis*) is a nectarivorous bat with a distribution from central Mexico to the southern United States. Currently it is listed as endangered in both countries and globally by the International Union for the Conservation of Nature (IUCN), due to a 50% reduction in its populations in the last 10 years. Evidence suggests that mainly pregnant females migrate north at the beginning of spring each year, following the blooms of century plants (paniculate *Agave* spp.). The objective of this study was to model the potential distribution of this "nectar corridor". I used occurrence data of paniculate *Agave* spp. distributed within the known northern distribution of the bat, and modeling algorithms (GARP and Maxent) to predict the geographic distribution of the corridor. The best models obtained, one for each agave species, were combined to produce an agave richness map. Findings suggest that areas with higher agave richness coincide with the occurrence data of *L. nivalis* and, in particular, with the location of known maternity caves. We are using the model results to help guide field assessments to confirm the status of foraging and roosting sites and define priority areas for conservation. This information is fundamental to direct conservation actions and maintain the pollination services that *L. nivalis* provides to populations of plants of ecological and economic importance in arid and semiarid ecosystems.

Effects of Experimentally Reduced Food Availability on a Captive Colony of Jamaican Fruit Bats (*Artibeus jamaicensis*)

Kelsey Gonzales and Rick Adams
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The effects of reduced food availability would predictably lead to increased intraspecific competition. We tested this hypothesis on a captive colony of *Artibeus jamaicensis* by systematically reducing availability of a favored food, bananas. Within a free-ranging flight chamber we placed equal amounts of banana in plastic cups hung together and spaced by 1 m. We used a night-vision camera and infrared lighting to record activity around cups for 10 minutes. We ran six trials, each consisting of three consecutive days wherein we reduced the number of cups each day from 5 to 3 to 1. We found significant increases in the number of approaches as availability declined ($P = 0.006$), but there were no significant differences in the number of landings ($P = 0.20$). We randomly removed nine of 32 individuals (29%) to test for density-dependent effects. We categorized data into: Before removal, 1-2 weeks post-removal, and 3-4 weeks post-removal. There were no significant differences in approaches ($P = 0.55$) or landings ($P = 0.08$) when 5 cups were presented. With 3 cups available, there was a significant increase in number of approaches between 2-3 weeks post-removal (mean = 26.9) and 3-4 weeks post-removal (mean = 72.7) (Dunns Multiple Comparison Test, $P = 0.04$), but there were no significant differences in landings ($P = 0.26$). When presented with only one food cup, there were no significant differences in approaches or landings ($P = 1$). Because *A. jamaicensis* forms harems, sociality may have a strong influence on competition patterns. The patterns of competition changed from before individuals were removed from the population to after. This could be a result that of the fact that the social structure was altered and therefore subordinate individuals changed their competition tactics. This alteration of social structure did not cause a significant difference in competition.

What Makes a Flower a Flower: The Bat Perspective

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Recent studies showed that bat-pollinated flowers have evolved characteristic acoustic features that facilitate their detection as they are conspicuous to echolocating bats. Many cacti depend on bats for pollination; however, the echo-acoustic properties of their flowers are poorly studied. To find out which floral structures are important for localization of the cactus flower opening we compared the flight and echolocation behavior of *Leptonycteris yerbabuenae* while approaching 7 different targets: a normal cactus flower, 4 differently modified cactus flowers and 2 artificial targets. In these experiments we exposed five bats individually to one flower type at a time, and recorded their behavior with two infrared video cameras and synchronized ultrasound recordings. In general, the echolocation behavior of bats was similar at all 7 targets, except for the hemisphere, which was not

visited at all. Before visiting a target the bats consistently emitted a long terminal group (6-20 calls). When exposed to modified flowers without petals or artificial targets, bats needed more inspection flights before they successfully visited the target. Additionally, we measured the echo impulse response of all 7 targets using a biomimetric sonar head. We measured ±90° around the front of the target in 2° steps. The modified flowers without petals generally showed the weakest echo of all targets. Our results show that the petals provide the loudest echo and thus are the acoustically most perceivable structure that helps the bats to find the opening of the cactus flowers.

3D-Flight Path Reconstruction and Echolocation Behavior in *Pipistrellus pipistrellus* Flying Together Do Not Indicate Jamming Avoidance

Simone Götze, Jens Koblitz, Hans-Ulrich Schnitzler, and Annette Denzinger
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In several studies of bats flying together it has been assumed that their echolocation behavior indicates jamming avoidance. It has been suggested that during encounters with conspecifics bats shift their echolocation frequencies apart to avoid interferences between the own ultrasonic calls and echoes with calls and echoes of conspecifics. We hypothesize that the observed frequency shifts during encounters do not indicate jamming avoidance but can be explained alone by a switch from search calls to shorter approach calls with higher frequencies. To test this hypothesis we recorded the signals of free flying *Pipistrellus pipistrellus* with an array of four microphones and reconstructed their three-dimensional flight paths in single flights and during encounters with a conspecific by cross-correlating the recorded signals to determine Time-Of-Arrival-Differences (TOAD). We calculated inter-individual distances of bats during encounters and studied how the call parameters were changed according to the actual spatial relation between the bats. In all encounters signals of the two individuals together showed a similar correlation between call duration and terminal frequency as in each individual when flying alone. All observed shifts can therefore be explained alone by a switch from search to approach signals. Our data clearly indicate that in encounters *P.pipistrellus* perceive a conspecific as a moving target and react with approach calls. A clear separation in frequency which would be mandatory for jamming avoidance occurred only in a few cases and could also be explained by our hypothesis.

Björn Siemers' Sensory Ecology of Bats – From Caves to Cowsheds

Stefan Greif and Holger Goerlitz
Max Planck Institute for Ornithology, Germany

Björn Siemers (25.05.1972 – 23.05.2012) headed the Sensory Ecology Group at the Max Planck Institute for Ornithology in Seewiesen, Germany, since 2006. His interest in the sensory ecology of bats was manifold. He started with aspects of foraging behavior, like prey detection, decision making or resource partitioning, which were his main focus during his PhD and assistant professorship at the University of Tübingen, Germany. This work laid the foundation for his ideas on how the adaptation of sensory systems can contribute to niche differentiation of sympatric species. Besides echo-based prey perception, his experiments revealed strategies how bats use other cues and eavesdrop on varying prey-generated signals. Keeping his sensory focus, he further expanded his research to understand how bats use their echolocation system for evaluating and recognizing their environments. This lead to research on habitat recognition, navigational mechanisms, species recognition and interspecific communication, which he expanded further to include related aspects of cognitive ecology, including learning and memory. Recently, he also integrated more applied aspects into his work and investigated the effects of noise and light pollution on bats. Centering his work mainly on European bats, he created a strong connection to Bulgaria by establishing a field station that quickly became a major hub for ecological bat research in Europe. This talk will illustrate the central theme of Björn's work, species coexistence based on sensory mechanisms, and give an overview of the variety of studies that he conducted to address this topic.

Bats around Water Bodies: Spatial Memory and Size Requirements

Stefan Greif and Björn Siemers
Max Planck Institute for Ornithology, Germany

Bats recognize water surfaces like ponds or rivers by their echoacoustic mirror properties. Most of the echolocation call energy is being reflected away, only the part hitting the surface perpendicularly is reflected back to the bat. However, what happens if a bat encounters a well-known pond, but does not receive the water coding echo

cues? Bats use echolocation as their key modality for close-range sensing, yet we know that bats can rely on memory when performing routine tasks in familiar environments. They demonstrate a very precise spatial memory, for example when foraging or navigating. In a flight room experiment we tested whether bats would recognize a pool despite experimentally manipulated echo reflection properties. The bats never attempted to drink from the pool while the surface was textured echoacoustically, irrespective of their previously acquired and consolidated spatial memory of the pool's location. We then showed that also wild bats in the Israeli desert do not try to drink from a pond when the relevant echo cues were removed/absent, despite likely having a spatial memory of the pond for years. However, the wild bats readily tried to drink from a smooth metal plate that mimicked water echoacoustically, even in a new location where water never pools naturally. In additional experiments we examined how big a smooth surface has to be so that a bat will drink from it. We found that this depends on two species specific factors: a bat's maneuverability and its sonar foot print.

Year Round Activity of Peripheral Bat Populations in the North Carolina Coastal Plain, USA

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When there is a major threat to core populations shifting conservation efforts to peripheral populations can be an effective way to mitigate core population loss. This is the case with White Nose Syndrome (WNS). Warm coastal temperatures along the Atlantic Coastal Plain, USA, may allow peripheral bat populations to remain active through winter, thus decreasing their susceptibility to WNS. Therefore, the objective of our study was to determine the distribution and activity of peripheral bat populations in the North Carolina Coastal Plain, USA. In summer 2012, we set up four mist-netting and recording stations along a 295 kilometer north-south transect in the North Carolina Coastal Plain to monitor bat activity year round. Our transect included intensively managed pine and bottomland hardwood forests. Over 62 nights of mist-netting we captured 467 bats of 9 species. Additionally, we established a Song Meter SM2Bat+ detector station to record bat ultrasound from sunset to sunrise for two years at each of the four sites. Total number of bats captured, species richness, and number of call sequences recorded was higher in bottomland hardwood forests than intensively managed pine forests. Recorded calls are currently being analyzed to determine presence and seasonal activity of bat species. Preliminary acoustic results suggest that on warm winter nights, winter activity of bats is comparable to summer activity. We will discuss significance of these results in relation to WNS.

Echolocation and Foraging Behavior in the Trawling Bat *Pteronotus personatus* (Mormoopidae)

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The trawling foraging strategy has evolved convergently in at least three families of bats and multiple lineages within Vespertilionidae. I used infrared video coupled with ultrasound recording to study the behavior of the Wagner's mustached bat in several areas in the Neotropics. I assessed the habitats used by the bat with ultrasound detection surveys. Wagner's bats forage almost exclusively over water in riparian and other wetland habitats. They fly regularly straight and very low over the water surface (5-15 cm), scooping floating insects with their feet or tail membrane. Less often, they catch insects that fly low above water. In contrast with other trawling bats, Wagner's bats use relatively long (7-10 ms) multi-harmonic curvilinear downward frequency modulated (FM) sweeps with a long narrowband tail (ending at 65-71 kHz, 2nd harmonic), when flying over wide and still water surfaces. When bats fly near banks or vegetation, the pulses become Z-shaped, with short initial (82-85 kHz) and terminal constant frequency segments separated by a brief downward FM sweep. While approaching prey, pulses shorten, and their structure evolves from the narrowband type to the Z-shape. The bandwidth remains conspicuously bounded between the fixed upper and lower frequencies until the buzz, when it narrows. Wagner's bat might use the ending narrowband segments to detect acoustic "glints" that may separate fluttering prey from floating debris. Changes in call structure in presence of background clutter points to the existence of compromises in the processing of narrowband vs. broadband elements. The findings show that the evolutionary avenues to the trawling niche are more diverse than previously thought. The amazing ecological diversity of the taxonomically little diverse mormoopid bats represents an evolutionary puzzle.

New Case of Complete Albinism in *Desmodus rotundus* (Phyllostomidae: Desmodontinae) from Southern Brazil

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The complete albinism is a hypopigmentary congenital disorder known to affect a variety of vertebrates, including bats. It is a rare phenomenon known only in 70 bats belonging to 43 species from 24 countries. The common vampire bat (*Desmodus rotundus*) is the species where the albinism is most frequently observed with 11 individuals from just three countries (Trinidad, Brazil and Mexico). In Rio Branco do Sul municipality, part of the metropolitan area of Curitiba city, State of Paraná, an albino male adult of *D. rotundus* was mist netted at the entrance of a karstic cave while it emerged at 22:30h on August 2011. The net was kept set between 18:00 and 23:00h, and other 22 normally brown furred individuals were also captured at the same night. Two others phyllostomid species (*Carollia perspicillata* and *Mimon bennetti*) also harbored in the same cave. More than 50% of albino bats were living in caves that offer protection against sunlight, water loss and predation by visually oriented predators. The albino vampires were captured mainly in caves, as the individual from this study. Our albino vampire from Paraná had 59.8 mm of forearm lenght and 44 g of bodymass. All bats were released in the same place and night with exception of albino vampire which was kept as a voucher specimen in the vertebrate collection of UNESP/Botucatu. The present record of complete albinism in *D. rotundus* represents 12th case to this species, the 7th case in Brazil and the 2nd in the State of Paraná.

Are Eocene Megabats Masquerading as Primates?

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The fossil record of megabats (Pteropodidae) is notoriously poor. Analyses of molecular and morphological data indicate that pteropodids diverged from other bats no later than the early Eocene (~50 MYA), yet few pteropodid fossils are known other than late Pleistocene-Holocene records. It is apparent that the highly-derived bunodont dentitions of extant pteropodids evolved from a tribosphenic insectivorous ancestry, making recognition of ancient megabats in the fossil record difficult. Similar dental transitions occurred in primates and may have taken place at about the same time. Some fossil taxa previously recognized as primates could be fruit bats instead. One famous example is *Propotto* from the early Miocene of East Africa, which was originally described as a lorisiform primate but later recognized as a pteropodid instead. *Maungthanhinius*, originally described as a strepsirhine primate from the late Eocene of Thailand, could represent a similar example. Its lower premolars (simple, triangular), molars (flattened trigonids, straight labial cristid obliqua incorporating the hypoconid, low, flat lingual talonid basin) and long, low mandibular body are reminiscent of *Propotto* and potentially reflect attributes expected in early megabat morphology. There is little convincing evidence that *Maungthanhinius* is a primate and it is possible that it is actually an early pteropodid. One possible reason why so few pteropodids fossils have been recovered over a 50 million year time span is that researchers may not have fully considered the potential phylogenetic affinities of some fossils. There is no necessary reason to expect that every small, bunodont, frugivorous Eocene mammal represents a primate.

Female-biased Natal Dispersal in a Bat with a Female-defence Mating Strategy

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Female-biased natal dispersal (FBD) is exceedingly rare in mammals, but provides a valuable opportunity to test the general validity of proposed ultimate causes of sex-biased dispersal patterns (i.e. inbreeding avoidance and avoidance of kin competition). Using long-term behavioural and genetic data on individually banded Proboscis bats (*Rhynchonycteris naso*) we show that this species exhibits exceptional FBD among mammals. All females dispersed from their natal colonies prior to reproduction presumably to avoid father-daughter inbreeding, since their age at first conception fell below the tenure of males. In contrast about half of the young males were faithful to their natal colonies and some even reproduced therein. Remarkably Proboscis bats are lacking the usual correlates of male philopatry in mammals (i.e. resource-defence by males and/or kin cooperation). Following a mating strategy based on female-defence with dominance hierarchies among males, local mate competition between male kin should be severe and contradicts the evolution of male philopatry in Proboscis bats. However, philopatric males may benefit

from acquaintance with the natal area and possibly achieve dominance easier and/or earlier in life compared to immigrated males. These findings support the significance of inbreeding avoidance in the evolution of natal dispersal patterns and show that resource-defence by males and/or kin cooperation between males cannot fully explain the evolution of male philopatry in mammals.

Conservation Status and Identification of Priority Areas for Conservation of Bats in Dry Forests in Cúcuta, Colombia.

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Dry forests are one of the most threatened ecosystems in Colombia and the world. In this country, what little remains of this ecosystem are poorly represented in national parks, and in the dry forest of Cucuta, currently there are no protected areas. In order to identify priority areas for the conservation of bats in the dry forests of Cucuta, bats inventories were conducted in seven locations in the metropolitan area. We considered only threatened species and species typical of dry forest as conservation targets. The spatial distribution pattern of each species using MaxEnt program, and for each a goal is determined according to conservation biology of each species. These models were used to identify priority areas through the Marxan software version 2.1.1. There was a total of 31 species of bats. We found five species keys to the dry forest, within which *Roggessa minutilla* is endemic this ecosystem, and currently this vulnerable state, and had not been reported for the area. The set of portfolios obtained with Marxan identified part of the Vereda El Trapiche, the south and the Vereda Agua Blanca, north of Cucuta Metropolitan Area as priority areas for bat conservation. We identified several threats as the expansion of the city, cutting wood for charcoal, and illegal coal mining as the main threats dry forest, required habitat of many species of bats found in this study. The results of this study have been socialized with as CORPONOR departmental entities, which have been taken into account to propose regional protected areas.

Is *Tanzanycteris* Actually a Hipposiderid?

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Tanzanycteris mannardi is the only known Eocene bat with extremely enlarged inner ears. The holotype is a single partial skeleton from the middle Eocene locality of Mahenge in Tanzania. The preservation is poor and most of the bone is dissolved. However, examination of 2D-microradiographs revealed large cavities inside the skull that reflect the huge size of the former inner ears. This surprising result was recently confirmed by means of micro-CT and new characters were recognized which clearly discriminate the inner ear morphology of *Tanzanycteris* from those of living rhinolophids and the mormoopid *Pteronotus parnellii.* However, inner ears of *Tanzanycteris* do show a very high similarity to hipposiderids, the third group of living bats with enormously enlarged cochleae. Thus, the question arises, whether *Tanzanycteris mannardi* (placed in its own family, Tanzanycteridae, when originally described) is actually an early hipposiderid. We compared *T. mannardi* with fossils with completely preserved skulls from Green River, Messel, and with the exceptional case of *Stehlinia* from Quercy. We detected by micro-CT some bony remains of the vestibular organ, which serve to establish a cochlear/vestibular size index. This cochlear/vestibular index permits comparisons with less complete specimens than does the cochlear/basicranial width index. This is important because several species from Quercy and elsewhere lack complete skulls but do preserved isolated cochleae and vestibular organs. This measure confirms that *Tanzanycteris mannardi* possessed a highly sophisticated echolocation system with constant frequency sounds and high duty-cycle echolocation and thus was very similar to living hipposiderids.

A Test of a Novel Attraction Hypothesis –Why are Bats Attracted to Wind Turbines?

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As wind energy production continues to grow rapidly worldwide, there are increasing concerns about the numbers of bat fatalities due to collisions with wind turbines. Several attraction hypotheses have been proposed to explain why bats are coming into contact with wind turbines; however, none of these hypotheses has yet been rigorously tested, they are not mutually exclusive, and may be species-specific. In 2012 and 2013, using a three prong approach at a wind facility in north-central Texas, we tested a novel attraction hypothesis that bats perceive

the smooth surfaces of wind turbines to be water. First, we conducted a playback experiment to characterize echoes from synthetic bat calls played on water, turbine surfaces, and ground. Second, we used night vision equipment to observe bat behavior at turbines and waters sources. And, third we used acoustic detectors to quantify species-specific activity at turbines and water sources. We found no significant differences in the physical characteristics of echoes generated from water and turbine surfaces in the playback experiment. Furthermore, night vision surveys revealed that bats behave at wind turbines as they do around water sources; we observed bats conducting behavior equivalent to drinking at turbine surfaces and observed bats foraging around turbines. This latter behavior was confirmed in acoustic monitoring, as terminal buzzes were recorded for each of the six species present at our site. Overall, our data suggest that bats may be attracted to wind turbines because the surfaces produce an acoustic signature that is indistinguishable from water.

Urban Connectivity and Bats

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Cities are growing in many parts of the world, with implications for local fauna. Urban bats in the UK are legally protected. Our development planning procedures can address risks posed to roosts, but struggle to conserve the broader habitats of urban bats. This reflects the nocturnal behaviour of UK species and the spatial heterogeneity of cities. A single common pipistrelle *Pipistrellus pipistrellus* might feed over numerous gardens in a single night, commuting along tree lines and crossing busy roads. Can these areas really be identified, protected and managed for bats? Initially we investigated how bat activity varied with built surface cover and as expected, urban centers performed poorly. However, some species *could* access and thrive in heavily built areas. Tree networks surrounding feeding areas were particularly important, so we focused our research on these features; studying the crossing behavior of bats at gaps in tree lines that varied in size and illumination. We found that increasing both the gap width and illumination negatively impacted bat crossing probability. These models were then applied to high resolution GIS maps of urban trees and lighting, to identify barriers to bat movement over an entire city. The results suggest that it should be possible to improve functional connectivity for urban bats by intervening at the scale of individual trees or lamps. These results also provide more evidence that even if the physical structure of a city were to remain static, changes to qualitative elements such as lighting may affect key ecological processes.

What Australia's Oldest Bat Says About Early Bat Evolution

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Australia's oldest bat, *Australonycteris clarkae* Hand, Novacek, Godthelp and Archer, 1994, was recovered from radiometrically-dated ($54.6 \pm 0.05 \times 10^6$ years) lake sediments on Tingamarra, near Murgon, south-eastern Queensland. The Tingamarra sediments, the continent's only terrestrial mammal-bearing Eocene deposit, have also produced Australia's oldest marsupials, frogs, lizards, snakes and passeriform birds. The generally archaic nature, earliest Eocene age and Southern Hemisphere provenance of *Australonycteris* made it a surprising discovery. Study of *Australonycteris*'s previously known, published remains (a petrosal, edentulous dentary, P4 and m2) left its phylogenetic relationships unclear. Since then continued collection and screen-washing of Tingamarra sediments have produced further bat remains, while at the same time other Eocene bats have been discovered in both the Northern and Southern Hemispheres, and global understanding of bat phylogeny has significantly improved. *Australonycteris* remains one of the world's oldest bats and of considerable biogeographic interest. New material of this taxon (C1, ?P3, M1-2, p4, m1-3, fragmentary humerus, radius and femur) is presented here, new data from previously published specimens added, and comparisons made with all known early Eocene bats. Quantitative phylogenetic and biogeographic analyses help resolve its likely relationships among early Eocene bats and underscore the global nature of early Eocene bat faunas, as well as raising questions about the source and likely route by which flying mammals first reached Australia – at that time still part of the southern supercontinent Gondwana and c. 3000 km more distant from northern continents than today.

Conservation Networks For Bats in Europe: BatLife Europe and EUROBATS

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Many of the 45 species of bats native to Europe are threatened by habitat loss, degradation and fragmentation, development, persecution and intolerance. Some species have already become extinct from countries within their natural range. In 2011, BatLife Europe was established as an international non-governmental conservation organisation (NGO), built from a partnership of national bat conservation organisations that are committed to promoting the conservation of all bat species and their habitats throughout Europe. Each NGO partner represents BatLife Europe and furthers BatLife Europe's aims within its own territory. Currently 30 NGO's from 28 countries in Europe are partners, actively exchanging information, expertise and resources to conserve bats. Batlife Europe advocates the conservation of bats to the European Union, independently and as a member of the European Habitats Forum. Europe is so far the only continent to establish an intergovernmental treaty on the protection of bats. The "Agreement on the Conservation of Populations of European Bats" (EUROBATS) covers the whole Western Palearctic region and provides the framework for trans-boundary cooperation between governments. Numerous NGOs throughout the Agreement area substantially contribute to its implementation. Batlife Europe is a key partner in achieving its goals. This presentation outlines the major threats and conservation opportunities within Europe, and describes ongoing BatLife Europe projects to identify, prioritise and implement capacity-building within the region and develop a pan European synthesis of bat population trends.

Communication and Education for Bat Conservation in the UK: the Bat Conservation Trust Experience

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Following the severe populations declines observed in many bat species during the twentieth century, all bat species are now protected in the UK and throughout Europe. Pressure on bat populations has come from many directions including agricultural intensification, land-use change, deliberate destruction of roosts and killing, and the loss of roosts to development and change in building practices. Bat Conservation Trust (BCT) has approached this diversity of threats with a wide range of education and communication approaches, centred on increasing public understanding and appreciation of bats, engaging the public in bat conservation and inspiring the many professional sectors whose work affects bats to assist bat conservation. Today BCT works in partnership with the UK statutory nature conservation organisations, professional ecologists and land-managers, around 90 local bat groups, hundreds of licensed volunteer bat roost visitors, and around 2000 volunteer surveyors. This presentation outlines how we have reached out to very different audiences. We include the examples of the Bat Helpline which receives more than 10,000 enquiries each year, the Volunteer Bat Roost Visitor Service which coordinates more around 1600 free volunteer visits to house-holders and churches and the Count Bat Project which engaged more than 20,000 people from diverse backgrounds. We conclude by highlighting some of the new education and communication challenges facing bat conservation.

Molecular Analysis of B- and T-lymphocyte Cell Markers in Different Bat Species

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Chiropteran species are known reservoirs for many emerging viruses and act as natural hosts for diseases with importance for both public and animal health. With expansion of the human population and encroachment of bat habitats, the contact between humans, their livestock and different bat species are becoming more frequent, which facilitate the spill-over of viruses found in bats and the emergence of novel diseases. Despite this epidemiological role, little is known about immunological processes in bats and how their immune system control viral infections. In order to gather more information about bat immune response we determined the sequences of the four main lymphocyte cell markers (CD3, CD4, CD8 and CD19) of species from three bat families (*Vespertilionidae, Phyllostomidae* and *Rousettinae*). Genomic DNA samples of spleens from three bat species (*Myotis myotis, Phyllostomus discolor* and *Rousettus aegyptiacus*) were used as a template for Polymerase Chain Reaction (PCR). Forward and reverse primers of CD3, CD4, CD8 and CD19 were designed from closely related

sequence data available in GenBank. The obtained bat sequences were compared with other published information and phylogenetic analysis was applied to gain further insights on the evolution of bat immune responses. Our results are also important in order to obtain specific immunological tools for the different bat species.

An Integrative and Comparative Approach to Detecting and Understanding Bat Fatalities at Wind Turbines

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Widespread fatalities of bats at wind turbines may detrimentally impact bat populations. However, few well-developed and integrated methods exist for directly observing bat interactions with turbines. In summer 2012, we conducted a study at the Fowler Ridge Wind Farm (FRWF) in northwestern Indiana to simultaneously monitor 9 turbines of 3 models using acoustic detectors, videography, radar, and fatality searches. Turbine operations were manipulated to investigate the hypothesis that bats are attracted to rotating turbines. We found 67 bat carcasses during daily searches between 15 July and 3 October. Fewer fatalities were observed at GE than at Clipper or Vestas turbines (χ^2_2=4.75, p=0.093), but there was no statistically significant difference between Clipper and Vestas models in total fatality. Only a small proportion of the many bat passes recorded on the nacelle indicated close approaches and feeding activity. Ground-based bat activity did not indicate any consistent pattern with distance or turbine operational conditions. Video detections uncovered relatively few bats moving through the lower airspace around the turbines. Radar monitoring showed a much greater number of animals present in the airspace at the height of the turbines than either acoustic or video monitoring indicated. Many video events involved tree bats approaching and responding to stationary or slow-moving turbines--often moving against the wind to do so. These preliminary video results challenge the hypothesis that most bats randomly collide with turbine blades while passing through the rotor swept area, and suggest some level of attraction may occur.

Predicting Bat Fatality Risk at Prospective Wind Farm Sites Using Acoustic Detectors

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Wind power can contribute to reducing greenhouse gas emissions from electricity production, but large-scale wind energy facilities can have serious impacts on wildlife. Bat fatality rates at some sites have been alarming, and proper siting of wind facilities is necessary to minimize collision impacts. Because fatality rates vary dramatically among sites, reliable methods of assessing collision risks prior to development are needed. Our goal was to develop a method for predicting fatality rates based on ground-level acoustic recordings. For three years, we monitored bat activity using acoustic detectors at locations including 9 wind farms and a variety of landscape settings, to address specific objectives: 1) examine the capabilities of the detector for use in pre-construction site assessments, 2) determine any relationship between call rates and fatality rates, 3) examine how activity patterns differ before vs. after a wind facility is built, 4) observe how call rates vary with respect to prominent landscape features, and 5) investigate whether bat activity levels are elevated near turbines. Our initial findings suggest a positive linear relationship between bat call rates and estimated fatality rates among wind farms. Additionally, we found elevated activity levels associated with certain landscape features but not others, and large variations in activity levels among geographic regions. Ground-based acoustic recording can be a useful tool for assessing general levels of bat activity at prospective wind farm sites. Also, findings regarding activity patterns at the landscape and regional scales may aid in improving future wind farm siting decisions.

The *Pipistrellus* Baculum: Individual and Phylogeographic Variation and Cryptic Species Discrimination

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With the discovery of further cryptic bat species, it is vital to find morphological species discriminating characters. *Pipistrellus pipistrellus* and *P. pygmaeus* have been recognized as separate species since 1997, but no reliable morphological species discriminating trait has been found. The baculum (os penis) has long been used successfully in species discrimination. In this study, we demonstrated how to reliably separate the common pipistrelle and the soprano pipistrelle by simple baculum measurements, and individual and phylogeographic variation of the *Pipistrellus* baculum were quantified. The bacula of museum specimens (Národní Muzeum, Prague) of the two species and of *P. hanaki*, which had already been identified by molecular genetic methods, were imaged with high-resolution microCT. Geometric morphometrics was used to quantify and locate variations in baculum shape. Several measurements were taken on the size-calibrated volume images and their value for species discrimination was tested by discriminant analysis with leave-one-out cross validation. *P. pipistrellus* and *P. pygmaeus* specimens can be discriminated by measuring the projected length, height, and width of the baculum. Variation in baculum shape (alone) cannot be used to separate these species. *P. hanaki* cannot be separated from the other two species by baculum shape. Most of the interspecific variation in baculum shape can be found in the proximal third (the base) of the baculum. Most individual variation can be observed in lateral view, especially in the shape of the curve. Quantitative details of morphology are becoming more important to distinguish cryptic species and understand their phylogeographic distributions.

Phylogeography of *Sturnira lilium* (Chiroptera: Phyllostomidae) in Mesoamerica

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In the tropical forests of Mexico and Central America (Mesoamerica) inhabits the frugivorous bat *Sturnira lilium parvidens*, previous studies suggest recognition of the group *S. parvidens* as a distinct species. In order to clarify the taxonomic status of *S. parvidens* group, we compiled 51 published sequences of the mitochondrial cytochrome-b gene (775 bp) of *S. lilium,* and we also generate the complete sequences at the same gene (1,140 bp) for 96 specimens of *S. l. parvidens* to complete our work and to assess as main goal the historical and geographic events in its evolutionary history. Phylogenetic analyzes showed that *S. parvidens* represents a clearly distinct monophyletic group merging in the species category, and suggesting the Cordillera de Talamanca in Costa Rica as its southern boundary. The species is composed by two different lineages: a haplogroup in the Gulf of Mexico - Central America and other located in the Mexican Pacific Slope, the phylogeographic pattern indicate a boundary between these lineages located in the Balsas River Basin. Analyzes of genetic diversity and historical demography support a scenario of recent demographic expansions, the origin of *S. parvidens* seems to be associated with the Great American Biotic Interchange, representing another case of diversification *in situ* in Mesoamerica. The diversification of haplogroups was posterior, suggesting a relationship with the climatic oscillations occurred in the late Pleistocene and early Holocene.

Historical, Recent, and New Records of Bats from Honduras: 125 Years of Study

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The objective of this research was to determine how increased knowledge of bat species for Honduras in 125 years of study (1887 to 2012), determine the representativeness of the species in collections and identify information gaps. The study of bats from Honduras could be divided into three periods, some of the oldest records date from scientific explorations in the nineteenth century, which were recorded in publications such as biologia Centrali Americana, from early to mid-twentieth century began a phase where a greater number of foreign researchers visiting the country, increasing scientific collections and bats become the group with the largest number of mammals deposited in collections abroad, the estimated number of 5,116 specimens of bats, collected by 73 researchers and deposited in 13 museums of natural history in the United States primarily, it is also at this stage where is created the Natural History Museum of the Autonomous National University of Honduras, for the year 1998 was known records of 98 species. During the twenty-first century with the use of new research techniques and

increased Honduran researchers begins to gather information and conduct fieldwork in areas with gaps in information and records is increased to 109 species.

Sources of Energy and Protein for Bats in a Mexican Semitropical Desert

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Energy and protein are two fundamental resources in the nutrition of bats. We used C stable isotope analysis (^{13}C, ^{12}C) on breath and blood samples collected from several species of bats in the Tehuacán valley to track the photosynthetic origin of food used to sustain energy and protein requirements. The Tehuacán valley is a subtropical semi-arid ecosystem in which several species of columnar cacti and agave (i.e., CAM plants) constitute the dominant elements accompanied by patches of trees and shrubs (i.e., C3 plants).Vegetation in Tehuacán is isotopically heterogenous because CAM plants have less depleted $\delta^{13}C$ values than C3 plants. Fruits and flowers of cactus and agaves offer abundant food to vertebrates, but their leaves might be less attractive to insects than the leaves of C3 plants. Therefore, we used carbon stable isotope analysis to test the hypothesis that C3 and CAM food would contribute asymmetrically to different guilds of bats. Our results showed that nectarivorous bats used CAM food as source of energy and protein, and that frugivorous bats obtained energy and protein from C3 food. Most insectivorous bats derived both energy and protein from C3 food but in some cases CAM food contributed significantly as energy source. Habitat heterogeneity in Tehuacán is important for bat conservation due to the asymmetric role of CAM and C3 food in the nutrition of different feeding guilds.

Patterns of Philopatry and Dispersal in the Foliage-roosting Bat, *Murina ussuriensis*

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Male-biased dispersal and female philopatry are common traits among social mammals, resulting in groups containing kin-related females. However, studies of bats have also found examples of female dispersal, dispersal by both sexes and philopatry of both sexes. We used genetic analyses to examine dispersal and kinship in the Ussuri tube-nosed bat in lowland warm temperate forest in Yakushima, Japan. Fifty four female and 26 male bats were captured using harp traps and acoustic lures. Each bat was fitted with an identifying ring and a biopsy punch of wing tissue was taken for DNA extraction. Analysis of the D-loop of the control region of mitochondrial DNA revealed six haplotypes. Spatial clumping of females of each haplotype was consistent with a high degree of philopatry. There was somewhat more evidence of dispersal among males, but only over short distances, and only one male had an mt-haplotype that was not found in females. Analysis of nuclear DNA indicated 9 female full-sib dyads. In each case both bats were caught at the same site. This species roosts mostly in suspended clumps of dead leaves, but also uses bark flaps and tree cavities. As roost sites are abundant, switched almost daily and rarely re-used, cooperative defence of roost sites by females is unlikely. We conclude that female philopatry is more likely related to cooperative defence of a feeding area, and discuss ways of testing this hypothesis. Limited dispersal by males may be sufficient to avoid inbreeding, while avoiding the potential costs of more long-distance dispersal.

Bat Flies (Diptera: Streblidae) on Neotropical Cave-dwelling Bats

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Streblid flies are obligate, blood-feeding insects, parasitizing bats mainly in the Neotropics. Most are specific to one host species and morphologically adapted to certain body regions, thus allowing multiple fly species to parasitize one host individual through resource partitioning. Species composition of these bat fly communities might be distinct between different bat colonies, due to regional and climatic conditions. Characteristics of bat roosts may also influence parasitation levels, revealing bat colonies with similar species composition but different parasite load. For studying these parasite-host relations, we captured bats and collected bat flies at seven caves in Costa Rica during the dry season in 2012. Focussing on the three most common bat species, *Pteronotus parnellii, Carollia perspicillata* and *Desmodus rotundus*, analysis of similarity revealed significantly different bat fly communities between colonies of each study species. As females showed significantly higher intensities in parasitation than males, we used only male individuals for comparisons between study sites. We found significant differences in parasite load between the study sites. Size of the bat colonies was the most important factor determining parasite

load, however without showing a consistent trend over all study species. Our study highlights a highly specific parasite-host-relationship with great variability in composition and frequency of the bat fly fauna within sample sites, as well as six new records of bat flies for Costa Rica.

Estimating Bat Species Richness and Their Community Habitat Relationships Using Hierarchical Models with Presence Absence Data in Southeast Sulawesi, Indonesia

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Estimates of biodiversity are increasingly being used to make conservation or management decisions. However, estimates of diversity and abundance can be biased if all species available are not detected and if detection rates vary across species. To eliminate this source of bias, probabilities of species occurrence and detection must be estimated simultaneously using a statistical model of presence-absence data. These models require presence-absence surveys to be replicated at some – but not necessarily all – of the locations selected for sampling. We conducted mist net surveys along an elevational gradient in the Masembo River watershed in the Mekongga Mtns. region in southeast Sulawesi. Each site was surveyed for three consecutive nights in order to estimate detection rates and probability of occurrence simultaneously. We modeled assemblages as a function of large-scale covariates (elevation, habitat) and small scale site covariates (forest structure, tree species diversity). We fit several models, each identified by a specific combination of covariates, to estimate the effect of these covariates on geographic differences in bat species richness and other measures of biodiversity. We found that there was considerable variation among species specific estimates of detectability. Model estimates ($\widehat{N}$=25) of species richness were greater than observed numbers of species (n=17). Estimates of alpha diversity differed across elevation and habitat. Estimates of beta diversity were relatively high between lowland and montane forest types. Our analysis of the bat assemblages illustrates the benefits of using modern analytical techniques to estimate unbiased measures of biodiversity and other community-level characteristics, which can be used to make informed conservation decisions.

Stars, Crosses, and Hemispheres – Microphone Arrays in Bat Research

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The commercial availability of multi-channel ultrasound recording systems allows researchers to tackle a wide variety of new research questions ranging from acoustic tracking of flight behaviour and source level measurements to sound field characterisation and acoustic scanning behaviour. We will start back at the beginning of the use of microphone arrays for the study of bat behaviour in the field. There will be a particular focus on Roland Aubauer's pioneering work on the acoustic constraints and optimal array designs for acoustic 3D tracking of free-flying bats. Then we will explore the use of linear arrays for the quantification of acoustic interactions of free ranging bats. Through acoustic characterisation of real interactions and interaction modelling we aim to understand how sound exposure might influence and even shape coordinated flight behaviour. Finally, the microphone array will grow wings in the form of the Chirocopter, an octocopter drone with an echo sounder and a 16 channel microphone array developed at the University of Antwerp. This is used to follow the flight corridors chosen by bats in the field in an attempt to capture the full acoustic information available to the bats, and to understand how their flight route choice might be governed by informational constraints.

Contamination by Polychlorinated Biphenyls (PCBs) and Bat Activity along the Hudson River, New York

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The upper Hudson River, New York, is contaminated with polychlorinated biphenyls (PCBs) because of historical discharges. Although elevated levels of PCBs have been found in the tissues of bats, it is not clear whether this contamination has affected bat activity along the Hudson River. We monitored bat activity at sites with varying levels of PCB contamination along the Hudson River between May and August of 2008 and 2009. To assess possible effects of PCB contamination on bat foraging behaviour, we measured *Myotis lucifugus* (little brown bat) and *Lasiurus cinereus* (hoary bat) activity along the Hudson River, as well as foraging times and distances covered

by radio-tagged *M. lucifugus*. Activity of *M. lucifugus* and *L. cinereus* varied along the Hudson River, and activity of both species was lower in 2009 than 2008. Compared to two sites on the Hudson River, *Myotis lucifugus* foraged longer and farther at a site away from the Hudson River. Comparisons of bat activity levels with differing approximate PCB concentrations indicate that the variation in bat activity along the Hudson River is not related to PCB concentrations. Our data indicate that PCBs have not significantly affected bat activity or foraging behaviour along the Hudson River.

Paleobiogeography of the Mediterranean Fruit Bats: an Unresolvable Issue?

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The abundant population of *Rousettus aegyptiacus* in the E Mediterranean poses a puzzling topic to historical biogeography. The only offshoot of the family Pteropodidae beyond tropes is an enigmatic issue: there is no clear idea on its origin, driving factors and modes of survival under quite unfavorable conditions. The present contribution summarizes the results of a multidisciplinary project intended to answer these questions. Detailed phylogeographic analyses (using both multiple molecular markers and biometric comparisons) demonstrated (a) homogeneity of the populations within the inner Mediterranean (except for Cyprus), (b) distinct subclades in S Arabia, Sinai, Egypt and Cyprus, (c) well marked divergence between the Mediterranean and sub-Saharan populations in some markers (dating the split to ca 1-3 My ago) but (d) a large amount of alleles and haplotypes common to both the clades. The default interpretations suggest the post-Neolithic spread throughout the Mediterranean as the major dispersal event and a source of it in the southern Arabia or sub-Saharan Africa. Yet, such "out-of-Africa-hypothesis" generates the scenarios which contradict both the observed geographic patterns of genetic diversity and the history of requisite contextual factors. A reversed approach supported by fossil remains in the Middle Pleistocene site Qesem, Israel, produces then the scenarios centered with a palaeochoric status of the Mediterranean form and suggesting that it could even become a source population for a spread to Africa. The respective scenario could also resolve the unanswered question on the background factors (including food resources) promoting long-term survival and peripatric diversification events in the region.

Beneficial Bacteria Present on Hibernating Bats in the Eastern United States

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White-nose syndrome threatens several hibernating bat species with extinction, and at present, there are no known effective treatments for this disease. Bacteria are broadly used as biocontrols against fungal diseases in plants, and more recently, in fish, and amphibians. Using culture based techniques, we isolated bacteria from bat skin and challenged it against the fungus that causes white-nose syndrome, *Geomyces destructans*. We found that *Pseudomonas spp.* present on bats can effectively inhibit the growth of *Geomyces destructans* in vitro. The natural occurrence of *Pseudomonas spp.* on hibernating bats, as well as their ability to successfully inhibit *Geomyces destructans*, make them promising candidates as biocontrol agents for reducing impacts of white-nose syndrome.

Is Bat Coffee a Potential "Wing-Wing" Tool for Biodiversity Conservation in Southwestern Sumatra?

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Bat-discarded coffee is a wildlife-associated product recently reported from coffee agriculture areas of southwestern Sumatra, Indonesia. Although bat coffee is well-known by local farmers, the ecology and the potential value of this bat-associated product in biodiversity conservation are not yet known. From 2011 November to 2012 July, we carried out camera trapping, mist netting, and transect-line surveys in coffee plantations subject to two different shade-tree management practices to evaluate the use of plantations by bats and to identify the producers of bat coffee beans. We also interviewed local farmers about their perception of bats and bat coffee. During the survey period, 14 bat species were recorded. The capture rates were significantly higher in high-shaded plantation than in low-shaded plantation. However, there was no difference in species richness between the two plantation types. Bat-

discarded beans were found beneath day or night feeding roosts of 21 plant species. All the bats observed taking coffee belonged to the genus *Cynopterus*, the most abundant phytophagous bats in the study area. Based on interviews, farmers were more aware of the presence of foliage- and house-roosting bats and their consumption of fruit in the plantations, but less familiar with other bats and the ecological services bats can provide. Some possible conservation strategies based upon our findings are discussed.

Dietary Analysis of Two Sibling Bat Species *Myotis myostis* and *M. blythii oxygnathus* in South-eastern Europe

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Myotis myotis and *Myotis blythii oxygnathus* occurs simpatry in Central and South Europe. In the western and central part of their areals they show very clear diet partition. The main prey of *M. myotis* are large epigaetic arthropods such as carabid beetles, which are found in a habitat with open accessible soil. In contrast, *M. b. oxygnathus* forages mostly for bush-crickets (Tettigoniidae) and cockchafers (Scarabaeidae: *Melolontha melolontha*) which are typical for open steppes and pastures with dense grass. But there had been no studies on the diets of the mouse-eared bats in Southeast Europe. In our study the diets of both species were investigated by faecal analysis of wild bats caught in Bulgaria. The results show that indeed *M. b. oxygnathus* eats large proportions of bush-crickets – 75 %, whereas in the diet of *M. myotis* not only carabid beetles (43 %) are present, but also some surprising taxa: Tettigoniidae (21 %), Opiliones (10 %) and Litobiidae (9 %). These significant differences in the diet of the Balkan populations of mouse-eared bats compared to the populations in central Europe may be due to more ancient sites of natural coexistence or other, hitherto unexplored environmental parameters.

Environmental Margin, Island Evolution, and Anthropogenic Impact in Middle Eastern Populations of the Egyptian Fruit Bat

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We present a study of the population genetic architecture and microevolution of the Egyptian fruit bat (*Rousettus aegyptiacus*) at the environmental margins in the Middle East using mitochondrial sequences and nuclear microsatellites. In contrast to the rather homogenous population structure typical of cave-dwelling bats in climax tropical ecosystems, a relatively pronounced population diversification was observed. The evolution of this pattern could be ascribed to the complicated demographic history related to the range margin fragmentation and complex geomorphology of the studied area. Lineages from East Africa and Arabia show divergent positions. Within the northwestern unit, the most marked pattern of the microsatellite dataset is connected with insularity, as demonstrated by the separate status of populations from Saharan oases and Cyprus. These demes also exhibit a reduction in genetic variability, which is presumably connected with founder effects, drift and other factors related to island evolution. Genetic clustering indicates a semipermeability of the desert barriers in the Sahara and Arabian Peninsula and a corridor role of the Nile Valley. The results emphasizes the role of the island environment in restricting the gene flow in megabats, which is also corroborated by biogeographic patterns within the family, and suggests the possibility of nascent island speciation. Distribution of subpopulations indicates ecological differentiation. Demographic analyses suggest that the colonization of the region was connected to the spread of agricultural plants; therefore, the peripatric processes described above might be because of or strengthened by anthropogenic changes in the environment and thus show some attributes of biological invasion.

Immune Gene Expression Profiles in Jamaican Fruit Bats Infected with Tacaribe Virus

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Tacaribe virus (TCRV) was isolated from several dying artibeus bats near Port of Spain, Trinidad and Tobago in the late 1950s. The bats exhibited signs of disease that were similar to rabies; however, no evidence of rabies virus infection was found, suggesting that TCRV was the cause of the disease. TCRV is an arenavirus that is related to Junin virus, which causes Argentine hemorrhagic fever (AHF). One of the two artibeus species that was infected with TCRV in the original study was the Jamaican fruit bat (*Artibeus jamaicensis*). Artibeus bats were

thought to be reservoir hosts of TCRV; however, recent experimental infections of Jamaican fruit bats caused substantial morbidity and mortality, which is contrary to a typical reservoir host/virus relationship. The bats in these studies, and their tissue histology exhibited features that parallel AHF. Using *A. jamaicensis* transcriptome data from work previously conducted in our lab, we developed a real-time PCR expression assay to evaluate the host response during fatal infection. We identified increased expression of genes in several immune pathways, including those of interferon pathways (*Irf7, Stat1*), inflammation (*Nfkb1*), B-cell class switching (*Tnfsf8*), and T-cell transcription complexes (*Nfatc2*) in infected bats, indicating an ongoing immune response that fails to protect the bats from disease. Considering that AHF and other arenavirus diseases have an immunological component, it may be that the immune response of artibeus bats contributes to the pathogenesis of TCRV disease.

Seasonality and Roost Fidelity of Common Vampire Bats in an Area with Previous Cattle Rabies Outbreaks in Mexico

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Common vampire bats (*Desmodus rotundus*) are a dominant reservoir and vector of rabies in Latin America, with significant agricultural and public health costs. Population and ecological parameters of vampire bats are crucial to predict the spatio-temporal dynamics of rabies. In this study we combined short- and long-term observations (radio-tracking and mark-recapture) to investigate the seasonal reproductive pattern and short- and long-term roost fidelity of common vampire bat colonies roosting in caves in an area of previous cattle rabies outbreaks in tropical Mexico. We predicted that colonies would show a seasonal pattern with an increase in juveniles during the wet season and short- and long-term roost fidelity would be high in this area where the dominant roost type are caves. In contrast to previous studies in Latin America, we found no seasonality on the number of captures, age class composition or reproductive state of vampire bat colonies. Short-term roost fidelity was considered high with 60% of radio-tracked individuals staying in their roost up to five days after initial marking. Long-term roost fidelity in the area is considered to be medium to low with most individuals being recaptured in their original cave for only one month after initial marking and only a few individuals being recaptured in their original roost up to five months after marking. No events of roost switching were observed during our study period. Additional studies are needed to understand whether vampire bats exhibit metapopulation dynamics and how this affects rabies circulation in this key reservoir.

The Social Behaviour of Little Brown Bats at Maternity Colonies

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The evolution of sociality in animals has fascinated humans for a long time. Darwin derived the idea of survival of the fittest, and from that we often assume that the natural state is to act selfishly, thus social behaviours may seem counter-intuitive. Regardless, being social has benefits including protection from predation, information transfer, thermoregulation, and fitness benefits from kin selection and cooperative breeding. Costs can include increased transfer of disease, competition and infanticide. Given these benefits and costs, what are the factors that cause and maintain sociality? This study investigated the latter by looking at the social behaviour of little brown bats (*Myotis lucifugus*) at two maternity colonies in Newfoundland, where there are over 100 and 500 bats tagged, respectively. Patterns of association and inter-roost movements were characterized using data from PIT recorders deployed at the entrance of bat boxes which are used as roosts. Juveniles formed social clusters which consisted of both males and females. Night roost switching behaviour for each individual increased as well as early morning activity as the season progressed. These findings may suggest increased exploratory and/or social behaviors which may be important for social structure and maintenance of social dynamics within colonies.

Can an Evolutionary Trade-off Between Bite Force and Detection Range Explain Anomalously High Frequency Echolocation Calls?

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The skulls of animals have to perform many functions. Optimization for one function may mean that another function is not optimized. Such trade-offs may be responsible for one or more functional traits deviating

from allometry. Here we investigate whether such a trade-off exists between the masticatory and echolocation functions of bat skulls. Several species of rhinolophids (e.g. *R. clivosus*) deviate from the allometric relationship between body size and peak echolocation frequency. Such deviation may be the result of selection for increased bite force resulting in a decrease in snout length. A decrease in snout length could lead to higher echolocation frequencies and consequent reduction in detection range. If so, there should be a negative relationship between bite force and detection range. We investigated bite force and detection range in several species of rhinolophids throughout southern Africa using bite force measurements, echolocation and skull morphology. Contrary to our prediction there was a positive correlation between bite force and detection range. After controlling for body size neither peak echolocation frequency nor bite force was correlated with rostrum length. Instead nasal capsule volume was a better predictor of peak frequency than nasal capsule length across rhinolophid species. Furthermore, *R. clivosus* has a smaller nasal capsule volume than predicted from its size. Thus the anomalously high peak echolocation frequency of *R. clivosus* cannot be explained by optimization of the masticatory function of the skull. Instead, it appears that selection has acted on nasal capsule volume directly resulting in an increase in echolocation frequency.

Patterns of Social Behaviour of *Rousettus aegyptiacus* in a Captive Breeding Colony

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Components of social behaviour of *Rousettus aegyptiacus* was studied in a captive colony of about 50 marked individuals in the Prague ZOO during 2010-2012 using quantitative post-hoc analyses of video- and audiorecords taken in a standardized way in weekly intervals, 90 mins prior to beginning of night activity. With few exceptions the adult individuals kept their fixed positions within the cluster throughout whole observation period. The largest variation in position within the cluster was typical for yearlings. In contrast to courtship behaviour and mating, which occured throughout the year, parturitions were strongly synchronized and appeared within a week (bimodally in Septemeber/October and March/April). Couples and mating behavior were regular component but frequencies of them exhibited a clear peak during early lactation. A specific male courstship calls produced through nose appeared just in these periods. Couples were initiated either by males and females (in almost the same percentages). Males claimed females either by violence, protection or gradual allogrooming - the manner of forming couples seems to be dependent on age of the female. In violent approach, allogrooming has never been observed. Mothers' care of juveniles is very long, common roosting and grooming appeared long after weaning. Appearance of specific juvenile calls used in communication beween young and adult decreased markedly in the third month after birth, but the last mother–young association was observed five monthes after birth. Bioacoustic analyses of courtship and juvenile calls are included.

Cryptic *Geomyces destructans* Infections in the Southeastern United States

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White-Nose Syndrome is an epizootic in hibernating bats and the causal agent has been identified as the fungus, *Geomyces destructans*. Detection of *G. destructans* in the field is limited by the ability of researchers to visually document fungal growth on affected bats and submit these bats for laboratory testing. Swabbing bats for fungal DNA provides non-invasive sampling for *G. destructans*, and the opportunity to document the accuracy of visual observations for detecting the fungus. To determine the presence of *G. destructans*, bats were swabbed on their muzzle and forearm, and it was noted whether any fungus was visible. qPCR was used to detect *G. destructans* DNA, if present. As part of a continent-wide study, 665 bats of 7 species were swabbed at 18 hibernacula in 3 states (TN, MO, AL) in the winter of 2011-2012, and 624 bats of 10 species were swabbed at 19 hibernacula in 4 states (TN, MO, AL, KY) in the winter of 2012-2013. *G. destructans* DNA was detected by swabbing as early as mid October and as late as the end of May on bats mist-netted near cave entrances. Results suggest the occurrence of "cryptic" infections; 109 bats of 6 species from the first winter of swabbing tested positive for *G. destructans* DNA without showing any signs of visible fungus. Only one little brown bat (*Myotis lucifugus*) tested negative for *G. destructans* DNA while showing signs of visible fungus. These data are useful for management purposes in documenting the presence of *G. destructans* in hibernacula.

Tropical Conservation by Means of Biodiversity Development: a Real Costa Rican Example

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Tropical complex conserved wildlands will survive indefinitely only if they are big, endowed, and thoroughly integrated with their neighboring, national and international societies. This means decentralized, and having the administrative authority to acquire the knowledge to tailor-fit the care, funding and integration process to the biological, geophysical, and sociological realities of the park. There is no shirt that fits all, an inconvenient truth for both central governments and global NGOs. A large complex conserved wildland needs to pay its way in its society but there are many innovative and feasible, non-damaging terms of payment on many possible schedules with many kinds of currency. Area de Conservacion Guanacaste, a 165,000 ha national park in northwestern Costa Rica, encompassing four of the five major tropical ecosystems (no desert), is a 47-year-old working example of on-the-job efforts to live these concepts. Despite its many small to large successes and failures, it has muddled through to a reasonable proof-of-concept. Perhaps the most poorly developed trait that has proved to be important may be termed "know thy park". One of the larger ironies of tropical conservation is that its biodiversity and ecosystems are poorly known by the park itself; if known, that knowledge is normally acquired and managed by visiting biologists rather than the permanent staff. It is as if the staff were to acquire, build and protect an enormous and very diverse garden without knowing anything in detail of what is planted in it, and how to harvest from it without trashing it.

Why isn't Conservation Heard? Lessons from Representations of a Human-Flying-fox Disease Conflict in the Australian Print Media

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Conflicts between bats and humans are increasingly grabbing media attention worldwide. The emergence of zoonotic diseases from bat populations in particular attracts controversy about how to manage human welfare and conservation issues. Understanding the key role the media play in framing public debate around such conflicts is essential for wildlife managers if they wish to guide public discussion. News stories employ myths and metaphors in their media spin to influence the audience's understanding of an issue. The 2011 outbreak of Hendra virus from Australian flying-fox populations provide a case study of how a human-wildlife disease conflict is depicted by the media. This study traces the depiction of this conflict within the Australian print media during a key period in this debate (June/July 2011) by examining how journalists, advocacy groups and government departments frame elements of the conflict.A total of 293 news articles from national, state and regional newspapers along with 38 media releases from government departments were analyzed. While all news articles highlighted human welfare values only 4% referred to bat conservation and only 15% quoted scientists or bat advocates.Risk, demonization and mitigation were the predominant types of spin used by the media. This research highlights how wildlife managers should address the communication of risk to the media together with the need for personalization in conservation stories. By recognizing how the media actively selects and shapes news stories, wildlife managers can frame their own messages to appeal to media news values and marshal support for conservation.

Behavioral Observations of a Western Red Bat (*Lasiurus blossevillii*) Maternity Roost in California

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The western red bat is a foliage-roosting species with a broad distribution through the western United States, Mexico, and Central America. While having a wide distribution, occurrences are extremely patchy and few actual records exist throughout its range. In 1998, the Western Bat Working Group examined all western bats to determine their status and the western red bat emerged as a species of primary concern in all occurrence regions. As part of a radiotelemetry study in 2011, a female western red bat was radiotracked to her day roost. This roost was located in a large Valley oak and contained two adult females and five juveniles. Over 14-hrs of nighttime infrared video (four nights) and 3-hrs of daytime video (three days) were obtained. These videos were examined to record behaviors of the adult and juvenile bats. Of particular interest was the observation of two adult female bats in the

roost. It had been thought that adult western red bats are solitary, thus the presence of two adult bats in this roost raises interesting questions regarding the social dynamics of this maternity roost. Behaviors between the two adult bats, adult behavior with the juveniles, and behavior among the juvenile bats are documented.

Engaging Local Communities to Protect Bats through Conservation Education Activities in a Transboundary Biodiversity Corridor

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A key step in any bat conservation strategy includes engaging local communities to protect species in the region. Bats are potentially effective ambassadors for elementary school enrichment activities. The problem lies with availability of materials, which are spread across many sources, challenging educators to find what is available. We addressed this problem by collating available materials, making them accessible on the web, while also finding better ways to engage students. We evaluated: (1) how effectively existing bat conservation materials address essential knowledge and skills needed by educators, and (2) which interactive activities (venues) are more readily obtainable: videos, hands-on, or role-drama. A network of people with knowledge of bat educational materials were contacted, starting with key actors in Bat Conservation International, and snowballing to others who were recommended. Educational materials were collated (n = 24), sorted within venue categories, and scored for essential skills and knowledge. All materials were assembled in an electronic binder, and posted online for easy access through the Biodiversity Stewardship Lab website. The materials gathered consisted of 55% videos, 38% hands-on, and 5% role-drama/stories. The subject matter included: 27% Arts, 25% Science, 16% Language Arts, 22% Social Sciences, 5% Mathematics, and 5% Performance. Since most activities were passive video or individual hands-on, we recommend more interactive role-drama adaptations of stories. Although existing materials address a variety of essential skills and knowledge used by educators, the effectiveness of role drama in engaging students of high priority bat conservation regions needs to be further investigated.

The Effect of Temperature and Infectious Dose on White-nose Syndrome in Captive *Myotis lucifugus*

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Since the discovery of white-nose syndrome (WNS) in North America in 2006, much has been learned about how infection with the fungus *Geomyces destructans* (*Gd*) leads to large-scale mortality among cave-hibernating bats. Much remains unresolved, however, including how variation in environmental conditions and level of exposure to the fungal pathogen promote differences in mortality in infected bats. To better understand WNS mortality rates, we collected 71 male and 77 female little brown bats (*Myotis lucifugus*) from the wild and placed them into artificial hibernacula. Captive bats were randomly placed into control and experimental groups artificially hibernated at 4° and 10° C. At each temperature, 14-15 bats were inoculated with a control solution or a solution containing 500, 5,000, 50,000, or 500,000 fungal spores. Bats were left in hibernation for 21 weeks to assess the influence of temperature and infectious dose on the progression of WNS and resultant mortality. Data presented will include analyses of mortality, decline in body condition, rate of periodic arousals from hibernation, and wing damage as influenced by sex, body condition entering hibernation, hibernacula temperature, and infectious dose. These data will provide important insights into patterns of mortality among wild populations of little brown bats in eastern North America, and help to understand future population declines as WNS continues to spread.

Genetic Connectivity Patterns of *Myotis septentrionalis* Within Mainland Atlantic Canada

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Delineating the connections between mating and summering areas is crucial to effectively manage migratory species. One method to characterize the connectivity among populations is to assess the genetic similarity between individuals sampled from these areas. For temperate bat species mating occurs in autumn and is termed swarming, while summering activity involves females rearing their offspring while males typically remain solitary. The connectivity of individuals among sites within and between each season is not known for most temperate bat species. For example, it is not known if individuals show fidelity to specific seasonal sites, or what the patterns of

movement are among sites between seasons. To address this issue we will characterize genetic connectivity of *Myotis septentrionalis* using nuclear and mitochondrial molecular markers between summering and swarming sites. Tissue samples of 600 individuals were collected from 15 summering sites and 10 swarming sites across New Brunswick and Nova Scotia. With each sample approximately 300bp of the HVII region of mtDNA was sequenced and 11 teteranucleotide microsatellite loci were used to genotype nuclear DNA. Results are expected to help us identify connections between discrete habitats for this species, which is essential for their management and conservation.

Monitoring Large Scale Solar Photovoltaic Energy Facilities for Potential Effects to Bats

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This is the first study to assess the effects of a large solar photovoltaic project on bat populations. We monitored bat activity with 18 passive acoustic detectors before and after arrays were developed and in nearby conservation lands at a 250 megawatt solar project on 1896 hectares. We deployed one AnaBat SD2, and one Song Meter SM2 BAT, in each of the arrays. We modeled the activity of each group of bats (*Myotis ciliolabrum, M. californicus*, and *Parastrellus hesperus* for high frequency, *Antrozous pallidus* for medium frequency, and *Tadarida brasiliensis, Eumops perotis*, and *Lasiurus cinereus* for low frequency bats) using generalized least squares models. The low-frequency bats' activity was affected by microphone location and month (p <0.05), but not by array status (p = 0.52). Likewise, mid-frequency bats' activity was affected by microphone location and month (p <0.05), but not by array status (p = 0.45). The high-frequency bats' activity was affected by microphone location, month, and array status (p <0.05); bat activity was higher for high frequency bats in energized areas, compared to conservation land and pre-construction areas. Areas with arrays had less overall bat activity then areas outside arrays (p <0.05). Total bat on-site activity was also affected by microphone location and month (p < 0.05). Our results suggest bats typically foraging in natural clutter prefer foraging in the anthropomorphic clutter of solar panels as opposed to adjacent open grasslands and that open aerial foraging bats do not discriminate between solar projects and open grasslands.

The Effects of Light Pollution on Bats

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Global ecosystems are currently subjected to climate change and habitat deterioration at unprecedented scales. Urban areas are expanding proportionally faster in a global context than any other land cover type, causing dramatic changes in ecosystem structure and functioning. Although research is now addressing the negative impacts of anthropogenic noise on biota, less attention has been paid to the effects of light pollution. Light pollution is a rising global problem affecting every inhabited continent, covering 100% of the land area in many countries. As human populations rise and become increasingly urbanized, global levels of light pollution are set to increase. As novel lighting technologies emerge, there is considerable scope for reducing negative impacts of artificial lighting on bats. We have used observational and experimental studies in the field to monitor potential impacts of artificial lighting on bats. Bats respond to artificial lighting in species-specific ways that correspond with flight morphology and likely predation risk. While many bat species that forage in open-spaces may exploit insects attracted to street lights, light-averse, slow-flying species such as lesser horseshoe bats show large-scale reductions in activity along commuting routes that are experimentally lit by high-pressure sodium (HPS) lights. LED lights show a similar effect size to HPS lights in reducing activity levels of lesser horseshoe bats, and dimming may be ineffective for mitigation. Impacts of lighting may be especially severe for bat communities that are rich in numbers and diversity of light-averse species, e.g., communities in Southeast Asia that include large numbers of horseshoe bats.

Pathology of Marburg Virus Infection in a Natural Reservoir Host, *Rousettus aegyptiacus*

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Marburgviruses (family *Filoviridae*) are the causative agents of Marburg hemorrhagic fever (MHF), a significant human disease because of its rapid person-to-person transmission, high case-fatality rate (up to 90%), and lack of specific therapy. Several lines of epidemiologic, ecological, and molecular evidence have shown that the

Egyptian fruit bat (*Rousettus aegyptiacus*) is a natural reservoir host of marburgviruses in Africa, and have directly linked outbreaks of MHF in humans to spillover from bats. Examination of limited sets of tissues collected during field studies of two large colonies of *R. aegyptiacus* in Uganda suggests that natural infection of bats with marburgviruses causes no significant clinical disease; this is consistent with the bat's suspected role as a reservoir host. In 2011, a captive breeding colony of *R. aegyptiacus* bats was established at the Centers for Disease Control and Prevention, Atlanta, GA, USA. Through experimental infection studies under Biosafety Level 4 laboratory conditions, we investigated the clinical and pathologic effects of experimental Marburg virus infection in Egyptian fruit bats. The tissue distribution and specific cell tropism of Marburg viral antigen were characterized using immunohistochemical staining techniques, and compared to findings in naturally-infected bats. These results contribute to the understanding of the pathogenesis of Marburg virus infection in *R. aegyptiacus*, and provide support for our experimental model of this virus-reservoir host system.

When to Approach Novel Prey Cues? Social Learning Strategies in Frog-eating Bats

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Animals can use different sources of information when making decisions. Foraging animals often have access to both self-acquired (private) and socially-acquired (public) information about prey. The fringe-lipped bat, *Trachops cirrhosus*, hunts frogs by approaching the calls that frogs produce to attract mates. We examined how the reliability of self-acquired prey cues affects social learning of novel prey cues. We trained bats to associate an artificial acoustic cue (cell phone ringtone) with food rewards. Bats were assigned to treatments in which their trained cue was either unreliable (rewarded 50% of the presentations) or reliable (rewarded 100% of the presentations) and they were exposed either to a conspecific tutor foraging on a reliable (rewarded 100%) novel cue or to the novel cue with no tutor present. Bats whose trained cue was unreliable were significantly more likely to preferentially approach the novel cue when compared to bats whose trained cue was reliable, and to bats that had no tutor. Reliability of self-acquired prey cues therefore affects social learning of novel prey cues by frog-eating bats. Few other studies have examined when animals use social information to learn about novel prey, although this question is key to understanding the social transmission of foraging innovations.

Neotropical Aerial Insectivorous Bats and Urbanization

Kirsten Jung and Elisabeth Kalko
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Urbanization is a dominant demographic trend throughout the world that involves massive habitat alterations. Understanding how urbanization affects biota is a crucial prerequisite for development and application of effective species conservation programs. Our study focuses on Neotropical high flying aerial insectivorous bats, an ecologically important, but so far seriously understudied group of vertebrates. Using acoustic monitoring, we assessed and compared species occurrence, composition and activity of aerial insectivorous bats at three site categories located on the isthmus in Panama: forest, urban areas and a forest–town interface. In 2 years of field work, we recorded 44,744 bat passes over the microphone and identified a total of 25 aerial insectivorous bat species. Species richness was highest in the forest, decreased towards the forest–town interface and was lowest at the urban sites, while dominance increased from the forest to the urban sites. Overall, general bat activity was highest at the forest–town interface and lowest at the urban sites. Multivariate analysis suggests compositional differences in species occurrence and activity among site categories with mainly molossid species occurring in urban areas. Our results clearly demonstrate species-specific differences between high flying aerial insectivorous bats concerning their adaptability and vulnerability to urban areas. Our results suggest that a suite of morphological traits including species mobility determine persistence of aerial insectivorous species in cities. Our results underline the necessity for detailed assessments of species-specific habitat requirements and dynamics of species occurrence and activity over time to develop meaningful conservation tools targeted at aerial insectivorous bats.

An Overview of Elisabeth Kalko's Life and Research

Kirsten Jung and Mirjam Knörnschild
University Ulm, Germany

When asked about her scientific interests, Elisabeth K.V. Kalko would outline her enthusiasm for sensory and behavioral ecology of bats and bioacoustics in general. She would talk about community ecology and biodiversity aspects in natural and anthropogenically shaped landscapes of tropical and temperate regions. She would highlight the importance of understanding biodiversity patterns and ecosystem services of species to integrate such knowledge into applied sciences such as conservation biology and zoonotic diseases with regard to wildlife and human health. She was enthusiastic and passionate about her work, creative in ideas and dedicated her lifetime to science. Elisabeth Kalko was the director of the Institute of Experimental Ecology at the University Ulm in Germany, staff scientist of the Smithsonian Tropical Research Institute in Panama and research associate of the American Museum of Natural History (AMNH) in Washington, D.C., USA. She was elected member of the National Committee for Global Change Research in Germany and the Heidelberg Academy of Sciences and chair of DIVERSITAS Germany. In our talk, we will give an overview of Elisabeth's life and scientific work. This introduction will be followed by cooperation partners and friends of Elisabeth who detail her research interest.

Using Trophic Patterns to Examine Links between Anthropogenic Inputs to Aquatic Systems and Insectivorous Bats

Matina Kalcounis-Rueppell, Stacy Huff, Victoria Payne, and Lindsey Zarecky
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As top predators in many aquatic systems, bats play a critical role in top down control of food webs and in the transfer of energy and nutrients to, and from, aquatic and terrestrial systems. In aquatic systems, bats feed on emergent and other insects in a relatively simple and traceable food web. The effects of anthropogenic inputs to aquatic systems can be examined through the analysis of both bat and insect activity and abundance, bat diet, and stable isotope (SI) values that are attributable to aquatic sources. In the headwaters of the Cape Fear River Basin, North Carolina, USA, we examined how point source urban wastewater treatment plant (WWTP) effluent influenced trophic behavior of bats. We determined whether bat species could be bio-indicators of water quality and whether anthropogenic nutrients in streams persist to bats. Within an urban landscape, we found nocturnal flying insect abundance and relative bat activity to differ up-, and downstream, of a WWTP. However, SI values and diet of bats did not differ. Rather, SI and diet values showed a general "urban" pattern. I will discuss various approaches, and their limits, to examining the influence of water quality on the trophic behavior of bats. Despite the critical, worldwide, role that insectivorous bats play as top predators in aquatic systems, few studies have made direct links between water quality and insectivorous bats. In the face of global water-quality decline, it is important to examine links between anthropogenic inputs to aquatic systems and insectivorous bats.

Resource Partitioning in Sympatric *Myotis lucifugus* and *Myotis septentrionalis* in a Northern Environment

Laura Kaupas
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Ecomorphology is often used to understand the coexistence of similar species in a community. In the Northwest Territories, Canada, *Myotis lucifugus* and *M. septentrionalis*, two small insectivorous species, live sympatrically. At more southern locations, they use different foraging strategies; aerial hawking and gleaning respectively. However, at northern latitudes, cold temperatures early and late in the active season limit the flight of aerial insects. We collected morphological and dietary data to examine if the two species are more similar, taking advantage of non-volant prey. We also aimed to understand what mechanisms allow for the coexistence of these species, if morphology and diet are similar. *Myotis lucifugus* had significantly higher wing loading and aspect ratio than *M. septentrionalis*. This suggests that *M. lucifugus* may forage further from vegetation than *M. septentrionalis*. Their diets were significantly different, with aerial insects being predominant in the diet of *M. lucifugus*, and prey that is often gleaned being predominant in the diet of *M. septentrionalis*. However, in early June and late August when nightly temperatures were below 10ºC, spiders were present in the diet of both species. The overlap in the diet suggests that there is flexibility in the foraging strategy of *M. lucifugus* and *M. septentrionalis*. The differences in

the proportion of prey that can be gleaned or captured aerially in the diet of the two species, and the trends in mass gain over the summer may provide insight into how their foraging strategies may differ.

Interspecific Roost Associations and Roost Choice in Neotropical Understory Bats

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Bats are among the most gregarious of mammals: sometimes thousands of individuals of different species roost communally, often in close physical contact. It is unclear whether these associations occur randomly or are due to similar roost preferences. In some cases, mutual benefits of associations have been postulated, such as predation avoidance or thermoregulatory benefits. To find out whether species actively associate with others in roosts, we observed roost selection behaviour in an understory bat community in the Caribbean lowlands of Costa Rica, where hollow trees are the most common roost type. We identified some principal species-specific roost selection parameters. We also found a positive correlation between roost size and bat abundance, as well as the number of species using the roost (but not always simultaneously). Additionally, we observed roosting behavior in artificial bat roosts to control for the influence of structural variation of roost physical characteristics on roost selection. Statistical models showed that roosting associations were not random and the presence of certain bat species could be predicted by structural roost parameters as well as by the presence/absence of other species. The association *Carollia sowelli* / *Glossophaga commissarisi* was most common in the forest habitat and we suspect benefits for at least one partner of the association, whereas some species excluded others from roosts indicating roost competition. These findings will help to understand the complex structuring of species rich bat communities in neotropical habitats and to identify the possible benefits of mixed-species roosting in bats.

Transmission of *Geomyces destructans* between Bats and the Environment

Marm Kilpatrick, Kate Langwig, Tina Cheng, Kevin Drees, Nicolette Janke, Jeff Foster, and Winifred Frick
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Understanding the role played by different species in the transmission of multi-host pathogens is necessary to determine which species are reservoirs and drive transmission, and to determine the impact of a disease on species as they decline in abundance. White-nose syndrome has devastated many populations of hibernating bats over the past six years and threatens some species with extinction. We examined patterns of infection with the fungus that causes white-nose syndrome among five species and the environment in hibernacula in the eastern USA to determine the extent to which transmission is predominantly within species, and to examine whether some species play disproportionate roles in contaminating the environment. We found that transmission was primarily within species and some species appeared to play larger roles in contaminating the environment. These results highlight the importance of social interactions among bats during hibernation for the transmission of *G. destructans*.

The Southeast Asian Bat Conservation Research Unit: Regional Bat Conservation Exceeding the Sum of Its Parts

Tigga Kingston and and *Tammy Mildenstein
Texas Tech University; University of Montana, USA

Regional networks provide for robust and resilient conservation efforts that promote consensus approaches to priority setting and action, as well as equitable distribution of management and leadership roles. The Southeast Asian Bat Conservation Research Unit (SEABCRU) is an open network of researchers, educators, and conservationists that seeks to promote the conservation of Southeast Asia's bat fauna through research, capacity building and outreach. SEABCRU is conducting a regional assessment of Southeast Asian bats centered on four priority areas identified by group consensus: flying fox distributions and population ecology; taxonomy and systematics; cave bat diversity and conservation; response of forest-dependent bats to landscape change. Each priority has a multinational team of experienced biologists and graduate and undergraduate students, who identify key conservation needs with input solicited from the regional bat research community through workshops and online communication. The flying fox priority, for example, has worked on numerous fronts to strengthen conservation efforts in SE Asia. We hosted two workshops tapping 118 local bat biologists to identify top threats and conservation needs across Southeast Asia. We developed a standardized population assessment protocol, which we vetted in a workshop of 35 regional bat experts to ensure its feasibility for locally-based conservation managers. We

developed a regional map of all known flying fox roosting colonies, >¾ of which were previously unrecorded. Drawing on the strengths of individual team members working at the country-wide scale, we are producing outputs that facilitate and coordinate bat conservation research on the regional scale of Southeast Asia.

Spatial Analysis of Species Interactions in Diverse Assemblages

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Texas Tech University, USA

In 2010, Brian McGill identified three key assertions common to six unified theories of biodiversity developed to explain recurrent biodiversity patterns (e.g. local species abundance distributions, species–area relationships, decay of similarity of distance). Two of these assertions are spatially explicit, requiring that: 1) intraspecifically, individuals are spatially aggregated and; 2) interspecifically, the spatial arrangement of individuals is independent. We test these assertions at local and landscape scales using diverse insectivorous bat assemblages within a contiguous, extensive tract of undisturbed lowland rainforest in Peninsular Malaysia. Five study grids were selected as spatially-independent lowland-forest replicates (> 6 km apart, < 300 m a.s.l). Four of the grids encompassed 100 ha each (22 km of trails) and one grid covered 120 ha (16 km of trails). Bat assemblages were surveyed 4-6 times at each grid with four-bank harp traps, the locations of which were all geo-referenced. To test assertion 1, we used univariate PERMANOVA to test for landscape-level clustering (comparisons among grids), and a concordance test of spatial autocorrelation to identify local clusters (within a grid). In testing assertion 2, pairwise comparisons of species capture rates between grids provided landscape assessments of interspecific spatial independence, and tests of interspecific correlations between within-grid capture localities and significant clusters provided for local-scale assessments. Species differed in the degree and scale at which they exhibited intraspecific clustering, and not all species were spatially independent of others. Our results indicate the influence of scale and interspecific differences in supporting McGill's assertions.

Distinct Regional Dialects in the Vocal Learning Bat *Saccopteryx bilineata*

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Regional dialects are frequently found in humans and vocal learning birds but they are comparatively scarce in non-human mammals. Most mammalian dialects can be attributed to genetic differences between populations, whereas vocal learning plays a less important role since many mammals are incapable of acquiring vocalizations through learning. Nevertheless, some mammalian dialects can be attributed to vocal learning abilities, for example in cetaceans, pinnipeds and bats. We studied the occurrence of regional dialects in a vocal learning bat, the Greater Sac-Winged Bat, *Saccopteryx bilineata*. Male *S. bilineata* have elaborate territorial displays including complex territorial songs that adolescent bats learn by imitating tutor males. We analysed 150 territorial songs from 30 males at twelve different regions in Costa Rica and Panama. The twelve different *S. bilineata* populations belonged to three different genetic lines. We compared acoustic, genetic and geographic differences between regions using partial Mantel tests. Our results revealed distinct regional dialects in territorial songs. The strongest acoustic differences existed between different genetic lines. Within each genetic line, acoustic differences between regions could not be linked to geographic distances, indicating that regional dialects are acquired by and maintained through vocal learning. Our work constitutes the first in-depth study of learned bat dialects, making *S. bilineata* a promising new species to investigate the process of dialect origin and, ultimately, cultural evolution in bats.

Horseshoe Bats Can Use Information in Echoes of Conspecific Calls for Spatial Orientation

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Bats in the wild often echolocate in the presence of other echolocating individuals. It is currently unclear if, in such situations, an individual bat experiences jamming by conspecific sonars or uses the information generated by conspecifics for its own means. We conducted behavioral experiments to address whether horseshoe bats are able to use spatial information in echoes reflected from conspecifics' calls. Greater horseshoe bats (*Rhinolophus ferrumequinum*) were trained to fly laps in a square flight tunnel that was lined with sound-absorbing foam. Pairs of bats were then introduced into the tunnel. When the two bats were passing a corner, a rapidly moving object was

triggered using computer-controlled light barriers. The front bat that has already turned the corner can detect the object with its own echolocation calls as it is now directly in front of him. The hind bat that is still approaching the corner can only detect the moving object behind the corner in the echoes of the front bat's calls, since they are less attenuated on the way to the hind bat than the hind bat's own calls. These are attenuated twice by diffraction on the way to the caller, whereas the echoes of front bat's calls diffract only once on the way to the hind bat. The control experiment confirmed that the hind bat reacted to the moving object only when it was ensonified by the front bat's calls. This is the first conclusive evidence that echolocators use information in the echoes of extraneous sonars. Such ability could facilitate sensory cooperation among echolocating bats.

Baseline Mercury Levels in Three Feeding Guilds of Neotropical Bats Prior to Mercury use in River Gold Mining

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The presence of excessive volumes of mercury in natural ecosystems may be an indicator of destructive human activity. In the last two decades as the price of gold has risen, there has been an increase in the number of unregulated artisanal river mining operations using mercury for amalgamation, especially in the Amazon basin, one of the most biodiverse areas on the planet. This study identified historical levels of total mercury from three feeding guilds of bats (piscivores, insectivores, and frugivores) using museum specimens collected in the Amazon basin of Perú and Brazil between 1923 and 1931. Analysis of fur from 101 individuals of *Noctilio leporinus*, *Myotis* spp., and *Carollia perspicillata*, revealed that baseline total mercury levels were significantly higher in *N. leporinus* (piscivore) than either *Myotis* spp. (insectivores) or *C. perspicillata* (frugivore), indicating that mercury biomagnifies as it moves up the food chain and may pose health risks to high trophic level organisms. The average total mercury in the piscivorous species was 9.51 ppm, which is lower than a previously reported toxicity threshold (e.g., >10 ppm/dw) at which neurobehavioral disorders have been recorded in rodents and mink. It is expected that present day levels of total mercury in *N. leporinus*, and likely in *Myotis* spp., will exceed this toxicity threshold, leading to neurological and behavioral changes in bats throughout tropical areas where unregulated gold mining occurs. While the method of using museum specimen skins to determine baseline levels of toxins has not been widely used, I argue it is a useful and non-invasive tool for documenting long term, ecosystem-wide changes, assessing conservation priorities, and determining human and ecosystem health risks. Future studies include present day sampling of the same species collected from museums from active and non-active gold mining areas in the Amazon basin.

Relative Humidity Is Not a Valid Ecological Variable

Allen Kurta
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Biologists often are interested in whether ambient moisture levels affect the activity of bats or their patterns of roost selection, presumably because of the decreased or increased rates of evaporative water loss. Almost invariably, field ecologists measure relative humidity and use this parameter in subsequent univariate or multivariate analyses. Relative humidity is defined as the ratio of the amount of water vapor in the air divided by the maximum amount of water vapor that could physically exist in the air (saturation vapor pressure). The saturation vapor pressure, however, is dependent on the temperature of the air, and the relationship is not perfectly linear. Consequently, it is easy to demonstrate that expected evaporation from the body surface of a bat hibernating at, for example, 95% relative humidity and 2 C will be less than the expected evaporation for a bat hibernating at 95% relative humidity and 10 C. Relative humidity is not a reliable predictor of evaporative water loss in variable field environments. These principles will be graphically demonstrated.

Bats in the Far North–Updated Distributions of Bats in Finland

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Bats are strictly protected in Finland due to the European Union legislation and EUROBATS agreement obligations. Hence up-to-date knowledge on species distributions is crucial for effective conservation. As a result of increased research and survey activities during the last decade, the species number in Finland has increased, being

now 13. To update and analyze the distributions of bats, we collated data from various sources: publications, survey reports, museum collections, ringing data and observation databases. Of circa 10 000 records identified to species level, 52 % concern the most common species, the Northern bat (*Eptesicus nilssonii*). The species diversity decreases towards the North, but instead of a gradual change in species composition, there seems to be an abrupt fall in species numbers in central Finland. The Northern bat is the only one inhabiting also the northernmost Lapland. Other common species occur mostly up till 64° N; however, the records are more abundant in the southern and eastern parts of the country. Recent studies of bat migration have revealed that the rarer species, such as Nathusius' Pipistrelle (*Pipistrellus nathusii*), also occur as north as the common ones. Potential factors hindering bat occurrence in the western and northern Finland include large barren areas, very light summer nights and lack of potential roosting sites. In Finland bats live on or close to the northern limit of their range. Thus climate change may affect the distributions of bats in the country in the near future.

Mitigating Bat Fatalities from Wind-power Plants through Targeted Curtailment: Results from 4 Years of Testing of CHIROTECH©

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An increasing number of bat fatalities is reported on some European wind facilities, which raises concerns about their impact on the viability of bat populations. It has been repeatedly suggested that targeted curtailment, i.e. stopping the wind turbines during periods of high bats activity, could effectively limit bat mortality. It also generates lost energy production and it is essential to ensure that curtailment is cost-effective. In order to check this hypothesis, we built a multi-factorial algorithm describing bats' theoretical activity under a wide range of environmental conditions and integrated it as a plug-in into wind turbine supervisory control and data acquisition software (SCADA). This has allowed us to remotely stop and start wind turbines according to modelled bat activity, and limiting losses of energy production. The efficiency of this patented device, called CHIROTECH©, was tested for two consecutive years on the 8 wind turbines of Bouin (western France), and two consecutive years on the 9 wind turbines of Saint-Martin-de-Crau (Southern France) as well as during bats fatality period in Bisnett (southern Ontario), Frontline (southern Ontario), Cruscades (southern France) and Coume (Nort-eastern France). Our results, based on an analysis of the number of bat carcasses found under regulated and controlled wind turbines, demonstrates a significant decrease of fatalities under regulated wind turbine, with a power output loss of less than 0.5% of annual production. These promising results offer renewed perspectives for reducing bat mortality induced by wind turbines facilities without compromising production targets or the economic viability of wind power plants.

Infection Loads of *Geomyces destructans* Influence Disease Impact

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Understanding *Geomyces destructans* transmission within multiple host species will allow for targeted disease management that may reduce the consequences of white-nose syndrome on bat populations. High pathogen loads on individuals may enhance transmission, and potentially drive mortality from disease. Seasonal changes in host behavior, as well as temperature and humidity differences among hibernacula, may also affect fungal growth, causing variation in mortality among species and individuals. We investigated transmission of the etiological agent of white-nose syndrome, *G. destructans*. Swabs from exposed wing and muzzle tissue of bats were collected and analyzed using real-time quantitative PCR. We found strong evidence of intense transmission during the winter, and by late winter nearly all bats were infected. For some species, pathogen loads increased significantly throughout hibernation, and females were more likely to be infected than males, possibly due to earlier entry into torpor. Species with high prevalence in early hibernation had the highest increases in loads, and the greatest mortality. In contrast, loads on big brown bats and Indiana myotis did not increase as greatly over the course of hibernation, and this may account for reduced mortality in these species. Pathogen prevalence and loads on little brown myotis decrease rapidly upon emergence from hibernation, suggesting that hibernacula serve as the source of the yearly epidemic. Changes in pathogen loads coupled with early timing of infection may be important factors in WNS mortality, and be important drivers of local transmission.

Landscape Features Associated with Attacks on Cattle by Common Vampire Bats in Central Mexico

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Bovine paralytic rabies, a disease transmitted by the common vampire bat (*Desmodus rotundus*), causes great economic losses in the livestock sector. Although the total number of cases reported in Latin America has greatly decreased due to the vaccination campaigns, economic losses may be significant for small holders. Identification of risk areas for vampire bat attacks on cattle would be useful to optimize efforts of preventive campaigns of bovine rabies. In this study, we analyzed the landscape features associated with the frequency of attacks on cattle by the common vampire in central Mexico. We sampled 61 locations (ranches) between May and July, 2011. At each location we quantified the frequency of attacks on livestock and described features of the landscape within a radius of 200 m around the site of night rest of prey: land topographic complexity, percent cover of forest, as well as the number of forest fragments and corridors, streams, tree lines, human-made buildings, and roads. We generated models describing relationships of attacks with human interference, prey availability, and bat movement facilitation. Frequency of attacks was best explained by the human interference model which combines the effect of the number of buildings and roads. In general, cattle are more vulnerable to vampire bat attacks in less confined night resting sites, which are far from human activity and in close proximity with relatively large forest fragments. Ours results suggest that preventive bovine paralytic rabies campaigns should focus on fragmented areas with little livestock management.

Shedding Light on Speciation Processes in Bats Using Phylogenomics: Where Do We Start?

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Next-generation sequencing technologies have created exciting new opportunities for studying the evolutionary histories of non-model organisms. A growing number of phylogenomic studies are utilizing these advanced sequencing platforms to screen for signatures of selection and to examine species boundaries in wild populations. Such studies have the potential to identify regions of the genome experiencing divergent selection and can elucidate speciation processes. However, exploring the historical processes underlying the origin of species within non-model organisms requires data from a number of sources. For example, it is important to have a well-supported phylogeny of all extant taxa and an understanding of the timing of lineage formation within the group. Here, we discuss recent advances in phylogenomic approaches (e.g., RADseq) and how these approaches might impact studies focused on bat speciation. We highlight lineages within the New World leaf-nosed bats (family Phyllostomidae) that are ideally suited for genome-scanning approaches and therefore have the potential to help us understand speciation processes in Chiroptera. In particular, we focus on the remarkable diversity present within the fruit-eating bats (genus *Artibeus*), wherein multiple speciation processes are hypothesized to have contributed to extant species-level diversity. We posit that phylogenomic analyses, when combined with traditional Sanger sequencing and morphological based methods, will help to identify unrecognized speciation and hybridization events in multiple taxonomic groups.

Unravelling the Mysteries of Winter Bat Ecology in Western Canada

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White Nose Syndrome (WNS) kills bats during hibernation; increased winter flights have been associated with WNS, and dehydration and starvation have been implemented in mortalities. We wanted to study normal hibernation behaviour in western Canadian bat species to begin to understand how this disease may unfold in the West, and which species may be more or less at risk. Our goals are to: 1) Determine species diversity and ecology during winter across British Columbia (B.C.); 2) Locate and describe hibernacula. We used both acoustic monitoring and radiotelemetry to examine winter distributions/movements of bats, habitat use, and behaviour. British Columbia has 16 species of bats, 14 of which may hibernate in the province. We present results from the first 2 years of this 4+ year project. We found late fall (November) activity of at least 8 species, suggesting they likely overwinter in B.C. During winter, we acoustically recorded and observed/captured 6 species of free-flying bats: big

browns (*Eptesicus fuscus*), silver-haired (*Lasionycteris noctivagans*), Townsend's Big-eared (*Corynorhinus townsendii*), Californian (*Myotis californicus*), Western small-footed (*M. ciliolabrum*), and Yuma (*M. yumanensis*). Hibernacula were located for these species, and roosts included rock crevices, mines, trees, snags, and buildings. We captured free-flying bats in winter at study sites across southern B.C., with the most active species being silver-haired and Californian. Silver-haireds mated in winter and frequently switched roosts, alternating between mine and tree hibernacula. Californians appeared to be foraging on dormant insects in low elevation mines, as determined through plastic laid in mines and acoustic monitoring.

Environmental Variables Affect Nightly Foraging Activity of Insectivorous Bats over Ten Years in Tropical Premontane Forest, Costa Rica

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We investigated the role of environmental and temporal variables in the foraging activity of 20 species of aerial insectivorous bats at a site in tropical premontane forest in Monteverde, Costa Rica. The study site was an opening in secondary forest adjacent to the Children's Rainforest at 1350m. We monitored the echolocation calls of all bats detected by an Anabat II detector all night for 1,147 nights from November 2000 through August 2010, from which we were able to identify the species in more than 250,000 bat passes. Simultaneously we recorded environmental variables. We found that five species accounted for most of the activity, but the relative frequency of these species fluctuated widely over the ten-year period. Using stepwise multiple logistic regression, we noted that the likelihood of any one of the three most common species being present was significantly influenced by the phase of the moon, rain, wind, the time of night, the season of the year, the presence of the other two species, and the number of passes by those two species. In general, full moon depresses bat activity, moderate to heavy rain halts bat activity, strong winds increase bat activity, bats are most active early in the evening, activity varies seasonally, and the activity of each of the three common species depends on the presence and activity level of the other two. Clearly, the environmental variables we measured have a major effect on insectivorous bat activity at our study site. Coincidently, we noted that the number of bat passes at the study site continuously declined over the ten-year period, but our data were unable to support any hypothesis to explain this unfortunate trend.

Changes in Survival over 14 Years in a Suite of Hollow-roosting Australian Vespertilionid Bats in a Forest Logging Experiment

Brad Law, Mark Chidel, and Peter Law
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Long term research on Australian bats has been glaring in its absence. Unlike many other taxa, base-line data to identify changes in status overtime is virtually non-existent for bats. Such data are vital for understanding climate change impacts and other environmental changes, especially logging or fire, because of the complex ecological processes that pervade long-lived systems like forests. We have undertaken two long-term banding studies, the first targeting a habitat specialist, the fishing bat *Myotis macropus* (17 years), and the second a suite of small, hollow-roosting vespertilionids (14 years). We discuss mark-recapture analyses for the second project, which is located in an experimental forest area in south-eastern Australia containing small catchments of unlogged and regrowth forest. We caught bats in harp traps as they foraged and banded 3043 with a 32 % retrap rate. Analyses allowed for dependence of survival on time, species, sex, and logging treatment. We found a strong transient effect, indicating a highly fluid local bat population. Yet a portion of the population remained resident and our maximum time to recapture was nine years. Inter-year survival was generally independent of species, sex and logging treatment, although there was a subtle interaction between these. Unexpectedly, survival did not show strong variation with time, even though our study spanned extreme El Nino and La Nina weather events. However, an index of recruitment varied significantly between years and was highly correlated with annual rainfall in the preceding 12 months. We recommend a greater emphasis on establishing, maintaining, analysing and publishing long-term research.

Population Monitoring of the Maternity Colony of *Miniopterus schreibersii bassanii* at Naracoorte Caves National Park, South Australia

Kristen Lear, Terry Reardon, and Lindy Lumsden
Naracoorte Caves National Park, Australia; South Australian Museum, Australia; Arthur Rylah Institute, Australia

The Southern Bent-wing Bat (*Miniopterus schreibersii bassanii*) is listed as Critically Endangered by the Australian government due to a 67% population reduction over the last 50 years, the species' limited distribution, and its reliance on just two maternity caves in southern Australia. The first goal of this study was to determine population numbers at the Bat Cave maternity site (Naracoorte, South Australia). An automated counting system based on thermal imaging technology was used to take population estimates several times per week from September 2011 to October 2012. During the maternity season there were regular fluctuations in the number present, indicating for the first time that significant numbers of bats may use surrounding caves during this time. Results also indicate an increase in peak numbers from previous years. However, we cannot assume a sustained population growth. Counts from previous years were taken only several times per summer and may have been taken when a significant proportion of bats had temporarily left Bat Cave. The second goal was to monitor the bats at their over-wintering sites. An extensive winter survey of 37 caves in 2012 resulted in a count of 15,479 bats, which is significantly lower than the peak summer population at Bat Cave of 40,464 bats. It is possible that we do not know all the over-wintering sites or that the bats use other structures besides caves during winter. These results highlight the importance of continued monitoring to accurately assess population trends and target recovery strategies for this Critically Endangered species.

Making Use of Old Biased Estimates: a Trait-based Model of Microbat Survival

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Survival rates form key demographic parameters in population studies, and must be estimated precisely to predict how populations will fluctuate through time. For many mammals, annual survival and longevity can be estimated by body mass. This is not the case for microbats, which live for decades in spite of their size, so it is a priority to identify alternative traits which will allow for estimation of vital rates. Ample data are available for this as researchers have been banding bats and estimating survival since the 1920s, but these are likely to be biased due to the statistical methods, and trapping and marking techniques historically used. We conducted a literature review and collected 194 published estimates on 44 species. We then constructed a predictive model of survival based on reproductive, feeding, and demographic traits, accounting for biases associated with older studies. We used this model to predict annual survival rates for *Chalinolobus gouldii* and *Tadarida australis*, which were the subject of an eight-year bat box monitoring program. The predictions were used to construct informative priors for Cormack-Jolly-Seber survival modelling of the bat box data in a Bayesian analysis framework. We demonstrate that incorporation of an informative prior greatly increases the precision of survival estimates, and reduces the number of years required to reach a given level of precision compared with empirical data alone. Bats are currently facing a suite of threats, so any technique which reduces the amount of field time required to build reliable population models presents a great advantage.

Bat Monitoring Project and REDD+ (Reducing Emissions from Deforestation and Forest Degradation) at Iwokrama Forest in Guyana

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An annual biodiversity monitoring programme was established in 2011 at Iwokrama Forest in Guyana by Operation Wallacea, an organization that combines conservation research at academic institutions with the training of university students. We report on the bat monitoring project that will contribute to the United Nations initiative to incorporate the conservation of biodiversity in Reducing Emissions from Deforestation and Forest Degradation (REDD+) in developing countries. Iwokrama Forest is home to almost 90 species of bats, making it one of the better documented and diverse protected areas in the world. Establishing long term monitoring based on standardized survey methods is an essential step in attaining a more complete understanding of this bat community. Five sites were surveyed using 18 understory mist nets arranged in nine pairs positioned at 50 m intervals in a 100-meter grid. Captured individuals were weighed, sexed, aged, and marked by wing puncture for release. Species richness

decreased from 30 to 20 species and capture rates decreased by half from 2011 to 2012. Five species were dominant (*Artibeus planirostrus*, *A. obscurus*, *A. lituratus, Carollia perspicillata*, and *Lophostoma silvicolum*), and accounted for 68% and 59% of total captures in 2011 and 2012, respectively. *Furipterus horrens* and *Mimon bennettii* were added to the list of known species of the Iwokrama Forest. Further monitoring is needed in order to ascertain whether the decrease in species diversity and relative abundance represent natural community and population variation or a downward trend of potential conservation concern, which may be correlated to climate change.

Phylogenetic Relationships of Bats in the Genus *Molossus* (Molossidae:Chiroptera)

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The taxonomy and evolutionary relationships of the velvety free-tailed bats from Central and South America has long been debated. Within the genus *Molossus*, and particularly the species *M. molossus*, specimens have been especially difficult to identify and are taxonomically challenging. Over the years, the eight currently recognized species of *Molossus* have been divided into subspecies and/or elevated into species based on morphological data. The objective of this project was to determine the relationship of *Molossus molossus* and its subspecies to the other species of *Molossus* using a molecular approach. We tested the hypothesis that analysis of DNA sequence data would recover 4 lineages within *M. molossus* consistent with current subspecies designations. The mitochondrial gene, cytochrome b (cyt b), was amplified from specimen tissues from several localities across the species geographic range. Cyt b was sequenced and analyzed phylogenetically using Bayesian Inference and a Maximum Likelihood approach. *Promops centralis* was used as an outgroup. Tamura-Nei (T92) plus gamma distribution was determined to be the best fit model for the data. Preliminary results support monophyly of *Molossus molossus*. However, the branching pattern is not consistent with current geographical subspecies designations.

Vocal Communication in Adult Greater Tube-nosed Bats (*Murina leucogaster*)

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Understanding vocal communication systems is essential to the study of animal behaviour and ecology, especially for animals that mostly rely on acoustic signals for communication. Vocal communication in bats involves communication calls consisting of rich repertoires that serve in social interactions, as well as echolocation calls that influence the behaviour of conspecifics and others. Few studies, however, have systematically examined vocal communication within a bat species in above-mentioned aspects. Therefore, we recorded vocalizations and behaviors of adult greater tube-nosed bat, *Murina leucogaster*, in a free-flight facility. Analysis revealed that this species exhibited a rich repertoire encompassing 17 distinct syllable types with diverse spectrotemporal characteristics which further categorized into 13 simple syllables and 4 composite syllables, and we identified 7 vocalizations types corresponding to different behaviors. In addition, we found FM pulses emitted for echolocation could be embedded within social vocalizations (syllable A) and bats changed echolocation call features in the presence of conspecies and in discomfort from human handling (syllable B). These echolocation-like vocalizations also appeared to serve communication role. Our study not only elucidates communicative vocalizations in a so far widely neglected bat species, *Murina*, but also provides the basis for future studies on neural control of communication systems.

Tracking White-nose Syndrome and Other Threats: a Population Monitoring Program for North American Bats

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Bats in North America are facing unprecedented threats including White-Nose Syndrome, wind energy development, habitat loss and fragmentation, and climate change. Yet, there is currently no coordinated monitoring program to track changes in their populations in response to these threats. A group of scientists and statisticians from the U.S., Canada, and Mexico is developing the North American Bat Monitoring Program (NABat), a framework for bat monitoring across North America. NABat will provide the statistical, biological and administrative architecture for coordinated bat population monitoring that will promote effective decision-making and long-term viability of bat

populations across the continent by providing robust data on changes in bat distributions and abundance. The sampling framework will likely be comprised of a nested grid consisting of 50 km cells as primary units, 10 km cells as secondary units, and 5 km cells as tertiary units; 1 km cells can be used for intensive research and local monitoring projects. A spatially balanced design will be used so that unequal and changing survey efforts can be accounted for in design-based and model-based population estimates of status and trend. The primary data sources will be maternity and hibernacula counts and acoustic data collected along driving transects or at stationary points across the landscape. Data will be housed and managed by the Bat Population Data (BPD) Project, an initiative of the USGS Fort Collins Science Center to foster data sharing and collaboration through a web-based bat population data management application.

Cranial and Mandibular Morphological Variation of *Carollia* in Colombia: Modularity and Integration, Sexual Dimorphism and Biogeographic Patterns

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Adaptations to dietary habits influenced the diversification of bats in the Neotropics, where Phyllostomid bats comprise species with high morphological and ecological plasticity which has resulted in the colonization of multiple ecosystems. *Carollia* is a group of frugivorous species identified with a high morphological plasticity; however the factors and mechanisms involved in this plasticity and the interaction between the cranial and mandibular morphology remain mostly unknown. In this study, using the Geometric Morphometrics methodology, were assessed the patterns of morphological variation in the species of *Carollia* presents in Colombia (*C. castanea*, *C. brevicauda* and *C. perspicillata*) analyzing the integration, modularity, biogeographic patterns and sexual dimorphism in the cranial and mandibular morphology. 286 specimens distributed across the country were analyzed. A priori hypothesis for modularity was accepted for all species (Skull RV=0.2058; Jaw RV=0.2690) showing differences in the partition of modules of the skull within the three species. Partial Least Square analysis for integration in cranial and mandibular morphology showed significant correlation for all the species (r=1.29E+2; r^2=1.65E-2). MANOVA for biogeographic patterns showed that specimens from the Andean region were the most significantly different across the country in the cranial morphology, this pattern was found for *C. brevicauda* and *C. perspicillata* (λ=0.5182; F=1.906; p=0.0018). Finally sexual dimorphism was not significant for any of the species (λ=0.9844; F=0.4848; p=0.8844). These results suggest that the patterns of morphological variation for *Carollia* respond differentially to the environment being these patterns specific for each species.

Short-term Effects of Bands and Transponders on Body Condition and Physiological Stress of Three European Bat Species

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Science often requires marking individuals to respond ecological or biological questions and, whereas it is commonly assumed that benefits from provided information prevail over the adverse effects upon animal populations, these impacts are not always quantified. Different marking techniques on bats have been used in research for many years, but banding has usually been chosen as the best method for bats. Although experience grew and more injury reports came out, these effects have probably always been underestimated and no severe assessment of the impacts has been conducted. Thus, the aim of this project was to conscientiously compare bands and transponders technique on three European bat species under natural conditions. We compiled an extensive literature review regarding detrimental effects, established a standardized injuries' classification key, assessed the detrimental effect for both methodologies along the three year project on *Miniopterus schreibersii*, *Nyctalus leisleri* and *Pipistrellus pygmaeus* using recapture and injuries' rates, and additionally compared chronic stress on *P. pygmaeus* by quantifying glucocorticoids in fecal samples. Bands caused significantly more proportion of injuries, as it was previously suggested in the literature, while we did not found any microchipped injured bat with subcutaneous tissue masses. Recapture rates seem to be similar while physiological stress condition was slightly higher on bands in comparison with both control and microchipped bats. Whereas transponders seem to be much less invasive technique, we consider essential to assess this long-term effect of bands to discuss and conclude an achievable level of incidences on bat populations within scientific research.

Perceived Predation Risk Triggers Cooperation and Selfishness in *Rhinolophus pusillus*

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The 'survival of the fittest', a basic evolutionary principle, drives actors' selfishness that maximizes own fitness. However, cooperation runs counter to selfishness that does widely occur in animal societies. Many researches focus on explaining cooperation based on kin selection, reciprocity, group selection, or manipulation. Less is known about how cooperation and selfishness coexist in nature. Here, we examined behavioral responses to risky cues of distress calls in adult least horseshoe bats (Rhinolophus pusillus), across broad geographic areas. Combined with potential predators (experimenters), environmental silence and distress calls from 4 allopatric colonies, were broadcasted outside 3 bat roosts at dusk. Analysis revealed that risky sound cues elicited synchronous mobbing and refuge reactions among audiences. Many R. pusillus rapidly approached torwards sources of distress calls, but some conspecifics still stayed in the roost beyond regular departure time. R. pusillus showed no specific responses to distress stimuli from different colonies. Generalized reciprocity may maintain cooperative mobbing between allopatric bats. We provide the first evidence that perceived predation risk triggers both cooperation and selfishness behaviours in echolocating bat. Predation may serve as ultimate selective pressure to promote the evolution of cooperation and selfishness.

Changes in Body Condition of Frugivorous Bats that use Banana Plantations in Rio de Janeiro, Brazil

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Banana plantations had higher frugivorous bat abundance than forest fragments, probably due to the constantly high availability of food. In Brazil, banana (*Musa* spp.) is an exotic plant and nutrients composition of the banana fruit differ from native fruits consumed by bats. Our objective was to test if body condition of bats that use banana plantations in Rio de Janeiro differ from those that use forest fragments. We selected 12 banana plantations in southwestern Rio de Janeiro, and carried out monthly sampling for two nights, one in a banana plantation and the other in an adjacent forest fragment, from November 2008 to October 2010, summing up 48 nights. Sampling was carried out with mist nets, which were opened before sunset and kept open all night long. Bats were identified, measured, marked with necklaces of colored cylinders and them released. We calculated body condition (weight/forearm) of frugivorous bats *Carollia perspicillata* and *Artibeus lituratus*. We used the Kruskal-Wallis test to compare these parameter between bats captured in banana plantations and in forest fragments. Pregnant females and young were excluded from analysis. In banana plantations we captured 450 individuals of *C. perspicillata* and 536 individuals of *A. lituratus* and in forest fragments 273 individuals of *C. perspicillata* and 227 individuals of *A. lituratus*. Body condition of both species was significantly higher in forest fragments. This result suggests that body condition of frugivorous bats is affected by banana consumption. A possible explanation is banana fruit deficiency in protein.

Bats of the Valle de Uxpanapa, Veracruz, Mexico: Knowledge and Strategies for their Conservation

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Over the last 30 years, around 86% of the tropical forests of Mexico have been transformed into productive systems. This process is particularly apparent in the forests of the state of Veracruz. Within this state, the region of Uxpanapa constitutes the most extensive and well-conserved remnant of the tropical forest in Veracruz, and is considered to be one of the most important centers of biodiversity in Mexico. The chiropterofauna of this region is estimated to number around 88 species (63% of the total for Mexico), and is undoubtedly one of the most diverse at the national level. Nevertheless, few studies have been conducted in the area, and very few have evaluated the diversity of the assemblages in both conserved and anthropized habitats. From 2010 to 2012, we used mist nets, harp traps and ultrasonic recording techniques to record a total of 43 species belonging to 7 families, with the family Phyllostomidae contributing the largest number of species, at 29. The high evergreen tropical forest is the habitat

with the greatest richness of species, followed by plantations of the rubber tree (*Hevea brasiliensis*) and the acahual, with 34, 26 and 21 species, respectively. The rubber plantations constitute the habitat with the greatest abundance of individuals, at 975, with *Sturnira lilium* found to be the dominant species in this habitat. Despite the extensive deforestation suffered in the last decades, Uxpanapa still constitutes one of the most rich and diverse region for bat fauna, and a priority for conservation policies.

A Global Analysis of Insectivorous Bat Diet in Relation to Land Cover

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Insectivorous bats consume massive amounts of insects each night, and several studies have attempted to relate morphological and echolocation traits to prey selection. Several studies have also evaluated the influence of habitat on prey consumption by insectivorous bats on a local scale, but few if any have assessed this on a global scale. We conducted an analysis of dietary patterns in insectivorous bats from around the world to evaluate possible relationships between prey selection and habitat fragmentation. To evaluate such patterns, we conducted a large-scale, phylogenetically informed analysis on dietary data in published literature. We found appropriate diet data for 224 populations of 110 species from 20 countries representing every continent with bats. We estimated dietary niche breadth with Simpson's Reciprocal Index and used GIS to determine land cover in 5, 20, and 50 km buffers around the location of capture. We used phylogenetic generalized least squares analyses to evaluate the relationships between land cover usage and 1) the prevalence of specific insect orders in the diet and 2) dietary niche breadth. Relationships were generally weak, but both insect orders in the diet and dietary niche breadth were related to availability of natural habitats and to fragmentation of the habitat.

Survey of Indian Bats: Current Status around the Mumbai Region (Maharashtra)

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Surveys of some species of Indian bats were carried out from 1989 to 2013 to understand the impact of Global environmental change and human intervention in around the Mumbai (Bombay) region. Some species like *Rousettus leschenault*, *Pteropus giganteus giganteus*, Pt*eropus pteropus*, *Taphozous melanopogon, Taphozous longimanus, Tahpozous taphozous*, *Taphozous kachanci*, *Megaderma lyra lyra*, and *Cynopterous cynopterous*, *Rhinolophus rouxi* were spotted at different places like Sanjay Gandhi National park at Borivali, where the two colonies were found. *Rousettus leschenaultia* and *Taphozous kachanci* were the two species found in abundant caves in Sanjay Gandhi National Park, Borivali, Mumbai. Population of species *Rousettus leschenaultia* recorded during year 1987-91 with huge population in a single colony. Latter on the survey carried out on subsequent years to note the population of these bats at each year showed large reduction in number in the month of January 2013 due to rapid human intervention. Places like Jogeshwari caves which is surrounded with thick human population where *Rousettus leschenaultia* colony spotted during 1987-91 with recorded sufficient number, which also declines rapidly with non availability of the species on the same spot in January 2013 as a result of human interference. *Taphozous melanopogon* and *Taphozous taphozous* were the two species spotted during these years on Elephanta Island near Mumbai shore showed drastic decline in population of these species and now can be rarely seen. Pt*eropus giganteus giganteus* and Pter*opus pteropus* are two major species were disturbed all around the Mumbai during these periods. Population of these species drastically decrease due to unavailability of big trees, but few colonies still survives in out skirts of Mumbai. *Cynopterous cynopterous* bat found all over the city from north end to south end but their population decreases notably due to non-availability of sufficient number of indigenous plants (which provides shelters to these animals) and also due to fast urbanization. Many other species like false vampire bats (*Megaderma lyra lyra*), *Taphozous kachanci* and *Minopterus schreibersii fuliginosus* spotted in other parts of the country like kandri mines near Nagpur and in Usmanabad Hills and in Robert cave near Mahabaleshwar respectively were seen rarely on the same spots are above to extinction. The details about impact of human intervention on bat population are discussed further.

A New Species of *Lonchorhina* (Chiroptera: Phyllostomidae) from Colombia

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Sword-nose bats genus *Lonchorhina* are characterized by the most developed telic structures among representatives of the Neotropical family Phyllostomidae, including the longest nosed-leaf ear pinna, and tragi in respect to their body sizes. These extraordinary morphological adaptations have been associated with a hyper-developed echolocation system that allows these bats to forage for their prey in stratified forests. Herein, we introduce a new species of sword-nose bat from the Colombian Guyana, representing the phyllostomid species with the largest nose leaf and tragus known (nose leaf > 41.5 mm, tragus > 22.3 mm). The new species is part of the large skull *Lonchorhina* (Greatest Skull Length, GSL > 21.5 mm) and it is closely related in its morphology to the rare *L. marinkellei* and *L. inusitata* from which it is easy to tell apart by its overall larger size (GSL media=27.31; Standard Deviation = 0.5) and more massive dentition. The holotype of *Lonchorhina sp. nov.* was collected at Rio Mesay, Puerto Abeja in the Southwestern portion of the Serranía de Chiribiquete, Colombian department of Caquetá, at 340 meters, in the Colombian tepuis, one of the most unexplored areas in the country.

Comparative Genomic and Phylogeographic Analysis of Horseshoe Bats

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Advances in phylogeography suggest taxonomic boundaries may commonly arise and persist in the face of gene flow. Consequently the formation and maintenance of reproductive barriers may involve just a few so-called 'barrier genes' that function in aspects of pre- and/or post-copulatory mate choice. Here we combined phylogenetic and genomic analyses to identify potential barrier genes in horseshoe bats (Rhinolophidae). Rapid diversification in this speciose family might have been further facilitated by their use of constant frequency calls that appear to play a dual role in echolocation and communication. Thus divergent selection on the echolocation call frequency for hunting or habitat-use could also lead to pre-mating isolation. We obtained RNASeq data from nine horseshoe bat taxa and built alignments for ~3000 coding gene sequences. From these we identified candidate barrier genes based on known function, including 85 hearing genes and 270 reproductive genes. To assess whether these genes have contributed to horseshoe bat diversification, we tested for positive selection at each locus across the clade and found 66 genes showing evidence of molecular adaptation, including one linked to hearing. Next, to determine whether candidate barrier genes show reduced gene flow between hybridizing horseshoe bat species, for each locus we compared the relative support of competing phylogenetic hypotheses consistent with and without nuclear introgression. Initial findings revealed numerous genes have resisted introgression, although these did not include the candidate barrier genes identified. These first insights into the genetic basis of bat species barriers highlight the promise of genome approaches for bat research.

Morphological and Ecological Similarity Influences Distribution of Closely Related Taxa: a Case Study in *Artibeus*

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Exploring the distribution of diversity and disparity is a topic of major interest in biology as it has important consequences for understanding the interplay between morphological evolution, ecological adaptation, and phylogenetic constraints. Such interplay plays a pervasive role in the structuring of communities and diversification processes as it determines the likelihood of rapid ecological speciation. Phyllostomid bats represent an ideal system to investigate patterns of morphological evolution in response to environmental pressures given their rapid ecological diversification, characterized by dramatic morphological and ecological variation associated with different feeding strategies. In particular, fruit-eating bats of the genus *Artibeus* are well-suited to study this topic because of their wide neotropical distribution and broad ecological, phenotypic, and genetic variability. In this study we explore the question of how this variation is spatially structured, and if it is mostly phylogenetically or environmentally driven. To address these questions, we investigate the degree of ecological and morphological conservatism across species of this genus. We then evaluate the association between species' geographic distribution and inter-specific morphometric variation by incorporating ecogeographic information through the use of geographic information systems. The broad-scale patterns of skull size and morphological traits' spatial variation in

the genus partially support the hypothesis of environmentally driven variation. Specifically, morphological disparity tends to be concentrated among species that inhabit different environments. This association between morphology and environment does not seem to be exclusively driven by phylogenetic relatedness. Together these results highlight the likely important role that habitat use played in the diversification of this genus.

Bat Research in Madurai, India (1977-present)

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The areas in bat-research that I have studied include social synchronization of circadian rhythm, breeding and mother-young relations, foraging behavior, prey detection and capture, fruit bats damaging orchards and possible solution, diversity of bats in Andaman and Nicobar Islands, location of caves harboring the endemic fruit bat *Latidens salimalii*; and the status of fruit bats in the Indian Wildlife (Protection) Act, 1972 and Amended Acts. A recent research revealed that male *Pteropus giganteus* exhibited cunnilingus before and after copulation. The duration of pre-copulatory cunnilingus and copulation was positively correlated. The duration of pre- and post-copulatory cunnilingus was negatively correlated. Pre-copulatory cunnilingus may enhance the arousal and lubrication of the female. The most recent observations on two groups of *Cynopterus sphinx*, occupying palm trees disclose that a few minutes prior to evening emergence, each individual involved in licking the inner surface of wing membranes. Afterwards all the individuals moved towards each other and covered themselves with wing membranes that led to the formation of a "ball". Their bodies and heads were not visible to the observers. However, it was easy to presume that they involved in grooming. The number of individuals involved in this process ranged from two to six. The duration of bats remaining in the ball ranged between 10 and 280 sec. When they withdrew from each other, their heads and shoulders were wet. After a few minutes the bats left the trees for foraging. We predict that the formation of grooming ball strengthens social bond among roost mates.

Training for Catching Bats

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Bats catching survey is a technique complementary to other survey methods that allow answering to scientific or conservation questions. It may be used to confirm species, sex and breeding status, to sample biological tissues or to fit radio-transmitters for further survey work. Given the protected status of all bat species in France and the fact that this method is invasive, it is essential that bat workers undergo a theoretical and practical training in the best interest of bats. In the context of the French national action plan for bats conservation and in response to requests from volunteer and professional naturalists, a training system is being set up in the French bat workers community. Training tools (training log, internships) and the implementation of the system within the network will be presented in order to compare and discuss what is done in other countries.

Current Trends in French Bat Populations Highlighted by Ancient Banding Data

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Bats are an important component of biodiversity but most European species have a bad conservation status due to various threats such as agriculture intensification, urbanization, and forest management. Few qualitative reports from the last fifty years indicate that most, if not all, of French cave dwelling bats have suffered since then a dramatic decline. Conversely, during the last 10 years in France, hibernacula counts indicate that many species of conservation concern are stabilizing or, for some of them, increasing. But how can we interpret these trends without a precise knowledge of those past declines? Therefore we used banding data uncovered from ancient registers of the National History Museum of Paris to analyze the evolution of past populations. From 1936 to the early 80's, more than 130 000 bats have been banded by volunteer bat workers right in roost. Poor handling, injuries arising from band itself and roosts disturbance were certainly responsible for some casualties' lethality but cannot account for the overall decline. At first, we proceeded to identify the limits of this old dataset; the lack of research guidelines at that time has caused a large variety of practices and therefore, important heterogeneity of data. Then, using population dynamics modeling, we reveal the huge decline which took place 60 years ago in the French cave dwelling bats

populations. These baseline statuses of the European bat populations are essential to justify current conservation actions.

Effectiveness of Operational Mitigation in Reducing Bat Fatalities at the Sheffield Wind Facility, Vermont

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Bat fatalities have been documented at every wind facility in North America where post-construction surveys have been reported, and fatalities are particularly high along forested ridgelines in the eastern U.S. Developing measures to prevent future wind-related bat fatalities is essential to avoid potential population-level cumulative impacts to bats. Our objectives are to determine the effectiveness of operational mitigation by raising the cut-in speed of turbines (i.e., curtailment) to decrease bat fatalities. We initiated a two-year study in spring 2012 at the Sheffield Wind Facility in Sheffield, Vermont, U.S. Between 3 June and 30 September, eight of the total 16 turbines were randomly selected each night of the study for an equal number of nights at each turbine to cut-in at 6.0 m/s rather than the normal cut-in speed of 4.0 m/s. Turbines were curtailed from half an hour before sunset to sunrise during periods of low wind and temperatures above 9.5° C, when bats are presumably more active. Preliminary results from daily fatality searches indicate that bat mortalities at fully operational turbines (i.e., non-curtailed) were 2.7 times higher than mortalities at curtailed turbines, resulting in an estimated 60% (95% CI: 29, 79) decrease in bat fatalities. Our preliminary findings are consistent with other studies and suggest that implementing operational mitigation during periods of high risk is effective in reducing bat fatalities.

Phylogeny of Vespertilionid Bats in Relation to White-nose Syndrome

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The white-nose syndrome (WNS) caused an epizootic in North America that could lead to multiple local extinctions of hibernating bats in the near future. While North American bats recognised with WNS belong to the genera *Myotis*, *Perimyotis* and *Eptesicus*, *Myotis* species are the most severely affected. Likewise, in Europe the *Geomyces destructans* infection (geomycosis), as well as WNS, were diagnosed in *Myotis* species. We hypothesized that closely related bats are more susceptible to the infection. We tested this on a maximum likelihood phylogeny based on DNA sequences from 13 mitochondrial and nuclear genes. Pruning the phylogeny to species distributed in North America and Europe, we tested the phylogenetic representation of geomycosis and WNS on 55 taxa. The results showed that the previously diagnosed taxa were significantly phylogenetically clustered (net relatedness index > 0) and the nearest relatives were more likely to be infected with *G. destructans* than expected (nearest taxon index > 0). However, the manifestation of WNS in nearest relatives was indistinguishable from random distribution of the trait on the phylogeny. Adding three taxa newly diagnosed with geomycosis, the phylogenetic relatedness indices decreased without changes in significance. We confirmed that bats with geomycosis are phylogenetically clustered and those with WNS are significantly clustered on the phylogeny, but the disease need not manifest in the nearest relatives. Our data indicate that the disease might affect distantly related taxa albeit the most likely ones to suffer would be related.

Influence of Intercropping Switchgrass in Intensively Managed Pine Forests on Ultrasound Produced by Bats and Rodents

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Vegetation type and density may impact how animal sounds propagate, especially high frequency sounds produced by bats and rodents. Intensively managed pine forests provide habitat for a diversity of wildlife species, including bats and rodents. In Kemper County, Mississippi, USA, Catchlight Energy LLC, is investigating intercropping switchgrass (*Panicum virgatum)* between rows of intensively managed loblolly pine (*Pinus taeda*) plantations for biofuel production. We determined whether intercropping influences ultrasound propagation, and bat

ultrasound spectral characters, in pine forests. We measured density of understory vegetation, determined the distance (m) ultrasound sound travels, and recorded bat ultrasound in pine only (pine), pine intercropped with switchgrass (intercropped), and no vegetation (control) sites. Pure tone, rodent, and bat ultrasound were broadcast at 20, 30, 40, and 60kHz at 80dB and 90 dB sound pressure level (SPL). Vegetation density was highest in intercropped plots. Across all sound types, sound pressure levels, and frequencies, the distance ultrasound travelled was the shortest in intercropped plots. We used a model for sound attenuation, due to spreading and absorption, to determine the decay constant for broadcast ultrasound in each of the treatments. Ultrasound in intercropped plots had the largest decay constant. Spectral characteristics of bat echolocation calls did not differ between pine and intercropped plots. Our results show that vegetation is denser and sound is attenuated more quickly in intercropped plots, but we found no difference among treatments in sound produced by bats.

Ethogram and Roosting Time Budget of a Group of Male Bachelor *Phyllostomus hastatus*

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Time budgets and ethograms of bats are rare, especially for the Neotropics. Because most studies were done on maternity colonies, it is important to also focus on groups neutral to factors associated with reproductive activity. In this sense, the study of male bachelor groups in the Neotropics may bring important answers. We studied a group of male bachelor *Phyllostomus hastatus* (Pallas 1767) in their roost for approximately 100 hours between January and August 2012. The group was roosting in an attic in Dois Rios village, Ilha Grande island, Rio de Janeiro, Brazil (23°10' S, 44°12' W). We registered the behaviors with an infrared camera and constructed an ethogram from the recordings. We adapted the protocol elaborated by Winchell & Kunz (1993) to obtain time budget data, using seven behavioral categories. We tested the differences between hours and months for each behavioral category using a series of ANOVAs. Twenty-four distinct behaviors were identified. We found differences between the time spent in each behavioral category ($F = 579{,}869$; $n = 7.632$; $p < 0{,}001$) and differences in behavioral categories between hours and months. The bats spent around 50% of the time in the roost sleeping, 14,6% immobile; 15,3% active; 0,9% crawling; 0,1% flying; 14,1% grooming; and 3,5% wing-fanning. The time budget was similar to those described for other Microchiroptera, with activity peaks before sunset and sunrise. The variation in behaviors may be associated to variation in roost temperature. Grooming and wing-fanning were noticeable and more studies must be done to untangle their functions.

Summer Bats to Winter Bats: Preparing Captive *Myotis lucifugus* for Hibernation

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Captive assurance populations can be a critical last resort for maintaining imperilled species. When chytridiomycosis threatened amphibians, researchers were skeptical of the potential for captive assurance because of captive maintenance and breeding difficulties. However, technical advances improved outcomes and many threatened amphibian species are now successfully maintained. Hibernating insectivorous bats present large and unique challenges for captive assurance but, given the enormous declines for many species due to white-nose syndrome, active research in this area is critical. Wildlife rehabilitation experts routinely keep little brown bats (*Myotis lucifugus*) in short, shallow hibernation over winter and some research groups have maintained little brown bats captured from hibernacula in long-term hibernation using temperature and humidity controlled incubators. An outstanding challenge is transitioning captive bats from summer active periods into hibernation. Recently, we brought little brown bats into captivity during the summer in preparation for hibernation experiments that winter. Attempting to transition bats from summer active season to winter hibernation, we provided an *ad libitum* diet high in polyunsaturated fatty acid. We then progressively exposed bats to cold temperatures of increasing duration and concurrently reduced food availability, hypothesizing that these factors mimic natural conditions experienced during autumn. We compared arousal frequencies over the first month of hibernation from these bats to bats studied in previous years where individuals were collected directly from hibernacula. To maintain captive assurance populations effective methods to transition bats from summer active periods and winter hibernation are needed. Based on our experience, we propose improvements which could enhance this transition.

Are Regional Habitat Models Useful at a Local-scale? A Case Study of a Threatened Insectivorous Bat in South-eastern Australia

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Habitat modelling and predictive mapping are important tools for conservation planning, particularly for lesser known species such as many insectivorous bats. However, the scale at which modelling is undertaken can affect the predictive accuracy and restrict the use of the model at different scales. We explored habitat use by a threatened insectivorous bat, *Mormopterus norfolkensis*, using three independent datasets collected at three spatial scales (regional, local and colony) that overlapped in extent. We used generalised linear mixed models to relate presence-absence records, from ultrasonic detectors placed at 98 sites, to environmental variables to create a regional-scale probability of occurrence map. We then created local-scale generalised linear models to relate activity levels, to environmental variables, using ultrasonic detectors placed at 47 new sites within the expected nightly foraging distance of a large maternity population. Finally, we related the continuous utilisation distribution of four radio-tracked lactating females from the maternity colony to habitat types to create resource utilisation functions. We found that the three methods had consistent predictions of broad habitat types, with *M. norfolkensis* preferring productive floodplain habitats and avoiding dry sclerophyll forest and urban areas. Additionally, our study supports the use of activity levels from ultrasonic detectors in habitat use studies. However, threshold dependent accuracy measures indicated a poor fit of regional predictive maps at a fine-scale and we advise caution when using regional models at a fine scale, particularly when the consequences of errors are severe, such as for making local land-use decisions on individual land parcels.

Nature's Options Values: the Ecological-economics of Insect-eating Bats

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If bats read the biological control literature they would learn that the most effective insect pest control agents are specialist predators that attack pests at early stages of the pest's life cycles and are capable of driving pest populations to near extinction. Bats would find that generalist predators traditionally have been eschewed as effective agents of biological control, and that eating a pest insect does not equate to providing an ecosystem service (ES). Indeed, bats would read that the reproductive capacities of insects are so great that eating huge numbers of pests need not suppress pest populations. We argue that bats know better. The few economic estimates of the ES of insectivorous bats suggest that the services of bats are much greater than previously appreciated, or even imagined. As highly mobile, generalist predators that persist in the environment on alternate food when pest populations are low and recruit rapidly to exploit pests when pest populations surge, much of the "natural capital" of bats exists not only in avoided costs but as "option values" resulting from the bats' presence in contemporary agro-ecosystems. Furthermore, the existing ES estimates for bats are "snapshots" in time and space. We illustrate how the ES values of bats fluctuate in time and space due to natural and socio-economic factors and due to investments in manufactured substitutions for natural capital (e.g. pesticides) and the depreciation of this manufactured capital (i.e. resistance evolution). As ES values fluctuate, option values are realized and the natural capital of bats enhanced.

Fluorescence, Fungal Load, and Severity of Disease

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Most studies of white-nose syndrome (WNS) to date report presence/absence of *Geomyces destructans* (Gd) (i.e., control vs. inoculated in the lab; affected vs. unaffected in the field) but we have little understanding of relationships between fungal loads, disease severity and potential infectivity. Quantitative PCR and histopathology allow for estimates of fungal load but are costly and require specialized expertise for interpretation. Ultraviolet (UV) fluorescence has potential as an inexpensive alternative but relationships between fluorescence, histopathology and

fungal load need to be determined. We used data from experimental inoculations with *Myotis lucifugus* and *Myotis myotis* to test the hypothesis that Gd load correlates with severity of clinical signs and quantitative estimates of UV fluorescence. We outfitted bats with temperature dataloggers, inoculated them with *G. destructans* and held them in temperature and humidity controlled hibernation chambers. For experiment 1, bats were kept at 7°C and one of four humidity treatments (85, 90, 95, or 99% RH). For experiment 2, bats were sampled from the incubators at monthly intervals to assess disease progression. Whenever bats were sampled we took UV photographs of flight membranes, swabbed forearms following a standard protocol, and preserved wing tissue for histopathology. We quantified torpor/arousal patterns based on skin temperature, fungal load using qPCR, scored histopathology using a 5-point scale, and calculated the area of each wing fluorescing in digital photographs. Our results provide new information on the relationship between fungal load and severity of WNS and the potential of UV fluorescence as an alternative/complement to other diagnostic methods.

Evaporative Water Loss in a Warming World: Respiratory and Cutaneous Partitioning, and Interspecific Variation in Heat Tolerance

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University of Pretoria, South Africa

Although evaporative water loss (EWL) in bats has been examined in several contexts, relatively little is known about interspecific variation in maximum cooling capacity and heat tolerance. We measured EWL, body temperature (T_b) and metabolic rates during summer in three species in a hot, semi-arid habitat in northern South Africa. Both *Sauromys petrophilus* (11 g; Molossidae) and *Taphozous mauritianus* (26 g; Emballonuridae) showed typical large increases in EWL as air temperature (T_a) approached T_b, with values of approximately 24 and 15 mg g^{-1} h^{-1} respectively at $T_a \approx 42$ ºC. However, *Nycteris thebaica* (12 g; Nycteridae) appeared to be considerably less heat tolerant and began increasing EWL at a much lower T_a to a maximum of 17 mg g^{-1} h^{-1} at $T_a \approx 39$ ºC. All three species exhibited maximum T_b values among the highest reported for bats. Another relatively unexplored aspect of EWL that is important for predicting performance at high T_a concerns the relative roles of cutaneous and respiratory evaporation. We trained ten *Epomophorus wahlbergi* to wear masks while hanging inside metabolic chambers, and measured EWL partitioning into cutaneous and respiratory components. Respiratory evaporation represented the majority of EWL at T_a = 10 - 35 ºC, but at higher T_a the cutaneous component increased to around 65 % at $T_a \approx 40$ ºC. A better understanding of EWL partitioning and interspecific variation in evaporative cooling capacity is needed to predict responses to more frequent and intense heat waves in hot environments, where extreme heat can cause large-scale mortality.

Determining the Factors Influencing the Energetic Expenditure of the Phyllostomidae is a Physiological Inquiry

Brian McNab
University of Florida, USA

The Phyllostomidae has the greatest diversity of food habits of any mammalian family. They include nectarivory, frugivory, insectivory, omnivory, carnivory, and sanguinivory. Although these food habits are usually associated with particular subfamilies, one subfamily, the Phyllostominae, has a diversity of food habits, including insectivory, omnivory, and carnivory, each of which correlate with distinctive basal rates of metabolism (BMR). The two greatest determinants of the basal rate of metabolism in this family and this subfamily are body mass and food habits. These two factors account for 87.0%, whereas body mass only accounts for 78.7%, of the variation in BMR. When a limit to an altitudinal distribution and an island (or hot cave) occurrence is brought into the analysis, these 5 factors (including mass) account for 98.7% of the variation in BMR. Preliminary observations on additional species belonging to the Phyllostominae, including the frog-eating *Tracops cirrhosus* and the insectivorous *Lonchorhyna aurita* and *Micronycteris schmidtorum*, reinforce the observation that species with these habits have mass-independent basal rates similar to other species with the same food habits, high in carnivores and low in insectivores. As a result of low energy expenditures, insectivorous species have a reduced capacity for temperature regulation. The ability to account for the level of energy expenditure is a response to a physiological question. Phylogeny concerns the cladistic distribution of food habits, but does not address energy expenditure.

Chasing Ghosts, Tongues, Noses, and Wrinkles: Challenges and Opportunities Working on Bats in Mexico

Rodrigo Medellin
Universidad Nacional Autónoma de México, México

Mexico has more species of bats than all but five countries in the world. Bats in Mexico face serious threats. Over the past 20 years, the Program for Conservation of Mexican Bats has studied and protected bats. In this talk I will cover the challenges and development of this Program and its progress and successes. Listing bats in Mexico's Federal list of Endangered Species is the first step, conducting research in rainforests, deserts, mountains, and islands, and working with communities to build partnerships. National and international collaboration has been constant. But listing species should only be the first step. Scientists should strive to recover and delist them. One successful example is the lesser long-nosed bat. We study its migration, foraging ecology, reproduction, and conservation needs. We also study and document ecosystem services provided by bats, illustrating how humans and ecosystems depend on bats for their functioning. Examples are agave plant pollination, seed dispersal by tent-making bats and others, and economic value of insectivorous species. An important line of work is bats and diseases. Bats already have a bad reputation, so we decided to launch a series of projects testing the dilution effect as an explanatory mechanism for the perceived role of bats as reservoirs of pathogens. Consequences of our Program have been a positive influence on the image of bats, the stabilization or recovery of many bat populations, the spread of these messages in the media, the increased number of human resources engaged in bat research and conservation, and fostering an international network for bat conservation at the continental level.

The Kalko Effect in Mexico: Triggering the Growth of Bat Science and Conservation in a Megadiverse Country

Rodrigo Medellin
Universidad Nacional Autónoma de México, México

Bat science in Mexico has been growing for decades. But certain events trigger or promote increased growth of this field. For example, when Bernardo Villa began his studies in the first half of the 20th century, the number of publications jumped significantly. A few non-Mexicans have had a similar effect. This requires an extreme commitment to science, a lack of selfish motivation, an increased level of generosity, and extraordinary scientific and intelligence skills. These are the characteristics of Elisabeth K. V. Kalko. Her links to Mexico are characteristically sealed with those features. From day one, her creativity and insight translated into a great diversity of projects and ideas to explore and pursue. Thanks to Eli we began a bigger effort studying acoustics of Mexican bats. Thanks to her we expanded our studies on feeding ecology of bats. Thanks to her ideas, many students improved and expanded their projects. She worked in northwestern, northeastern, central, and southern Mexico. She worked in the rainforest, in the tropical dry forest, in the Sonoran desert, and in the temperate forests. She worked on acoustics and natural history, ecology and migration. A typical interaction with her would normally lead to new branching of projects, expansions and deepened scientific insight. Given Mexico's position as the 6th country with the largest number of bat species, Eli's presence became essential for the growth of the Mexican scientific agenda on bats. Her legacy lives on and continues to grow, but we miss her.

Conservation of Bats in Nicaragua

Arnulfo Medina-Fitoria, Octavio Saldaña, José Martínez-Fonseca, and Yuri Aguirre
Bat Conservation Program of Nicaragua, Nicaragua

The chiropteran fauna of Nicaragua consists of 8 families, 57 genera and 101 species, representing 48.5% of the mammals of the country (Medina-Fitoria y Saldaña, 2012). However, until recently we did not know with certainty the total number of species at risk, so it was a priority to implement a Risk Assessment Method (Sanchez et al, 2007) to identify and prioritize those species most at risk for conservation and / or research. A total of 14 species of bats were at risk according to the RAM, nine species threatened: *Cyttarops alecto, Glyphonycteris sylvestris, Vampyrum spectrum, Sturnira luisi, Uroderma magnirostrum, Mesophylla macconnelli, Ectophylla alba, Thyroptera discifera and Rhogeessa io,* and five endangered of extinction: *Mormoops megalophylla*, *Tonatia saurophila*, *Phylloderma stenops*, *Artibeus inopinatus* and *Furipterus horrens.* According to the Red List of Threatened Species IUCN (2008), out of the total species in Nicaragua, three are Near-Threatened (NT): *Vampyrum spectrum, Ectophylla alba* and *Bauerus dubiaquercus;* one does not have sufficient data for assessment (DD):

Artibeus inopinatus; and 97 are of low concern (LC), which two have declining population trends and for 49 of them, is unknown its population trend. The main threats to bats in Nicaragua are: habitat destruction (advancing agricultural frontier and towns), lack of knowledge from people about the environmental benefits of bats, fire (mainly in critical habitat as dry forest), wind farm development (at least 5 projects and there is no constant monitoring effort to understand its impacts), cave vandalism (direct destruction of shelters and continuous destruction of individuals), population control affecting communities from poorly implemented control methods. Research initiatives: dynamic use of caves by bats in Nicaragua, determining areas and important sites for conservation.

Fitness Consequences of White-nose Syndrome

Melissa Meierhofer, Joseph Johnson, and DeeAnn Reeder
Bucknell University, USA

Little brown myotis (*Myotis lucifugus*) have experienced significant population declines in the face of white-nose syndrome (WNS). Although infection with *Geomyces destructans* (Gd, the causative agent of WNS) does not always result in death, little brown myotis survivors may experience fitness consequences. We collected 71 male and 77 female little brown myotis believed naïve to Gd from the wild and placed them into artificial hibernacula. Captive bats were either sham inoculated or inoculated with variable doses of Gd and left to hibernate for 21 weeks. Bats that survived were trained to eat a captive diet and maintained in a flight cage; differences in body mass, wing wound healing, and metabolic rate will be presented in relation to severity of infection and sex. These data are important in assessing the future survival abilities of little brown myotis.

Disentangling Bats from the Web of Life

Marco Mello
Universidade Federal de Minas Gerais; Brazil

It is known from studies at the organism and population levels that bats play important ecological roles as seed dispersers, pollinators, and predators, among others. However, much less is known about the communities formed by bats and their mutualistic partners, prey, and natural enemies. Network theory has helped us much understand the "web of life" formed by millions of species and the ecological bounds that unite them in complex systems. In this talk, I will summarize recent studies on bats with a network approach, focusing especially on bat-plant interactions, and I will also show some pieces that my collaborators and I have added to this exciting puzzle. It has been observed, for instance, that although most mutualistic networks share some universal properties, "small worlds" formed by specialized kinds of interaction, such as chiropterochory and chiropterophyly, have their own properties, which makes mutualistic networks mosaics instead of fractals. In addition, recent evidence points out that dietary specialization explains at least part of the centrality of bats in mutualistic networks, and that this biological attribute is more important than others traditionally considered. Nevertheless, much of the variation in parameters such as modularity and centrality remain to be explained, and this intriguing variation is probably related to strong emergent properties. Finally, I will discuss some perspectives for bat research based on network theory, aiming at disentangling bats from the web of life.

Looking for the Master Key to the Small World of Bat-fruit Interactions

Marco Mello
Universidade Federal de Minas Gerais, Brazil

Since Elton's studies and even before his time, one of the major tasks in Ecology has been to identify which species hold together their communities. In other words, who are the keystones of natural systems, according to Paine's definition. However, identifying keystones is a very complicated job, and only recently did the right tools for this job come out. An important advancement has been to look at small worlds defined by particular ecological interactions instead of complete communities. Network theory has helped much too, as the concept of centrality provides us with interesting proxies for a species' relative importance to the structure of its community. In studies on bat-fruit seed dispersal networks, as well as on bee-flower pollination networks, we have discovered that dietary specialization is the best ecological correlate of centrality, although widespread species show large variation in centrality among local networks. Furthermore, the most central positions in a mutualistic network seem to be always occupied by the most specialized mutualists, contradicting the current belief that generalists would be the most

important actors in the mutualistic theater. In bat-fruit interactions, highly specialized carolliines and stenodermatines were identified as the cores of the guilds detected in the modular structure of their networks. In this talk, I put those findings in a broad context and also present some new perspectives adopted in our current studies, which aim at identifying keystone frugivorous bats that play the role of 'master keys' that 'open up' several plant species in mutualistic communities.

Bat Activity in a Wetland- and Riparian-dominated Landscape

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Eastern Michigan University, USA

Wetland- and riparian-dominated habitats are known for their importance to wildlife, and these areas are often protected as refuges for animals, such as waterfowl and migratory song birds. There is less known about the use of these areas by bats. The Shiawassee National Wildlife Refuge (SNWR) is located at the junction of the Tittabawassee, Shiawassee, and Flint rivers, in central Michigan, U.S.A. The SNWR (3,885 ha) consists of open wetlands, rivers and streams, bottomland forests, and agricultural land, and offers a variety of foraging potential for different bat species. We identified habitats available to bats with GIS and used passive acoustic monitoring to measure bat activity during June–Aug 2013. We sampled from multiple hydric habitats within the refuge, including creeks, open-water wetlands, and wet meadows. We predicted that bat activity would be highest in riparian habitats and higher in wetlands with riparian corridors compared to isolated wetlands. Information on habitat preferences allows refuge managers to include strategies for bat conservation into their management practices.

Improving Conservation Biology by Comparing the Theories of Countryside and Island Biogeography

Chase Mendenhall, Daniel Karp, Christoph Meyer, Elizabeth Hadly, and Gretchen Daily
Stanford University, USA; Universidade de Lisboa, Portugal

Islands ecosystems have inspired foundational theories in evolution and ecology, and remain attractive subjects for biologist due to their simplicity as discrete microsms and their role as Petri dishes in experiments nature set in motion ages ago. In fact, the equilibrium theory of island biogeography—which uses island size and isolation to explain patterns of biodiversity—is the major pillar of conservation biology. Undoubtedly, the default strategy to conserve biodiversity has been the implementation of nature reserves, designated as islands in a sea of habitats modified by man. Despite the influence island ecosystems have had on the way we understand and manage the biosphere, their mainland analogues in human-dominated landscapes consistently defy patterns and fates of biodiversity expected under island ecosystem models. We compared a countryside ecosystem to an island ecosystem and found they each support homologous bat biodiversity in fundamentally different ways. Specifically, we found the island ecosystem to support the equilibrium theory of island biogeography, with smaller size and increased isolation of islands corresponding with losses in species richness and evenness. The countryside ecosystem, in contrast, maintained species richness and evenness in forest fragments, but underwent a community shift with decreasing amounts of native habitat. Compared to local nature reserves and forest fragments, the agricultural matrix in the countryside ecosystem supported a less speciose bat community that was equally even, but compositionally novel. Our results demonstrate that countryside biogeography recognizes previously overlooked opportunity to conserve biodiversity in the human-dominated landscapes that comprise 75% of the global land surface.

Intrinsic Factors Relateded with Threats in Bats and How to Estimate the Risk of Data Deficient Species

Poliana Mendes and Daniel Brito
Universidade Federal de Goiás, Brazil

Extinction is a natural process that vary in magnitude and may have different causes, which range from environmental to intrinsic factors of the species. This study aimed to test whether intrinsic variables of species associated with a slow life history, lower dispersal capacity and greater resource acquisition environment are related to extinction risks in bats. Information regarding biological traits and extinction risks of bats was obtained from databases available at the internet, scientific publications and from the IUCN website. Additionally, it was verified that these characteristics are phylogenetically autocorrelated. The forearm size, wing length and body weight presented relation with the extinction risk. However, there was no effect of duration of gestation and age of sexual

maturity on the extinction risk. Data deficient species had their body weight values related to a lower risk of extinction. As for other variables, there are data deficient species that have attributes associated with higher and lower risks of extinction. For example, *Nyctimene draconilla* and *Plerotes anchietae* are data deficient species that obtained values of wing length comparable with those from endangered species. Given that there are 203 species of bats categorized as Data Deficient by the IUCN and that there are intrinsic characteristics of bats related to their risk of extinction, one possibility to predict possible degrees of threatened species poor data would be by using these features. This approach would allow the planning of conservation strategies for these species, as they still cannot be evaluated regarding the degree of threats.

Prey Selection by *Myotis velifer* and *Tadarida brasiliensis* in Mexico City

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Universidad Nacional Autónoma de México; Universidad Juárez Autónoma de Tabasco, México

Insectivorous bats play a key role in natural ecosystems by reducing rates of herbivory. In human-made landscapes, insectivorous bats provide valuable ecosystem services by preying upon pest species affecting crop production. However, their ecological role and their impact on pest insect populations have been little explored in urban ecosystems. In this study, we analyze patterns of prey selection by *Myotis velifer* and *Tadarida brasiliensis* in Mexico City, which is one of the largest and most populated urban landscapes in the world. We used harp traps to capture bats at emergence in one urban roost located in the southern edge of Mexico City, during the 2012 dry (April-May) and rainy (June-July) seasons. Fecal samples from 13-30 individuals were taken from each species at each season (except *M. velifer* in the rainy season). Simultaneously, we collected samples of free-ranging insects using 15 traps distributed within 15 km of the roost. Insects in feces and traps were identified at order-level in the lab to estimate their relative frequency. Both species exhibited some level of selectivity in both seasons. *M. velifer* mostly selected lepidopterans during the dry season, consuming in lesser extent members of Orthoptera, Diptera and Homopthera. During the rainy season, it preyed exclusively upon dipterans. Interestingly, most of the diet of *T. brasiliensis* consisted of dipterans in both seasons, although it strongly selected lepidopterans during the dry season. Our results suggest that insectivorous bats may contribute to control pest insects in heavily urbanized landscapes.

Bat Rabies in Illinois

Jean Mengelkoch, Joyce Hofmann, Connie Austin, and Steve Amundsen
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Rabies is caused by a virus (genus *Lyssavirus*) that attacks the mammalian central nervous system. In the United States rabies persists mostly in wildlife, because cats and dogs are typically vaccinated. The primary reservoirs are raccoons, skunks, bats, and foxes. In Illinois animals are tested for rabies at the Illinois Department of Public Health Infectious Disease Laboratories and the Illinois Department of Agriculture Animal Disease Laboratory. After the bats are tested, we identify the bats to species. We have been identifying nearly all the bats submitted for testing since 2002. We have found that the number of bats that have been submitted for rabies testing has increased dramatically. The majority of bats that are submitted for testing are big brown bats (*Eptesicus fuscus*), which frequently roost and hibernate in buildings. Big brown bats also account for most of the positive tests. However, the prevalence (percent of animals testing positive) of rabies is more significant. Since 1990 the prevalence of rabies in bats has ranged from 7.96% in 1996 to 2.76% in 2003, with an overall average of 4.09%. Hoary bats (*Lasiurus cinereus*), eastern pipistrelles (*Perimyotis subflavus*), and eastern red bats (*Lasiurus borealis*) have the highest prevalence of rabies of the bats in Illinois. These bats are not frequently encountered by people; thus the ones that are found might be acting atypically and have a higher probability of being rabid. We will continue to monitor and examine long term trends of bats submitted for rabies testing.

Rewarming Rates of Bats

Allyson Menzies, Quinn Webber, Jamie Turner, Lisa Warnecke, and Craig Willis
University of Winnipeg, Canada

Torpor is an energy-savings adaptation used by many endotherms to avoid the cost of maintaining euthermic body temperatures. Although torpor can drastically reduce energy consumption, rewarming back to euthermic body temperatures requires large amounts of energy. The rate of rewarming has a strong impact on energy expenditure and rewarming rapidly is less costly than rewarming slowly. Due to the costs of rewarming, many

species exploit external or passive heat sources during the rewarming phase and these result in large reductions in energy requirements. We compared rewarming rates of silver-haired bats, a temperate, migratory species, to those of 41 other bat species to test the hypothesis that habitat type and degree of sociality influence rewarming rates of bats. We predicted that: 1) temperate species would have higher rewarming rates due to frequent exposure to low and variable ambient temperature; and 2) that species roosting in larger colonies would have lower rewarming rates because of their propensity to cluster and potential to share warming costs. We found evidence that silver-haired bats had higher rewarming rates than most of the other species, likely due to their temperate environments and tendency to roost solitarily or in small groups. Understanding factors that influence variation in rewarming rates can help explain variation in thermoregulatory strategies across species.

Effects of Habitat Loss and Fragmentation on Tropical Bats: a Review and Future Research Prospects

Christoph Meyer
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Over the last decades the process of ongoing human transformation of much of the Earth's natural ecosystems has sharply accelerated. Anthropogenic habitat loss and fragmentation are considered key drivers of the current global biodiversity crisis and are among the most serious threats to tropical biodiversity. Having become a central issue in conservation biology, fragmentation research has garnered much attention, as reflected in the burgeoning literature on the subject. Recent years have seen an increase in studies that have evaluated responses of tropical bats to habitat fragmentation, warranting a synthesis of the presently available evidence. I conducted a systematic review of the pertinent scientific literature to draw general conclusions from the range of studies currently available and to identify future research directions. Recent landscape-scale studies conducted in different matrix types have advanced our understanding of how tropical bats respond to habitat loss and fragmentation at the population and assemblage level, suggesting that species responses are often idiosyncratic or ensemble-specific, and may vary with spatial scale. Several aspects remain, however, poorly studied, including the temporal dynamics of fragmentation effects, the genetic consequences of fragmentation, and the influence of fragmentation on disease prevalence. Moreover, despite the well-established functional importance of bats in tropical ecosystems, few studies have explored to which extent fragmentation erodes their capacity as crucial ecosystem service providers. Finally, a strong geographical bias, with Asia and particularly Africa understudied, currently prevent a balanced understanding of fragmentation effects on tropical bats and calls for increased research efforts in those regions.

An Investigation of the Links Between Dimensions of the Ecological Niche in European Bats

Shankar Meyer, Isabelle Le Viol, Jean-François Julien, *Christian Kerbiriou
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In the context of global changes, it has been widely observed that specialist species (ie species with a narrow ecological niche) are noticeably more affected than generalist ones, and it has been shown that the former were currently undergoing a worldwide and concerning decline. To pursue the ongoing investigations on ecological specialization, we explore the existing links between the numerous axes of the ecological niche in European bats: trophic resources, foraging habitat, roosting sites, thermal range. In addition to correlation between specialization axes, we also attempt to relate ecological specialization to specific traits, such as wing morphology or phylogeny. In this regard, we used the large datasets provided by the French large-scale bat monitoring program, as well as about 150 research papers to conduct a meta-analysis. We aimed to compare diet, roosting and foraging site specialisation, as well as climatic range, for 30 insectivorous bat species from Europe. For each of these ecological axes, we quantified specialization using several indices (dietary niche breadth, specialization index, thermic index). This allowed us to highlight significant variations of dietary specialization, throughout the seasons for instance. Despite these first encouraging results, the relationships between dimensions of the ecological niche still have to be more thoroughly investigated, in order to determine the drivers of the specialists' decline and to link them to anthropic pressures.

20 Years Presenting Bat Programs: How to Motivate Your Audience

Rob Mies
Organization for Bat Conservation, USA

Bats are under immense stress in our world due to habitat loss, human persecution, pollution, and other factors. The Organization for Bat Conservation is conserving bats and preserving the natural balance of our ecosystem, through live animal programs, community education, collaborative partnerships, and research support. As a founder and Executive Director of the Organization for Bat Conservation, I have traveled around the United States giving presentations at schools, clubs, museums, nature festivals, and conferences for over 20 years. Thousands of programs later, I have discovered what makes a great program and what puts people to sleep. A strong digital presentation (images, sound, and video), personal stories from the field or laboratory, hands-on demonstrations, interactive experiences, and simple ways to get involved will all contribute to an inspiring program that will leave your audience wanting to learn, share, and engage.

Status and Current Research on Bats in American Samoa

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Three species of bats are indigenous to the islands of American Samoa, a U.S. territory located in the heart of the South Pacific. Throughout the 1980's, populations of two species of flying foxes, the Samoan flying fox (*Pteropus samoensis*) and the Insular flying fox (*P. tonganus*) were heavily impacted by both commercial and subsistence hunting. Concern over the future of these species led to creation of the National Park of American Samoa and a ban on commercial hunting by the end of the decade. The populations were further reduced when two severe hurricanes struck American Samoa in 1990 and 1991. Some estimates suggested an 80% decline in the population of flying foxes on the island of Tutuila, and a full hunting ban was instituted in an attempt to save the species. Over the past 20 years populations have rebounded suggesting that the hunting ban has been effective in the absence of severe hurricanes, though populations of the Samoan flying fox remain low but stable. The Pacific Sheath-tailed bat (*Emballonura semicaudata*), in contrast, was last detected in American Samoa in 1998. Reasons for its rapid decline are unknown, but unlike other islands in the Pacific, a major decline of the White-rumped Swiftlet (*Aerodramus spodiopygius*), which share cave roosts, has not occurred. Current research on bats in American Samoa include investigating methods to increase reliability of flying fox population estimates, investigating flying fox movements through GPS tagging, and using bat detectors to determine the status of the sheath-tailed bat throughout Samoa.

Gross Anatomy and Histology of the Prostate in Two Neotropical Bats, *Sturnira erythromos* and *S. lilium* (Phyllostomidae)

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The great diversity of bats on earth is reflected also in reproductive patterns, which vary with latitude, with the abiotic factors and food availability, all unique among mammals. Bats also have a wide variation in the morphology and in the composition of their reproductive glands. However, there are few reports on the structure of the reproductive tract, and accessory glands of the males in Chiroptera. Thus, the aim of the present study was to characterize macroscopically and microscopically the prostate of two species of the genus *Sturnira* (*S. erythromos* and *S. lililum*). We studied the prostates of 10 adult and 14 subadult specimens using several light microscopy and stain procedures (Hematoxylin-eosin and PAS, Periodic Acid & Schiff). The macroscopic analysis has permitted us to distinguish two regions in the prostate, a dorsal and a ventral one, also confirmed histologically. The ventral region has an unclear epithelium with secretory cells, and its secretions were PAS positive. The dorsal region receives the two deferens ducts, has a columnar epithelium with secretory cells and two types of secretions: a basophilic one, and other that mixes PAS positive, with PAS negative. In turn, the prostate has a regionalization in a cranial to caudal sense, where dorsal glands disappear as glands arise from the ventral region. The prostatic anatomy of these two species resembles that described in *Artibeus planirostris* but not to that of any other mammal. The seminal vesicle is absent in this two species.

Educational Actions for the Conservation of Bats in Brazil: Stigmatized Bats Should be Disclosed

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Brazil has distinct cultures from north to south, thus it is difficult to speak the same language. In other words, when the theme is conservation the socioeconomic contrasts are not in accordance with preservation, conservation or sustainability. Little information is divulged about ecological services performed by bats such as: pollination, seed dispersal and insect predation. So, we have the hypothesis that educative activities focusing different groups of people of different ages may generate sensibilization, a gradual change of attitude and consequently, less rejection of people concerning these animals. Since 1990 the work has been done to demystify in Rio Grande do Sul and in the state of Paraná it started only in 2002. Among the methods employed, creativity, motivations, sensitivity and novelty were continuous in presentations, research with target audience, interviews for the media and contact with people. The guiding theme was the importance of bats in nature, and the works showed positive results, mainly when participants observed a living bat and were able to make reflections about their importance in the environmental context. Likewise, the people in the last ten years has sought to learn more about the ecological roles, value of bats in productivity and live together in peace with bats. It is important to share the knowledge, innovation and technical information, supplying the curiosities and sensitizing people. Which is not conserved is unknown. What really works is education.

Free Nature Services: Flower-visiting Bats as Pollinating Agents for Mangrove (*Sonneratia*) Trees in Malaysia

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Flower visitors may act as either pollinators or nectar robbers while visiting flowers for food. In Malaysia, mangrove (*Sonneratia*) trees are known to be important food resources for bats. The role of these bats as pollinating agents for the trees was determined by recording the number of pollen grains adhering to their bodies while visiting the flowers. A total of 137 bats were caught with mist nets placed near the flowering trees. The pollen grains were collected by swabbing the bats' bodies with cotton wool and preserved in vials containing 75% ethanol, observed under a light microscope and identified. Eleven plant taxa were identified from pollen grains, with six identified to species and five to genera. *Eonycteris spelaea* carried all of the 11 pollen types recorded (1-8 types per bat, n = 128), while *Cynopterus brachyotis* carried nine pollen types (1-6 types per bat, n = 18). The single individual of *Rousettus amplexicaudatus* caught was found with 4 pollen types. *E. spelaea* carried an average of 2.27 pollen types (SE = 0.12) with mean pollen loads of 2330 grains. For *C. brachyotis*, the average number of pollen types was 2.17 (SE = 0.35) per bat and mean pollen loads of 301 grains. The majority of pollen grains collected from the wings (83% in *E. spelaea* and 66% in *C. brachyotis*) is due to their landing behaviour while visiting the flowers. Our study suggested that these bats provide important ecological services as pollinating agents in mangrove ecosystems of Malaysia.

Fibroblast Growth Factor Gene Family Diversity in Bat Wing Evolution

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The question of how bats evolved wings adapted for powered flight from limbs adapted for walking has been a topic of fascination for centuries. In On the Origin of Species, Darwin (1859) proposed that divergent limb morphologies evolved through "successive slight modifications" of a conserved pattern, stating "there will be little or no tendency to alter the original pattern" and that "The bones of a webbed foot might have all its bones, or certain bones, lengthened and the membrane connecting them increased so as to serve as a wing". One hypothesis fitting well with Darwin's ideas as well as comparative molecular data, is that divergence in form arises primarily from changes in gene expression during development. We are testing this hypothesis using a comparative genetics approach. We have obtained preliminary evidence that the fibroblast growth factor (FGF) gene family has evolved differently in bats relative to other mammals. FGFs have essential functions required for development of limbs and other tissues during development. Various FGF family members are involved many aspects of limb development, including induction, outgrowth, patterning and differentiation of the limb bud. We find differences both in which

members of the FGF gene family are expressed as well as in the expression of individual FGF genes. We speculate that these differences could account for some aspects of the adaptation of limbs into wings in bats, and may have played an important role in the evolution of powered flight in mammals.

The Distribution of Bat Species Richness in Sub-Saharan Africa

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Sub-Saharan Africa harbours a high diversity of bat species across a spectacular array of landscapes and habitats. Many of these species face threats from habitat degradation, roost disturbance and over-exploitation as food sources. Understanding the distribution and drivers of species richness may assist with focusing conservation attention, but such studies have yet to be published for sub-Saharan Africa. Our main aim is to map bat species richness across sub-Saharan Africa, and to correlate this with environmental features of the landscape. We achieve this by estimating the potential distribution of 215 species of bat using environmental niche-based models based on 14,145 unique locality records. Neither sampling effort, nor species richness is evenly distributed across the region. Highest species richness is recorded in the Albertine Rift, the northern shores of Lake Victoria in East Africa, and the Upper Guinean forest zone of West Africa. Other areas of high richness include eastern South Africa and southern Mozambique, Zimbabwe, Malawi, coastal Kenya and Tanzania, the Ethiopian rift valley, the Congo basin north of the Congo River and the humid Guinean woodlands north of the rainforest in West Africa. Uniformly species poor areas include the arid zones of south-western Southern Africa, the entire Sahel zone of North Africa, and the Horn of Africa. Species richness was not correlated with sampling effort, altitude or altitudinal roughness. The well-defined richness gradients facilitate further work on the drivers of phylogenetic and functional bat diversity on the African continent.

Group Movement Patterns and Acoustic Signaling in Spix's Disc-winged Bats

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The limited availability of refuges may represent an important constraint promoting sociality, particularly in bats. Spix's disc-winged bats (*Thyroptera tricolor*) show highly specialized morphological adaptations that enable individuals to roost inside furled musoid leaves. This roosting ecology presents major challenges, as leaves rapidly unfurl, forcing bats to locate new roosts on a daily basis. Further, *T. tricolor* form stable group associations lasting up to 22 months. We studied the social mechanisms that may be involved in maintaining the group stability observed in *T. tricolor*. For this purpose, we monitored the movement patterns and social interactions of bats when visiting potential roosts. We evaluated the visiting behavior of potential roosts by placing a video and acoustic recording system in the vicinity of suitable furled leaves. Individuals continuously approach furled leaves, and we determined that during the majority of visits, bats produced a variety of distinctive social calls when assessing a potential roost. In addition, we used proximity data loggers to simultaneously evaluate the movement of tagged bats during the night. Our results indicate that bats spend most of their night activity within the roosting area, and that individuals encounter each other repeatedly during the night. We argue that the presence of a rich vocal repertoire may allow individuals from a roosting group to coordinate nightly activity, and potentially locate suitable leaves more efficiently. These behavioral strategies may represent important mechanisms influencing sociality in this highly specialized group of bats.

Susceptibility of *Desmodus rotundus* Primary Bat Cell Lines to Dengue Infection

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Bats have been involved in zoonotic disease outbreaks all over the world, however information about their diseases are scarce. Dengue is one of the most important human emerging viral diseases in the developing world. Recently, several research groups have detected dengue antibodies, presence of viral nucleic acid and viral proteins in sera of different American bats. Furthermore, high viral dose experimental dengue 2 infection of *Artibeus intermedius* has proven that bats can become ill and show some clinical signs. Nevertheless, studies about the susceptibility to *in vitro* infection by different dengue serotypes are needed in order to assess if bat cells are actually permissive to viral entry and able to produce viral progeny. We established *Desmodus rotundus* primary embryonic

kidney and fibroblast cell lines and infected them with different amounts of dengue serotypes 1, 2, 3 and 4. After 72 hours, cells were stained with an anti-dengue Env antibody. Bat kidney and fibroblast cells showed mild fluorescence suggesting that *Desmodus rotundus* cells are infected but not highly permissive to the virus. Different infection rates were observed depending on the serotype used. It is tempting to speculate that at least the vampire bat can be slightly susceptible to infection with dengue, but due to the limited cell infection observed *in vitro* this species might not play an important role in the transmission cycle of this virus. However more studies are needed to completely elucidate if bats may sustain dengue virus infection.

Coronavirus Detection and Phylogeny Analysis in Neotropical Bats from Costa Rica

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Bats have been involved as reservoirs in outbreaks of zoonotic emerging diseases. After the 2003 SARS outbreak and its putative bat origin, several research groups have found alpha- and betacoronavirus in different bat species throughout the world. In Costa Rica, several genera of bats previously detected with Coronavirus (CoV) are present. Thus, the screening for CoV in this country is of utmost importance due to its high bat biodiversity, its geographical role as species crossing bridge, and could provide clues concerning virus evolution. 150 anal swabs/fecal samples were screened for CoV RdRp gene sequences. Four families, 12 genera, and 20 species of bats were analyzed. Low frequency (1.3%) for the targeted sequence of the bat CoV genome was found. Surprisingly the frequency for *Artibeus jamaicensis* was 3%, and for *Carollia perspicillata* was 4,16%. Analysis of nucleotide sequences showed that all CO-Bat-CoVs found belong to alphacoronavirus. *Artibeus* Bat-CoV showed similarities to those published for African bat alphacoronaviruses, while *Carollia* Bat-Cov was extremely similar to a sequence from the same bat species but from Trinidad. Nevertheless, there is enough dissimilarity suggesting that Costa Rican samples may represent unique coronaviruses. The two different bat species found positive, were from urban locations, so anthropogenic changes of the habitat might be an environmental stressor influencing bat CoV positivity. None presented obvious signs of disease suggesting subclinical or persistent disease. More genetic studies are needed to assess accurately the taxonomy, ecology, evolution, of the Costa Rican Bat CoVs and how it affects bats.

A New Early Miocene Phyllostomine from Panama: Evidence for a Mid Cenozoic Interchange of Bats between the Americas

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Two lower jaws of a large phyllostomine bat (Noctilionoidea: Phyllostomidae) of early Miocene age were recently collected in Panama. Associated mammalian faunas and radioisotopic dates indicate an age of ~21 Ma for a partial left dentary with p1 from the Las Cascadas fauna and an age of ~19 Ma for a partial left dentary with p4-m1 from the Centenario fauna. The oldest previous fossil of the Phyllostomidae is an m3 of a large phyllostomine from the early Miocene of Argentina (~20 Ma). The Miocene phyllostomines from Panama and Argentina are similar in size to the living *Phyllostomus hastatus*. The occurrence of the basal noctilionoid †*Speonycteris* (†Speonycteridae*)* in the Oligocene of Florida indicates a noctilionoid radiation and possible North American origin for the Phyllostomidae, with overwater dispersal to South America across the Central American Seaway (CAS) in the late Oligocene or early Miocene. The phyllostomines from the early Miocene of Panama and Argentina represent one of the earliest examples of dispersal of terrestrial mammals across the CAS prior to the late Miocene (~9 Ma) onset of the Great American Biotic Interchange (GABI). The presence of early Miocene phyllostomids and Oligocene to medial Miocene emballonurids, molossids, and vespertilionids in both North America and South America suggests an earlier unrecognized phase of the GABI. Pre-late Miocene overwater dispersal across the CAS, primarily from South America to North America, also has been proposed for several other vertebrate groups, including boid snakes, caimans, and turtles, as well as freshwater mollusks and plants.

The Effect of White-nose Syndrome Mortality on the Genetic Structure of New York's *Myotis lucifugus* Population

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White-Nose Syndrome (WNS), caused by the cold-temperature tolerant fungus, *Geomyces destructans*, is an emerging infectious disease that affects hibernating bat species in North America and Europe. Since the initial 2006 outbreak in Howes Cave, New York (NY), WNS has spread to all major hibernacula in NY, leading to unprecedented mortality in several bat species. The WNS-induced mortality has resulted in an estimated 95% decline in the NY *M. lucifugus* population alone. Given the devastating outcome, the impact of WNS on the genetic diversity of bat populations has not been fully evaluated. We propose to establish the genetic structure of the NY *M. lucifugus* population prior to the onset of WNS, and determine if the spread of WNS westward from the epicenter of infection results in a loss of genetic diversity, both spatially and temporally. We utilized 11 autosomal microsatellite regions and the HVI and HVII regions of mitochondrial DNA to sample genetic diversity. Preliminary results indicate that the pre-WNS population (2003 - 2005) has genetic structure and the population as a whole maintains some genetic diversity across NY in subsequent years (2008 - 2011). Any loss of genetic diversity will decrease the likelihood that this species will return to its former effective population size in NY. Not only will this study provide wildlife managers with information vital to the development of recovery plans, but it also is a unique opportunity to study the impacts of an emerging infectious disease on a wildlife population.

Variability in Bat Detector Microphone Response and Standardized Testing Methods

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Bat detectors are inherently complex and variable in operation and function. They provide different methods of obtaining signals from bats, interpreting those signals and storing the information. This complexity makes if difficult to standardize or replicate acoustic bat monitoring programs, especially when coupled with variability in environmental conditions, varying types of weather protection, physical setup and analytical processes. One source of variability both within and between bat detector types may be the response of the microphone associated with each unit. Golder has developed methods to test the response of microphones of various brands and models of digital data storing bat detectors. Golder enlisted these methods to test the response of over 300 different detector-mic configurations of 11 different models contributed by numerous government agencies, private companies and non-government organizations in northeastern North America. A software application was created by Myotisoft to extract data from the wave files collected from each detector configuration in a standardized format and present it graphically and numerically. These tests resulted in a range of expected responses and variability for each model and a comparison within and between models. Detectors that fall outside of expected responses should be evaluated more rigorously by the manufacturers under a more strictly controlled environment.

Active Sensing for 3D Spatial Perception and Navigation

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From a barrage of acoustic stimuli, a bat must detect, sort, and track biologically relevant signals to communicate with conspecifics, seek food, engage in courtship, avoid predators and navigate in space. The perceptual organization of acoustic stimuli, commonly referred to as auditory scene analysis, must be coordinated with actions to enable a variety of adaptive behaviors. The bulk of research on auditory scene analysis has employed simplified acoustic stimuli in artificial tasks. Furthermore, movement, which would typically influence the listener's perception of a natural soundscape, is often excluded from studies of scene analysis. Our talk will describe research that attempts to bridge this gap by taking advantage of the active sensing system of the echolocating bat. We will present results from laboratory studies that use high-speed stereo video recordings to track the big brown bat's 3D flight path, combined with microphone array recordings to characterize the bat's adaptive sonar behaviors. Results from these studies reveal the bat's active control of the directional aim, timing, frequency content, and duration of echolocation signals to "illuminate" the environment in natural tasks. Detailed analyses of the bat's sonar behavior convey how the animal's actions play into a rich 3D representation of the environment, which then guides motor commands for subsequent call production, head aim and flight control in an adaptive feedback system. The bat's

dependence on biological sonar for spatial behaviors provides a distinct opportunity to bridge work on hearing and vision, and to broaden our understanding of perceptual, motor and cognitive processes.

Injury in Bats by Metallic Forearm Ring in the State of Rio de Janeiro, Brazil

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Bat marking in Brazil is a new fact and requires further studies regarding a less intrusive method for the individual. In Brazil, some marking methods that might cause local injuries to bats are being applied. Consequently, some of these methods may compromise not only bat population, but also a better comprehension of their habits. This study aims to report six cases in which bat marking by metallic forearm ring with and without forearm flap offered risk to individuals. Four cases occurred at Guapiaçu Ecological Reserve (REGUA), located in the municipality of Cachoeiras de Macacu, in the State of Rio de Janeiro, in 2012, where two *Carollia perspicillata* and two *Molossus molossus* were found presenting dermatosis with bleeding on the forearm. The *C. perspicillata* were capable of flying after removal the forearm ring and asepsis, however the two *M. molossus* individuals died for weighing less than usual. The forearm ring was apparently bit, so that identification was not possible. Another two cases were registered in the municipality of Itaguaí, in the State of Rio de Janeiro, in 2011 and 2012, where two *C. perspicillata* also had their forearm rings removed after finding that individuals had dermatosis with bleeding. Both were able to fly after asepsis. Bat marking with forearm ring is an important method for understanding population dynamics and displacement, however further studies are required in order to develop other kinds of bat marking that would be adequate to each species and, therefore, contribute for long-time studies.

Anoura Floral Diet, Pollen Placement, and Extreme Tongue-Flower Coevolution

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Nectar bats feed from a variety of flowers, and typically show high overlap in foraging patterns; that is, co-occuring species tend to indiscriminately feed from all bat-flowers locally available. The exception is the tube-lipped nectar bat, *A. fistulata*, which prefers long-tubed flowers that match its extremely long tongue. Previous experiments suggested that these extreme lengths co-evolved because long tongues benefit bats by allowing access to more nectar, while long tubes benefit plants by increasing pollen transfer. However, these experiments failed to uncover why tube elongation increases pollen transfer: longer tubes did not affect visit duration or the force with which the bat's pushed their heads into the flowers. In the present study, I captured *Anoura* in eight sites throughout both cordilleras of the Andes of Ecuador and examined their floral diets by identifying pollen carried on their bodies. Results show that the various flowers *Anoura* visit are able to reduce interspecific competition by placing pollen in different regions of bats' bodies. Two species with long flower tubes were exclusively pollinated by *A. fistulata*. Both deposit pollen on the tops of bats' heads, leading to the hypothesis that pollen placement may influence selection on tube length. Experiments with artificial flowers confirmed this idea: the greater the nectar depth, the more bats lifted their heads up during visits, maximizing the amounts of pollen transferred. I suggest that this phenomenon provided the initial trigger for the remarkable coevolutionary race that has played out between *Anoura fistulata* and long-tubed flowers.

Contributions to the Taxonomy and Distribution of the Genus *Myotis* (Chiroptera: Vespertilionidae) in Colombia

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Insectivorous bats in the genus *Myotis* are currently represented in Colombia by six widely distributed species (*Myotis albescens, M. keaysi, M. nigricans, M. oxyotus, M. riparius* and *M. simus*) occurring in different environments, from the lowlands up to the highlands of the Andean system. Despite their importance, our knowledge on the diversity contained in this group of bats and their distribution in the country still fragmentary. In this preliminary work, we assessed the morphological and morphometric variation of Colombian *Myotis* specimens. As a result of our evaluation, we introduce the first record of *M. nesopolus* for the country, represented by a specimen collected in the arid environments of the La Guajira Peninsula in the Colombian Caribbean; in the same

way, we redraw the distributional limits of *M. keaysi* and proposed the recognition of *M. pilosatibialis* as a full species; and finally, we evaluate the phenetic variation of Colombian *M. riparius* and report the presence of an individual with a divergent morphology closely related to that described for the Central American form *M. elegans*. As a result of this preliminary assessment we recognize nine species of *Myotis* for the Colombian territory and discus on the taxonomic and conservation implications of these findings.

The Dorsal Patch: Reproductive Implications during the Mating Season of the Long-nosed Bat, *Leptonycteris curasoae* in Northern Venezuela

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Chemical signals facilitate individual recognition, communication, and mate selection. Chemical signals may play an important role during the mating period, especially if females select mates based on the information obtained through olfaction. An odor-producing structure (dorsal patch) was recently reported in adult males of the Neotropical nectar-feeding bat, *Leptonycteris curasoae,* and exclusively observed during the mating season. The goal of this study was to evaluate possible relationships between the dorsal patch of males and the mating season in *L. curasoae* from northern Venezuela. More than one-third of all males sampled showed conspicuous dorsal patches during the mating season, although size and general appearance were highly variable. Chemical profiles of dorsal patches analyzed using solid phase microextraction were variable and chemically complex, with nearly 70 different compounds associated with this structure. Body mass, ectoparasite load, and testes length were significantly associated with the presence of a dorsal patch. Males with conspicuous dorsal patches were smaller than males without dorsal patches, and showed lower ectoparasite loads. Results from this study suggest that the development and manifestation of the dorsal patch is the outcome of a complex stereotyped "smearing" behavior described herein for the first time in bats. This novel behavior performed by males of *L. curasoae* involves use of four different body fluids smeared onto the dorsal patch, and might facilitate explicit sexual interaction during the mating season. An experiment designed to test the hypothesis that individual females perceive/prefer males with dorsal patches revealed that females were able to detect (and prefer) the odor from dorsal patches than the odor from males without them.

Geographic Variation in the Echolocation Calls of a Species of Horseshoe Bat, *Rhinolophus simulator*

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Geographic variation (GV), as an indicator of incipient speciation has poorly understood underlying processes. Geographic variation in southern African mammals has been little studied despite the region's varied geography which is likely to result in great phenotypic variation as populations become adapted to local habitats. We investigated GV in echolocation calls of an African horseshoe bat, *Rhinolophus simulator* in the context of James' Rule and two other hypotheses (foraging habitat and humidity hypotheses). We measured the morphology and echolocation peak frequency of 89 *R. simulator* individuals across their distribution range. There was little variation in echolocation frequency of *R. simulator* and contrary to James' Rule and the foraging habitat hypotheses, the peak frequency of *R. simulator* was not correlated to body size or vegetation index, respectively. However, the peak frequency at one site was significantly lower than at the other sites and this site also had highest mean annual rainfall and temperature. This suggests that the lower peak frequency evolved at this site because it increased detection range in the more humid conditions (humidity hypothesis) that prevailed here.

Foraging at Wastewater Treatment Works Increases Health Risks in an Urban Adapter, the Banana Bat

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The Banana Bat, *Neoromicia nana,* is an urban adapter that exploits swarms of pollution-tolerant chironomid midges at wastewater treatment works (WWTWs). We have previously shown that although WWTWs are beneficial to *N. nana* in creating an optimal food resource in the short-term, there are also long-term costs, specifically the accumulation of metal pollutants such as cadmium, chromium and nickel in the muscle, liver and

kidney of *N. nana*. Here we investigated how foraging at WWTWs versus unpolluted sites, impacts various levels of the physiology of *N. nana.* We used haematocrits to assess haematological differences, hepatosomatic and renalsomatic indices to evaluate relative size differences in detoxification organs, and gonadosomatic indices to evaluate relative size differences in reproductive organs of male bats. We found that haematocrits were significantly higher in *N. nana* foraging at WWTWs indicating that *N. nana* may be compensating for a chronically low oxygen circulation within the body or kidney damage. In addition, hepatosomatic and renalsomatic indices were significantly higher suggesting hypertrophy of the detoxification organs. Finally, the gonadosomatic index of the testes were also significantly larger at WWTWs, suggesting that reproductive potential of males may be compromised, hence warranting further analyses, currently underway in our laboratory. Sub-lethal damage from pollutants is evident in *N. nana* foraging at WWTWs and chronic health problems may ultimately extend to the population level.

Myotis bechsteinii in the Mediterranean or the Consequences of Long-term Deforestation

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Most of the data on the ecology of the Bechstein's bat come from Western and Central Europe, where this species is assumed to reach maximum distribution. Recent data have shown, however, that the species can be even common in certain spots in the Mediterranean range. We addressed roost selection, foraging habitat selection, and prey selection in Atlantic and Mediterranean domains of the Iberian Peninsula. Ecological requirements appeared conserved throughout, but apparently the warmer climatic conditions in the Mediterranean allow bats to be less restrictive regarding roost selection, particularly pertaining to tree size or age. Larger commuting distances and foraging areas in the Atlantic, together with higher habitat fragmentation and poorer prey availability suggest that habitat quality in the Mediterranean localities exceeds that of the Atlantic ones. Diet was comparable across localities, although the frequency of different taxa varied matching differences in availability. From our results, forests in the Mediterranean do not appear as marginal habitat. Results support instead the hypothesis that the current distribution pattern of *M. bechsteinii* in Europe reflects not only the climatic changes that happened in the last thousands of years, but also the severe deforestation of deciduous woodlands in the Mediterranean, where those bats might find optimal ecological conditions today, if still present. This scenario is a clear demonstration of the effect that long-term deforestation imposes on forest specialists such as Bechstein's bats, and can serve to demonstrate the effect of historical landscape transformations in the current distribution patterns of other forest species.

The Edge Effect: Diversity and Abundance of Phyllostomid Bats in Three Types of Disturbance in Ecuador

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The different degrees of the habitats changes, either natural or human related, generate alterations in biodiversity. A clear example of this is the changes in wealth, abundance and guild composition of bats by the modification of the landscape at different scales. We analyzed the relationship between wealth, number of individuals and feeding guilds of bats in three types of human disturbance (oil platform, pipeline and human settlements). The study was conducted for eleven months in the Pastaza province, Ecuador, among 2007 and 2008. Six sites were selected for sampling, three associated with oil production (platform oil development and pipeline) and three human settlements. In each research site, 900 m transects were established from the edge of the human intervention towards the interior of the forest. For the analysis, transect was divided in three segments of 300 m each. The human settlements showed the more evident edge among the three types of impact, due to a greater abundance of generalists species adapted to perturbations near the edge than at the interior of the forest. The impacts of human settlements and well pad showed a tendency to diminish the abundance of bat species, as the sampling was carried out farther away from the edge; the flow line impact shows a stable tendency in the abundance, richness and compositions of bats throughout transect. The accumulation of frugivorous was due, probably, to the compositions of the flora, because of the abundance of fruits in succession areas (edges). A high numbers of species of insectivores and carnivores is a good indication of low levels of perturbation.

Research Needs for Bat Conservation in Latin America and the Caribbean

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For the Latin American Network for Bat Conservation (RELCOM), scientific research represents one of the three pillars that sustain the Latin American Bat Conservation Strategy. Throughout research, the members of our network seek to detect and counteract threats to bats and their habitats. We have identified 17 research priorities as a function of five main threats to bats: habitat loss, roosts' destruction and disturbance, human-bats conflicts, abuse of toxic chemical substances, and emergent threats (e.g. eolic parks, emerging animal diseases). These research areas include: species' conservation status assessment, geographic distribution, ecosystem services assessment, bat's response to disturbances, identification of areas and sites important for bat conservation (AICOMs/SICOMs), roost use patterns, bat roosts' susceptibility assessment, artificial caves' design, new approaches for vampire control, design and testing of bat exclusion protocols, identification of main toxic substances responsible for bat fatalities, evaluation of bats as pest insects controls, impact of eolic parks, impact of invasive species, and preventive measures against the White-nose Syndrome. RELCOM has responded to these research needs with over 110 projects across Latin America under the responsibility of researchers, undergraduate and graduate students, environmental officers, and volunteers. Research efforts conducted until now are mainly biased towards a few disciplines, including community and population ecology, roosting ecology, trophic ecology, and bat-plant interactions. We observe a marked deficit of studies addressing bat poisoning by chemical pollutants and potential impacts of wind turbines on bats. Our proximate goal is to promote the development of investigations on these areas in the coming decade.

Communication and Education about Bats: a Powerful Tool for Changing Misconceptions

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In Latin America, most of the threats suffered by bats are increased by the general population's lack of knowledge and sensibility. RELCOM aims to work in the education and communication fields, in order to change these misconceptions. Here, we are presenting the development of diverse strategies made by the network's members that have proven to be successful in changing the current image possessed by bats. The strategies that have been used are: 1) the creation of a webpage in which people can review the documents created by the network and communicate with the representatives from all the RELCOM countries and 2) the publication of a bulletin that publishes news regarding Latin American activities. Furthermore, October 1st has been established as the Latin American Bat Day, and, during this day, we have educational and communication activities in all the PCMs. One important activity was the travelling batcase, which constitutes a strategy to encourage educational activities. In this suitcase, Marcelo the bat is travelling with a notebook around all Latin America. In each country, we have to write a summary of all the finished activities and, at the end, publish them and their pictures in a blog. This information is also being divulged via Facebook. Finally, we have conducted several training workshops about education and communication in Central and South America and the Caribbean countries. All of these activities have been extremely successful, since they have achieved the integration and participation of all the countries, and, some of them have been replied internally.

Foraging Ecology of Temperate Bats in North Dakota

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Many habitat studies of temperate North American bats have focused on characterizing roosts and landscape-level foraging habitat use, while fewer have investigated foraging habitat use at a fine scale. The purpose of this study is to investigate micro-level foraging habitat use in multiple vespertilionid species found in the various habitats of North Dakota. The methods being developed incorporate two approaches. The first approach involves documenting bat activity at different sites using passive acoustic monitoring, and coupling this data to detailed measurements that characterize the recording conditions and immediate surrounding habitat (temperature, moon phase, insect prey presence, elevation, tree species/size, vegetation density, canopy cover, ground cover, distance to, type, and dimensions of water sources). The second approach is to track bats during nightly foraging bouts with an autonomous telemetry system and use triangulation to map flight paths of individuals as they move through a study

area. Data was collected from May to August of 2012 and 2013. Ultimately, this research will provide insight into how bats forage, as well as provide information for developing a state conservation plan for bats.

Roosting Behavior in a Summer Colony of *Eptesicus fuscus*

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This study examines a colony of *Eptesicus fuscus* roosting in the attic of a house in western North Carolina, USA. The bats roost upon a mesh screen that covers the entrance to the attic. As a result, the bats are distributed over a two-dimensional vertical surface that can be filmed from within the attic (Sony SR12 video camera with IR illumination). Sensors are placed within the roost to record the temperature gradient that occurs from the highest to the lowest parts of the roost. Data from 2012 (July 16 to Sept. 08) found that temperatures within the roost ranged from 7.3–52.5°C, and were significantly higher in the upper portion of the roost than in the lower portion. Temperatures were consistently warmer in the roost than outside, especially at higher outside temperatures. Bats showed distinct changes in clustering and positional behavior that were correlated with temperature inside the roost. At lower temperatures, bats clustered tightly together higher in the roost. Bats tolerated very high temperatures, but spaced further apart and moved to lower (cooler) parts of the roost as temperature increased. Bats became less active when roost temperatures exceeded body temperature. A second season of observations was started in April will continue through the summer, which will generate additional information concerning the repopulation of the roost, colony size fluctuation, and the positional and clustering behavior of adults and young. We expect to observe patterns of parturition and nursing occurring in this colony this spring.

Hibernation Phenology and Survival of *Myotis lucifugus* in Central Canada

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Phenology and energy allocation should reflect both extrinsic (e.g., weather, climate, predation risk) and intrinsic (e.g., reproductive timing, age/sex class) factors. Males of hibernating species which mate following hibernation (e.g., ground squirrels) both immerge into and emerge from hibernation before females, which may reduce predation risk in late summer and increase access to mates in spring. Bats, which mate prior to hibernation, should exhibit opposite patterns, with females emerging and immerging earliest. Climatic severity should also affect phenology by extending hibernation duration. This, in turn, is expected to increase pressure on animals to accumulate large fat stores and/or lead to decreased survival. I used a short-term dataset based on passive transponders (PIT tags) to examine the influence of reproductive timing on the hibernation phenology of *Myotis lucifugus* and a 20-year banding dataset to test the hypothesis that weather conditions and winter duration influence survival of little brown bats in central Canada. Adult females emerged earlier than both adult males and subadult females, and adult males were active significantly later in the fall than adult females. Annual survival was constant and extremely high at all sites (>0.90), despite inter-annual variability in precipitation. High survival may result from the tendency of bats in central Canada to obtain a large pre-hibernation fat reserve and hibernate for long periods which could reduce extrinsic mortality. Bats from my study site are between 24-37% heavier at hibernation onset than bats in eastern North America which may lead to an increased ability to tolerate White-Nose Syndrome.

Floral Resource Use by Nectarivorous Bats (Phyllostomidae: Glossophaginae) in Cloud Forests of Costa Rica

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Plant-bat interactions have been recorded for many plants and bat species in the tropics. Interactions like seed dispersion and bat pollination demonstrate the importance of this integral relationship, making bats a key focus for conservation. The cloud forest presents more than 3000 species of plants and 7 species of nectarivorous bats. Only a few short-term studies have addressed bat-pollination and the nectar-feeding bat community in the cloud forest. This is the first yearlong study conducted to determinate the diet of the nectarivorous bat community in the Monteverde Cloud Forest Reserve, Costa Rica. We caught four species of nectarivorous bats, all of which were carrying pollen. Of the total 415 captures, 61% were males and 39% were females. *Anoura geoffroyi* was the most frequently caught species followed by *Hylonycteris underwoodi*. We found a total of 14 morphotypes of pollen

carried by the bats that belonged to 6 plant families, of which 10 morphotypes were identified to genus, and 4 to species. A high overlap in diets was detected in two species of bats *Anoura geoffroyi* and *Hylonycteris underwoodi*. Overall one plant species,*Werauhia tonduziana,* plays an important role in the diet of both of these species evidenced by its pollen high encounter frequencies from both bat species. Our study suggests an essential ecological interaction between plants and the nectarivorous bat community of Monteverde, which contributes to our understanding of the importance of bat-pollination and the need for ongoing conservation efforts in this area.

Echolocation Divergence in Horseshoe Bats Despite Extensive Gene Flow

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Horseshoe bats (Rhinolophidae) have evolved a unique echolocation system and geographic variation in resting frequencies (RF) across species' distributions is well documented. Whether these patterns are the result of selection, neutral drift or their interaction remains unclear. Here we used ecological parameters together with neutral and functional genetic variation to investigate the evolution of echolocation divergence (ED) in the Cape horseshoe bat, *Rhinolophus capensis*. A clinal pattern of increasing RF from west to east characterises the species distribution (75.7 - 86.5 kHz), which spans several major biomes and a pattern of increasing rainfall. This translates into a habitat gradient from open and sparse (west) to more cluttered habitats (east). Patterns of variation at the mitochondrial control region revealed minimal evidence for population structure (Φ_{ST} = 0.38) but significant asymmetric migration between populations. Genetic distance accounted for <10% of RF variation but mean annual rainfall (a proxy for habitat structure) explained 82%. Thus selection for higher frequencies in more cluttered habitats (foraging habitat hypothesis) appears greater than the homogenizing effect of gene flow in *R. capensis*. This could be the result of variation in the 'hearing gene' *Prestin* which encodes the mammalian cochlear amplifier and has evolved under strong positive selection in the ancestors of horseshoe bats. However, sequence data from the coding region of *Prestin* in several *R. capensis* populations revealed highly conserved gene sequences. Therefore, ED can occur despite genetic homogeneity and a lack of functional gene sequence variation. Instead, differences in gene expression/regulation may play a significant role.

Long-term Persistence of Bat-colony Social Structure: Implications for Conservation of Threatened Species

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How populations of threatened bat species are structured may influence fitness, resilience to stochastic events and potential to recover from population declines. Living in groups is one of the primary social systems displayed by mammals including bats. In bats, group-living confers a number of fitness benefits to group members such as those associated with thermal clustering and information transfer. An earlier 5-year study indicated that the threatened New Zealand long-tailed bats (*Chalinolobus tuberculatus*) live in closed social groups. We investigated stability of social structuring using a 19 year mark-recapture dataset (332 capture sessions; 12953 captures of 2325 bats). We calculated association indices and used cluster analysis in programme SOCPROC to examine social structure. Strong social bonds within groups were retained over 20 years. We found non-random associations of individuals, a low degree of mixing among colonies and strong fidelity to natal colonies. Few bats (8.6% of individuals, 1.8% of total captures) switched among four adjacent colonies and the majority (>70%) returned to their original colony. Females of known fate (97.6%) returned to their natal colonies to breed. These behavioural data support the hypothesis that long-tailed bats live in closed societies over long time frames. Despite the potential advantages of strong social structuring, this strategy may be disadvantageous if it restricts either immigration of individuals into colonies reduced in size as a result of threatening processes or re-establishment of colonies in areas where bats have become extinct or limits gene flow.

Indiana Bat Roost Habitat Selection in the Southern Appalachian Mountains

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The federally endangered Indiana bat (*Myotis sodalis*) is being impacted by white-nose syndrome and habitat loss across much of its range, and climate change may pose additional threats. A better understanding of

roost ecology of the species may facilitate conservation of healthy populations and could be critical to the overall survival of the species. Our goal was to identify the multi-scale characteristics of roost habitat for Indiana bats in the southern Appalachian Mountains. From May–August 2008–2012, we attached 0.32–0.42 g radio transmitters to adult females and juveniles, and measured characteristics of trees and 0.1 ha plots for 86 day roosts and associated random trees. We used 76 roost locations to identify important landscape-scale predictors with the presence-only modeling approach of MaxENT. Most (76%) roosts were yellow pine (*Pinus* subgenus *Diploxylon)* snags, but white pine (*P. strobus*) and hemlock snags were also used. Roosts were taller (18.7 m), larger in diameter (37. 7 cm), and in a lower state of decay than random trees. There was similar canopy closure in roost (58%) and random (73%) plots, but closure was low (<30%) directly above roosts. The spatial model validated our field observations that, in the southern Appalachians, optimal roosting habitat for Indiana bats is near the ridgetop in a south-facing mixed pine forest at elevations from 260–700 m. Management activities that promote these conditions and create or preserve large snags should aid in the management and recovery of the Indiana bat.

The Role of *Pteropus rufus* in Forest Regeneration in Madagascar

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Madagascar has three endangered and endemic species of fruit bats. The largest one, *Pteropus rufus*, is relatively common and distributed widely in the country. So far 110 plant species have been identified in its diet, including 59 (55%) endemic species. This suggests that *P. rufus* has a very diverse diet, which has enabled it to adapt to areas with vastly differing vegetation types, e.g. dry deciduous forest in the south, littoral forest on the coast, and lowland rain forest in the north-east. This study aimed to determine the efficiency of Malagasy bats in promoting forest regeneration by comparing the germination success of seeds from faecal and ejecta pellets with those of ripe fruits. The seeds were exposed to progressively more natural challenges. Treatments were performed in conditions ranging from the laboratory, where sterilized seeds were placed on filter paper in a Petri dish, through differently treated soil and finally, in their natural conditions. Additionally, using high resolution GPS tags, we recorded the movement and foraging patterns of the Madagascar flying fox in a fragmented landscape. Findings will illustrate the role of *P.rufus* in forest regeneration through long distance seed dispersal, habitat preferences and movements across isolated forest fragments. Knowledge about this behaviour in relation to constant disturbance and hunting may help in further conservation actions and assist with the protection of these important Malagasy mammals.

The Ecology and Field Surveillance of Bat Viruses

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Bats have received growing attention as reservoirs for emerging infectious diseases, including a number of high profile viral zoonoses with significant human and animal mortality including Nipah, Ebola, SARS and a novel coronavirus from the Arabian Peninsula. Several studies have suggested that bats may be special among mammals in their ability to harbor and transmit viruses, particularly in terms of their unique ecology and possible immune function. A rapidly growing number of novel viruses are being identified in bats annually, but to understand the real risk that bats pose for viral spillover and human health, an ecological or One Health approach must be taken. In order to measure epidemiological significance, viral discovery in bats must be concomitant with investigations of host taxonomy, genetics, and ecology, including studying roosting and foraging behavior. Lastly, bats provide vital ecosystem services and are increasingly threated by human activities, thus understanding these human-bat ecological interactions is critical for conservation as well as public health. Here we highlight our approach to ecologically-focused bat disease investigations and give specific examples that includes the development of non-lethal sampling techniques; investigations of Nipah virus and foraging ecology in Bangladesh; integration of biodiversity surveys and viral surveys across an urban to pristine forest environment; the use of spatial ecological models to predict bat zoonoses risk; and the application of ecological metrics developed for biodiversity science to maximize viral discovery efforts.

50 Years of Bat Tracking: a Review of Device Attachment and Future Directions

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Radio telemetry or GPS-based approaches have been essential to understand the behavior and biology of bats, whose small size and cryptic lifestyles continue to make them challenging to study. While advances in knowledge have been made, large gaps still remain due to technological limitations, particularly device weight, and the duration of device attachment. We review nearly 300 bat tracking studies to determine how devices have been attached and how guidelines have been followed or changed relative to the best compromise among transmitter size, battery lifespan, attachment method, scientific gain, and animal welfare. Half of available studies used devices greater than 5% of body mass with minimal justification, but 98% of devices were less than 10% of body mass. . On small bats, devices were generally glued directly to the back and were attached for an average of 9 days, which is far shorter than the lifespan of most devices. Devices on flying foxes were typically attached with permanent collars. Since the first tracking studies, there has been little development or testing of alternative attachment methods, and few studies have assessed the impact of device attachment on animal welfare. We consequently developed and tested a collar for small bats with a degradable weak link that allows longer habituation and tracking times, while ensuring the device drops off within 30 days. Future work is needed to build on previous knowledge to find the best attachment method, size and shape for individual study species to truly promote wildlife tracking.

Frugivorous Bats and Seed Composition in Tropical Secondary Forests of Tabasco, Mexico

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Forests in southeastern Mexico have been strongly affected by human activities. In this study, we analyzed the species composition of frugivorous bat assemblages in three fragments of secondary forest that form a gradient of perturbation in Tabasco, Mexico. We also analyzed the composition of seeds in bat feces. Bats were captured with mist nets. A plastic sheet was placed under each net in order to collect feces of captured bats. We compared the similarities in bat and seed species composition among sites using ANOSIM (Analysis of Similarities) and SIMPER (Similarity Percentage) to determine which species are contributing most to the dissimilarities among sites. We captured 317 frugivorous bats (12 spp.) and 141 feces. ANOSIM based on presence-absence of bats showed significant differences between the study sites ($R = 0.51$, $P = 0.001$); where *Sturnira lilium*, *Carollia sowelli,* and *S. ludovici* contributed the most to these differences; 17.06, 15.77, and 13.26 respectively. Using abundance data, there were also significant differences between sites ($R = 0.44$, $P = 0.017$), and *Artibeus jamaicencis* and *A. lituratus* contributed 59.98% to these differences. The analysis of seed composition revealed significant differences among the fragments (R= 0.54, P <0.001) and *Ficus sp*., *Cecropia peltata,* and *Piper auritum* contributed most to these differences; 16.01, l2.32, and 10.85 respectively. These results allow us to assume that the composition of frugivorous bats and seeds dispersed by them is affected by the conditions of the secondary forest fragments, such as structure, grade of perturbation, and plant species composition.

Sperm Storage Champions: What are the Criteria for Determining Female Sperm Storage versus Sperm Longevity in Bats?

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What does it mean to store sperm? The answer has clear implications for natural selection, mating system evolution, and sexual conflict but the criteria for defining female sperm storage are unclear. This is particularly true of female mammals which often lack specialized sperm storage structures. However in regards to sperm storage in mammals – bats remain the 'champions' and present valuable study species for those interested in mammalian sperm storage. We present the current knowledge about the distribution of female sperm storage in bats and discuss ways to refine thinking about sperm storage, outline gaps in our knowledge and nuances of accurately determining if a species stores sperm or has long-lived sperm. Focusing on bats as a model group we synthesize information on reproductive physiology, evolutionary ecology, and behavior to explore the question; what is sperm storage and how does it differ from sperm longevity?

Aspects of the Diet of *Sturnira lilium* (E. Geoffroy, 1810) in Neotropical Forest Fragments

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Studies about feeding habits of species which consume vegetal sources are relevant in ecology. The aim of the present study was to evaluate the feeding spectrum and niche amplitude of *Sturnira lilium*, in Neotropical forest fragments. Collects were performed monthly (March to September, 2012) in four forest fragments in Mid-Western Brazil, beginning at nightfall with a six hours duration. Eight mist nets were set in possible flight routes. Bats were captured, identified, marked, photographed and released. Fecal material was collected in the moment of the capture. Occurrence frequency was calculated by sex and trophic niche breadth was conducted by calculating the indices of Shannon and uniformity. Sixty-nine individuals *S. lilium* bats were captured (42 males and 27 females), the sex ratio was 1.5 males per females. The diet was evaluated by of thirty three fecal samples (22 males and 11 females), and it was composed by 13 vegetal species. The preference of items varied among males and females bats. The most consumed by females was *Piper amalago*, *P. hispidum* and *Solanum viarum*, for males the most common was *Maclura tinctoria*, *S. pseudoquina* and *Solanum* sp. In the total of items consumed, there was a predominance of the family Solanaceae. Males presented higher niche width and the highest uniformity in resources exploration. These results suggest a possible segregation of niche among genders. It was also observed that *S. lilium* feeds on pioneer plants. This suggests its potential for rehabilitation of neotropical forest fragments.

Marine and Terrestrial Food Sources in the Diet of *Myotis vivesi*

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Island vertebrate consumers of marine crustaceans and fish are particularly susceptible to seasonal fluctuations of oceanographic conditions. The endemic fish-eating Myotis bat (*Myotis vivesi*) is restricted to a few insular ecosystems in the Gulf of California where it feeds on both marine and terrestrial preys; yet it is unknown whether its diet co-varies with marine primary productivity. We determined the relative contribution of marine and terrestrial food sources to the diet of the fish-eating Myotis to test the hypothesis that seasonal changes in oceanic primary productivity would dictate general feeding patterns of this bat species. We predicted that marine food would predominate in the diet of the bat during the winter followed by an increase in the importance of terrestrial food sources as the summer approaches. Carbon and nitrogen stable isotope analysis of bat blood and the examination of food remains in feces showed that marine food was the main source of dietary protein for the fish-eating Myotis throughout the year. The importance of terrestrial food was marginal during most of the year, with a modest increase in the summer. Due to its predominantly marine feeding habits, the fish-eating Myotis transfers allochthonous nutrients to the islands where it roosts.

Thermoregulation during Pregnancy in Temperate Forest-dwelling Bats

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The reproductive state has a great effect on thermoregulation as foetal growth is energetically costly and undelayed parturition can only be assured by high body temperatures. Foetal growth, and, therefore, high energy requirements, starts in early spring. A reduction of body temperature during pregnancy is likely to result in reduced rates of embryonic development and prolonged pregnancy, whereas a constant and elevated body temperature during pregnancy might ensure undelayed foetal development and parturition. Therefore, we hypothesized that with ongoing pregnancy skin temperatures should remain at normothermic levels. In the years 2011 and 2012 we tagged each 7 individuals of *Myotis bechsteinii*, *M. nattereri* and *Plecotus auritus* with temperature-sensitive radio transmitters during pregnancy and compared recorded skin temperatures. To be able to account for yearly fluctuations we corrected days of data acquisition with ambient temperatures. With ongoing pregnancy torpor phases were avoided and skin temperatures remained high. Moreover, skin temperatures were significantly correlated with undelayed days of pregnancy (Spearman Rank correlation, $n = 41$, $R = 0.672$, $P < 0.001$). The results support our hypothesis that with ongoing pregnancy skin temperatures remained at normothermic levels. This suggests that close to the end of pregnancy thermoregulation is restricted despite the fact that pregnancy is an energy demanding process.

Neotropical Mosaic: An Eli Kalko Approach to Understanding Sensory Niche Partitioning, Species Coexistence, and Eavesdropping in Phyllostomid Bats

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The extraordinary diversity of the Neotropics makes it an ideal place to study sensory niche partitioning and the community interactions of the arms races between eavesdropping predators and their prey. Neotropical gleaning bats feed heavily on katydids. Due to the challenges of distinguishing stationary prey from background vegetation, most gleaning bats rely on prey-emitted cues, such as katydid mating signals, to locate prey in clutter. Katydids in turn have evolved a variety of defenses against bat detection and predation, with species varying widely in their mating calls, as well as their defensive armor and their calling behavior. Here we study eavesdropping in both predators and prey. We quantified the behavioral responses of four gleaning bat species (*Lophostoma silvicolum*, *Micronycteris microtis, Tonatia saurophilia*, and *Trachops cirrhosus*) to the mating calls of thirteen katydid species. We also broadcast bat echolocation calls to seven species of calling male katydids that span a spectrum of predator defense strategies, and quantified katydid responses. We found that 1) all bat species show preferences in the species of katydid to which they respond, 2) the katydids eliciting the greatest responses were different for each bat species, and 3) katydids vary across species in their reaction to bat calls. These results indicate species niche partitioning in the eavesdropping behavior of a Neotropical community, both in bats that eavesdrop on the mating calls of sexually advertising katydids, and katydids that eavesdrop on the echolocation calls of hunting bats.

Learning, Decision-making, and Flexibility in the Fringe-lipped Bat, *Trachops cirrhosus*

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The Neotropical fringe-lipped bat, *Trachops cirrhosus*, feeds on a variety of frogs and insects, using prey-emitted cues such as prey mating calls to detect, assess and locate its prey. Here we present an array of studies demonstrating that the associations *T. cirrhosus* forms between prey cues and prey quality are both highly plastic and learned over time. To assess natural variation in bat response to prey cues over space and time, we examined the responses of bats between two populations with different prey communities (Soberanía National Park in Panama and La Selva Biological Station in Costa Rica), and between seasons within a single population. We show that bat response to spatial and temporal variation in prey cues is highly dependent on the prey species, with significant differences in predator response to different prey cues dependent on space and time. In addition, we present data on variation in response to prey cues between juveniles and adults, and discuss the ontogeny of this bat's acoustic repertoire of signals that it associates with palatable prey. Finally, we present evidence suggesting that the extreme flexibility evident in the foraging behavior of *T. cirrhosus* is associated with its use of multiple sensory modalities to sequentially assess its prey, such that a mistake made at one stage of the hunting approach is corrected at a later stage. Together these studies show how learning and flexibility affect foraging decisions in a Neotropical bat.

Diversity of Bats in Osununú Private Reserve, Misiones, Argentina

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Osununú Private Reserve is an area of 168 hectares, located over the Parana River in the Department of San Ignacio, Misiones, Argentina. The Reserve and its surroundings present particularities of soil, topography and climate, with components of Cerrado of Brazil's flora, which gives the area a great importance for conservation. In order to know the species of bats that inhabit the reserve, three campaigns were conducted in the months of September and December 2012, and March 2013, totaling eight nights of field work. Mist nets were used for sampling, the average sampling effort was 115 m^2net/night, also rocky crags were visited in search of shelter. We captured 55 individuals assigned to eleven species of the following families: Phyllostomidae [subfamilies: Glossophaginae (8), Carollinae (14) Stenodermatinae (16)], Vespertilionidae (4) and Molossidae (13). According to the Red Book 2012 of the Argentine Society for the Study of Mammals, three species are categorized as Vulnerable

(*Pygoderma bilabiatum*, *Glossophaga soricina* and *Carollia perspicillata*), three as Near Threatened (*Artibeus lituratus*, *Platyrrhinus lineatus* and *Nyctinomops laticaudatus*) and one as Data Deficient (*Vampyressa pusilla*) which corresponds to the fifth record of this species in Argentina. A building at the Biological Station is used as a roost for *G. soricina* and *C. perspicillata* species. We also described here the first natural roost of *N. laticaudatus* known for the country. Taking into account the variety of species found in terms of effort, it is expected that further work will allow to add new taxa in this protected area.

Lipid Profiling of Bats and *Geomyces* to Understand Trophic Interactions in a Host/Pathogen System

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Host integument supplies nutrients to the microbial community colonizing the skin. Mechanisms responsible for microbial acquisition of integumentary molecules may provide targets for disruption of pathogen infection. Lipid profiling provides evidence at a molecular level of initial nutrient levels in a host/pathogen system. Furthermore, differences in lipid profiles contribute to understanding of taxonomy, life history, and clinical signs of disease. We obtained lipid profiles for 13 species of bats and 2 species of *Geomyces* (*G. destructans* and *G. pannorum*). Bat sebaceous lipids are a complex mixture of glycerolipids, sterols, wax/sterol esters, squalene, and free fatty acyls (FFAs). Bat fatty acid methyl ester profiles are species specific. *Geomyces* produced primarily triacylglycerides (TAGs), FFAs, and sterol with minor amounts of mono/diacylglycerides and sterol esters. *G. destructans* lipids are more unsaturated compared to *G. pannorum*. Proportion of TAG to FFA increased when *G. destructans* was cultured in stressed conditions. These results provide baseline information on host lipids that may interact with *G. destructans* during infection. *Geomyces* have different lipid profiles, which can be used in disease diagnostics and detection. *G. destructans* may alter lipid ratios to lower cellular toxicity or stimulate reproduction in stressed environments. Increases in lipid unsaturation may also partially explain the psychrophilic life history of *G. destructans*. Further experimentation should highlight differences among lipid profiles of additional *Geomyces* species and metabolic processes involved in digesting bat integumentary lipids.

Bat Awareness Movement – Advocacy for Long-tailed Bats in Auckland City

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The threatened long-tailed bat (*Chalinolobus tuberculatus*) is one of two endemic bat species in New Zealand and are the only native terrestrial mammals in the country. This species is classed as being nationally vulnerable but it is only recently that bats have been discovered to use human-dominated ecosystems, including peri-urban environments in cities like Hamilton and Auckland. The main threat facing cryptic local populations is ongoing destruction and fragmentation of habitats used by foraging and roosting bats. Auckland Council has been supporting bat advocacy and research over the past two years. Educational talks to schools, community and interest groups, and a number of positive media articles have grown the awareness of these widely unknown bats. New records of long-tailed bats have also been discovered by monitoring in likely habitat types across Auckland. The accumulation of this work was celebrated with hundreds of local Aucklanders in a bat awareness event with attitudes being assessed via survey. Survey results have shown 82 per cent of respondents would actively check trees for bat occupation before felling. This has illustrated how a successful bat awareness movement can be implemented to the public urban community.

Avian Diet of *Nyctalus* aviator: a Molecular Approach

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Bats show wide variety of diets, unexampled for a single order of mammals or even other vertebrates. Due to the fact that direct observations of feeding events are often impossible, the diet of insectivorous bats is traditionally studied through the morphological identification of microscopic prey remains in faeces, normally chewed up to tiny pieces, primarily fragments of arthropod cuticles. PCR-based techniques have proved to be highly effective and versatile and are rapidly complementing or even displacing traditional approaches. The birdlike Noctule (*Nyctalus aviator*) is an insectivorous bat from Northeast Asia that has recently found to feed on migrating

passerines during their nocturnal journeys as well as the closely related specie *Nyctalus lasiopterus*. The discovery was based on the finding of feathers inside faecal pellets collected from three day roosts in Japan. The objective of this study was to describe the species composition of the avian diet of the birdlike Noctule using molecular approaches. After extracting the total DNA contained in the bat faeces and using specific passerine primer pairs, we amplified and sequenced exclusively bird DNA that was identified to the species level. Our results show that the birdlike Noctule preys at least on 16 different passerine bird species captured across Spring, Autumn and early Winter.

Molecular and Morphological Approaches Reveal Previously Obscured Species Diversity in Southeast Asian Archipelagic Horseshoe Bats, *Rhinolophus* Gray, 1825

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The present study sheds light on species delimitation in what has been previously described as *Rhinolophus arcuatus*, a morphologically conservative bat species complex nominally distributed throughout archipelagic Southeast Asia from New Guinea to Sumatra. Given that rhinolophids tend to be relatively weak fliers, hence have low vagility, we hypothesized that some specimens attributed to *R. arcuatus* but originating from geographically disjunct populations may in fact represent distinct species. To test this hypothesis, we examined specimens attributed to *R. arcuatus* as well as to other species in the *R. euryotis* species group using both morphological techniques and mitochondrial cytochrome b and control region sequences. Careful morphological analysis reveals heretofore cryptic but nevertheless distinct, species–level morphological differences among specimens derived from geographically isolated locations. Furthermore, molecular data illuminate the existence of several species level sequence divergences among specimens heretofore attributed to a monolithic *R. arcuatus* complex. These analyses similarly suggest the existence of additional species in other Southeast Asian *Rhinolophus* previously considered monotypic. We suggest minimally one description to be undertaken of a previously unrecognized species, as well as the elevation of several others from sub–specific to specific status.

Delimiting Cryptic Species for 'The Bats of Kenya' – the Genus *Miniopterus* (Miniopteridae)

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We are conducting a country-wide survey and inventory of bat species in Kenya, a megadiverse country with more than 100 mostly insectivorous bat species. This work entails characterizing and delimiting a number of cryptic and poorly understood taxa. Among the latter group, the Old World bent-winged bats *Miniopterus* (Miniopteridae) are especially challenging. Since 1999, when only 11 species were known, the number of *Miniopterus* species recognized has more than doubled. Both vocalization calls and analyses of genetic and morphological variation have contributed to this taxonomic proliferation. During surveys in Kenya, we identified at least three species of *Miniopterus* in the field. Through a series of analyses, we (a) present an expanded phylogeny of the genus *Miniopterus* that includes these forms; (b) distinguish the species from each other in vocalization, genetic, and morphological terms; (c) determine their ecological and geographic distributions; and (d) assess the proper names to apply to these forms, through comparisons with the holotypes for both *M. rufus* Sanborn 1936 and *M. africanus* Sanborn 1936.

Molecular Systematics on the Neotropical Families Noctilionidae and Mormoopidae: Unraveling the Hidden Diversity

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Molecular techniques have contributed enormously to bat diversity as known today, successfully revitalizing and improving our understanding in systematics. Several studies generated information regarding genetic variation, many of them described a hidden diversity for Neotropical bat groups. Using mitochondrial markers and sampling across species geographic distribution, I present phylogenetic researches carried on the families Noctilionidae and Mormoopidae. The Family Noctilionidae has one genus with two species currently

recognized: *Noctilio leporinus* and *Noctilio albiventris*. The phylogeographic patterns suggest that *N. leporinus* arose from an *N. albiventris* population, which is paraphyletic. *N. albiventris* is formed by at least three divergent lineages and potentially represents a cryptic species complex, deserving deeper investigation for description of its diversity. The Family Mormoopidae has two genera, *Mormoops* and *Pteronotus*, with eight living species described. Recent studies point to the existence of cryptic diversity in more than one species of *Pteronotus*, and *P. parnellii* is suggested to harbours at least four genetically distinct taxa, although none was formally described. My results show that at least six lineages can be recognized in the "*parnellii*" complex. The phylogenetic analysis also suggests that *Pteronotus personatus* comprises three divergent lineages, while *Pteronotus davyi* is paraphyletic, presenting two independent lineages. One of them is sister-group of *Pteronotus gymnonotus,* the other is basal to this clade. The frequency with which cryptic species are uncovered by molecular data suggests it should be incorporated in the research of alpha-taxonomists, helping to drive new systematic studies on bats.

Use of Large-scale Acoustic Monitoring to Detect Intraspecific Spatial Patterns

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Thanks to the effort that can be developed by citizens, citizen monitoring programs allow to collect large scale-datasets particularly useful to reveal patterns of species distribution and evaluate species trends facing global changes. For bats, standardized acoustic monitoring surveys are now developed at national scale in some countries to monitor population trends. Here we examined whether the collected information also allows to measure changes at the individual level in addition to changes in species activity patterns. Call frequency was hypothesized to be negatively related to the size of individuals, and consequently should exhibit latitudinal gradient according to Bergman' rules. To test it, we used the data from the French national bat monitoring program that collects bat calls along road transects (n=1500 sites). We showed that call frequency of *Pipistrellus pipitrellus* was correlated to latitudinal, temperature, and precipitation gradients. Using this example of results, we highlight the possibilities offered by such programs to detect biodiversity patterns and to better understand the underlying mechanisms of responses of species facing global changes.

Social Interactions and Behavioral Patterns of Harems of *Carollia perspicillata* in Natural Conditions

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The bats sociability involves interactions among individuals that depending on the sequencing of occurrence these can present patterns deterministic, stochastic or probabilistic, and random. In great measure by its gregarious behavior *Carollia perspicillata* presents a complex social system and polygynous mating system in which females' composition seems to be stable. Females changed on average 3.8 groups every 6 months, showing preference for certain groups and sites. Very few studies describe the behavioral pattern of the harems in numerous colonies in natural conditions. In this paper we described how are social interactions and behavioral patterns within and between harems in roosting sites of *Carollia perspicillata* in the cave Macaregua, Santander (Colombia). Social interactions of harems were described made an ethogram of all behaviors views. Behavioral patterns were identified by a Markov chain analysis and determined the stability of these through social networks. We described 34 behaviors, 7 states and 27 events, of which "lick the roof" was not registered. *Carollia perspicillata* in roost sites within the cave dedicated a high percentage of time in activities related to the alert and the movement (36%), rest and lick the roof (32%). Harems that showed the least amount of agonistic behaviors tend to be more stable.

Conservation Value of Tropical Dry Forest Fragments for Bats in the Colombian Caribbean Region

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In Colombia, the tropical dry forest (TDF) is the most threatened terrestrial ecosystem and the Caribbean region has suffered a high reduction. Currently remains less than 1.8% of the original cover, which mainly has been transformed in livestock landscapes. Given this scenario it is important to determine how different species of bats

have been able to persist in the few remaining TDF fragments that are inside livestock matrix. To obtain information about this issue, we sample bats from six localities in the department of Córdoba between 2009 and 2012. Bats were captured inside TDF fragments and surroundings. These forests are immersed in extensive livestock matrices under silvopastoral management (two forests) and conventional management (four forests). 4,042 bats were captured represented 52 species of 9 families (80% of the reported species for the department). Bats inside fragments in silvopastoral systems were significantly more abundant than in traditional systems fragments. Only 8% of the species were found in all sites. Species richness per site was higher in silvopastoral systems. The TDF fragments in livestock landscapes are maintaining high representativeness of the regional diversity of bat species and the ecosystem services than they provide.

Conserving Cave Bats in the Philippines: Assessing the Impact of Cave Disturbance on Bat Assemblages

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Cave-dependent bats serve essential ecological and economic roles (pollination, insect suppression, forest regeneration) in the Philippines, yet human disturbance of cave landscapes threaten their persistence. On Bohol Island in the central Philippines human pressures on cave bats are occurring at multiple scales: i) loss of foraging sites to agricultural expansion; and ii) localized disturbances from residents (hunting, cave tourism, guano collection) causing bats to abandon caves. Such threats jeopardize the viability of cave-dependent bats. No studies to date have quantified the impact of human disturbances on cave-dependent bats in the Philippines though this is needed to devise effective conservation strategies as outlined in the Philippine National Cave Act. My study aims to compare cave-dependent bat assemblages among caves experiencing differing levels of human disturbance to: i) assess the status of cave bats in an increasingly human-dominated landscape to identify priority caves; and ii) pinpoint threats that have the greatest impact on cave bats. Specifically, this study quantified disturbance levels at 60 caves using a modified karst disturbance index, and compared with species diversity and composition of bat assemblages documented over 2 nights. Preliminary analysis of data collected from July 2011 to April 2013 indicates that bat assemblages inhabiting the least disturbed caves have on average the largest number of captured individuals and greatest species richness and diversity with more endemic species. Final results will be used to evaluate the significance of individual caves for maintaining viable populations of cave-dependent bats, a priority under the National Cave Act.

A Model for Translational Regulation in Development and Morphological Evolution

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Genetic mechanisms underlying morphological evolution are almost completely unknown. Related, relative roles of mutations occurring in open-reading frames or cis- or trans- regulatory genomic regions in providing a genetic background for selection to function are also poorly understood. A significant percentage of mRNAs are UTRs, regions functioning in regulating protein translation rate. Recent studies indicate that translational control, rather than transcriptional, primarily determines protein concentration in a cell at a given time. This is relevant to development and evolution in that spatio-temporal timing of protein expression is highly critical to developmental processes. This study combines comparative genomics with cellular and embryo studies to develop a hypothesis for the role of 3'UTR regulation in morphological evolution. The 3' UTRs of genes thought to be relevant to craniofacial development were queried from genomes of 36 mammalian genomes. Orthologous sequences were analyzed for presence of all known UTR regulatory elements, and the conservation, frequency, range, and correlation of these elements was quantified. A candidate regulatory mechanism was identified, which was validated through reporter assays on bat 3'UTRs. Embryonic expression domains were assayed through immunohistochemistry. Evolution of Musashi regulation (an RNA-binding translational regulatory protein) was identified as a candidate mechanism for morphological evolution. Studies in 3'UTR evolution are a promising avenue for understanding developmental mechanisms of large effect which have been targeted by natural selection.

Transcriptomes and Genomics: Pathways to Understanding Chiropteran Adaptation and Evolution

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Adaptive radiation and flight are the two hallmarks of chiropteran evolution. Morphology, especially of the skull, face, and dentition is diversified and coincides with dietary diversity. At the tissue and cellular levels similar patterns of diversity have been discovered and reported. In particular, the numerous salivary glands, gastric mucosa, and kidneys have been compared at the histological, immuo- and histo-chemical, and ultrastructural levels. However, until recently it has not been possible to uncover the genetic basis for adaptation. Transcriptome sequencing reveals the genes expressed in particular cells or tissues. These data together with genome sequencing can be used to test hypotheses about the genetic basis of adaptation, especially if the genetic data are combined with comparative morphological or microscopic datasets. Our team has used the transcriptome of a submandibular salivary gland from the little brown bat, *Myotis lucifugus*, to explore the role of this gland in bat insectivory and flight energetics. Transcriptome data also can be used to identify genes probably responsible for cell phenotypes and the evolution of cell 'types.' Genomic data can be integrated into the transcriptome data to elucidate evolutionary mechanisms including gene acquisition, gene duplication, changes in regulation, modifications or creation of gene and protein networks, and loss of genes. Insofar as insectivory is concerned, the data support the hypothesis that lipid-rich insects are required by the metabolic pathways in microbats. Indeed, metabolism might be the key driving force behind dietary diversity in bats.

Evolution of Bat Immunity and Parasites: the TLR2 Gene and Trypanosomes

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Bats have been implicated as reservoir hosts of several infectious diseases, and apparently bats have a greater number of pathogens than other specious mammals (i.e., rodents). Life history characteristics and ecological factors of bats correlate positively with pathogen diversity; however, there are limited data on the evolution of bat parasites and potential molecular adaptations of the hosts' immunity genes. To understand better the interplay between bats and their trypanosome parasites we explored the diversity and evolution of species within the *Trypanosoma cruzi* clade, a group of parasites that mostly infect bats. Also, we inferred the evolutionary history of the toll-like receptor 2 gene (TLR2), a component of the innate immune system deployed in pathogen recognition including trypanosomes, at inter and intraspecific levels in noctilionoid bats. Firstly, we constructed phylogenies and performed biogeographic analyses of the trypanosome parasites to follow the association of the parasites and their bat hosts. Secondly, we compared levels of selection in the TLR2 gene among and within different noctilionoid bat species and contrasted those with similar datasets of rodents. The results clarify a long evolutionary relationship between bats and their trypanosomes. Also, these results will indicate if the TLR2 gene is evolving at different rates in bats and rodents, and will show if trypanosome infections are correlated with molecular adaptation at this locus. This study could serve as a model to study other parasite groups and immunologically important loci in bats using a comparative framework.

Accounting for the Perplexity of 'Ope'ape'a: Is there Genetic Variation and Geographical Structure in the Hawaiian Hoary Bat?

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The 'Ope'ape'a, or Hawaiian Hoary Bat (*Lasiurus cinereus semotus*), is a federally endangered subspecies whose current distribution, population size, and potential movements across the Hawaiian Islands are unknown. Recent research into the biogeographic history of Hawaiian bats has produced a fascinating picture of multiple colonization events and investigated the effective population sizes, rates of gene flow, and time of dispersal that separated this subspecies from North America. As part of a collaborative effort to understand current bat distribution and delimit population boundaries, this proposed study would explore the potential differences that may exist across the major islands of Hawaii, Maui, Oahu, and Kauai by comparing bat morphology, call structure, and multilocus genetic data. Products of this proposal would include estimates of current population sizes on the islands of Maui

and Kauai, as well as determining rates of possible interisland migration from using genetic and genomic techniques. As the state of Hawaii's only endemic land mammal, research yielding information on population structure and genetic variation will aid local conservation management efforts to protect this species from threats such as habitat loss and the impact wind energy.

Population Biology and Conservation of Bats on St. Thomas, U.S. Virgin Islands

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There are five resident bat species in the U.S. Virgin Islands, a small archipelago in the Caribbean to the east of Puerto Rico at the top end of the Lesser Antillean island chain. These species are: *Artibeus jamaicensis*, *Brachyphylla cavernarum*, *Stenoderma rufum*, *Molossus molossus*, and *Noctilio leporinus*. Since 2008, we have conducted regular monitoring surveys at a nature preserve on St. Thomas, along with occasional surveys at other sites, including known roosts. Bats have been tagged for individual identification since 2011. *A. jamaicensis* and *M. molossus* are most frequently captured, while *B. cavernarum* and *N. leporinus* are infrequently observed. Less than five *S. rufum* have been captured during the duration of the study. The recapture rate for *A. jamaicensis* is low, less than 10%. *M. molossus* are readily recaptured, with a rate of around 30%, which provides valuable information on individual reproduction rates and other biological parameters, as well as allowing site specific population estimates. Data suggest that *A. jamaicensis* potentially breed twice annually, while *M. molossus* breed once a year, in the summer. While capture numbers of each species have fluctuated throughout the study period, the body condition indices (mass/forearm length) have remained relatively constant, indicating little variation in the foraging capabilities of the bats. In addition to the biological studies, we also conduct public education events ("Meet the Bats"), install bat houses, and produce information on local bats and their conservation needs. Despite this effort, there is still much to be learned about these species.

Mating System of *Myotis myotis* (Chiroptera, Vespertilionidae): Components and Variation

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In contrast to its sibling, *Myotis blythii*, which forms multi-male lek-like aggregations during autumn mating period, *M. myotis*, one of the most common European bats, is characterized rather by a strict territoriality of males separating individual roosts. With recently increased abundance of *M.myotis* in the Czech Republic the pattern has changed. Two dense aggregations of males' roosts in tubes of highway bridges (occupied in total by 60 individually recognized males) enabled us to test between-individual variation in roost occupancy, territorial and advertisement behavior and harem formation (starting 2008, since 2010 with automated acoustic and video recordings and 24 hrs observations). About a half of males reside their roosts already since late April while the others appear temporarily and only at the beginning of mating season (late July) almost all available roosts are occupied. The unoccupied roosts can be later temporarily colonized directly by alien harem groups. Individual males differ considerably also in amount of territorial behavior, social vocalization and success in harem formation. Female choice with active night screening throughout the tube was the major driving factor of harem formation followed by considerable differences in social signature of particular sectors of the tubes. The hot-spots with highest density of male territories showed the highest values of mean intensity of male social vocalization, mean harem sizes and frequency of night visits by alien individuals (females?). The strong fights among males (either at time of spring colonization of roosts and at the beginning of mating season) appeared only there.

Does *Geomyces destructans* Infection Impair Reproductive Capacity in *Myotis lucifugus*?

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White-nose syndrome (WNS) is a disease caused by a cold-adapted fungus, *Geomyces destructans* (*Gd*), that results in devastating population declines of North American cave-hibernating bats. Rates of decline at most sites are estimated by annual counts, so it is uncertain whether declines are due entirely to increased mortality or if reduced fecundity also occurs. Female little brown bats (*Myotis lucifugus*) store sperm and a single Graafian follicle throughout hibernation, and will not produce any offspring if storage fails before spring emergence. Bats with WNS become emaciated and dehydrated, which could compromise their ability to maintain the stored follicle and sperm.

We conducted a histological study of reproductive tissues from 58 hibernating female *M. lucifugus*, including both *Gd*-positive and *Gd*-negative individuals. We hypothesized that *Gd*-positive females would be less likely than *Gd*-negative females to maintain a Graafian follicle and stored sperm. We found that *Gd*-positive females were less likely to maintain a Graafian follicle, but results were not significant. If *Gd* infection reduces fertility in hibernating *M. lucifugus* females, the effect is small. Additional studies of reproductive capacity of females at maternal colonies will determine if *Gd* infection reduces the probability of maintaining pregnancy in the post-hibernation season.

Ontogeny of Vocal Communication of the Egyptian Fruit Bat and the Role of Learning in its Acquisition

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Acoustic communication is fundamental in social systems of many animal species. Vocal learning, the competence to learn new vocalizations from auditory inputs, is a key element of complex vocal communication, and has been described mostly in courtship songs of birds and of a few mammals. However, experimental evidence of vocal learning in broader contexts is scarce. The sociality and acoustic abilities of bats present an excellent model for studying the development of vocal communication. We followed the vocal ontogeny of the extremely social and vocal Egyptian fruit bat (*Rousettus aegyptiacus*), from birth to adulthood. Pups were reared in small colonies or in acoustic isolation, and were monitored continuously by audio and video. The captured video enabled identification of speakers and contexts. Computational tools, developed specifically for this task, created a library of dozens of thousands of calls, where each call is associated with its context and speaker. Using this massive annotated lexicon we could follow the ontogeny of vocal communication. We grouped the entire corpus into few clusters, and observed the gradual assimilation of pups' calls into the adult clusters. Furthermore, pups reared in isolation demonstrated delayed vocal development, and their calls differed from the adult repertoire, compared to pups in the same age, which were raised among other bats. These results illuminate the ontogeny of social communication and imply a role for vocal learning in the acquisition of the diverse repertoire of *R. aegyptiacus*. Our data and tools also facilitate the comprehensive description of a rich vocal communication system.

Monitoring Long Term Survival of New Zealand Long-tailed bats in Relation to Exotic Predators and Predator Control

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New Zealand long-tailed bats (*Chalinolobus tuberculatus*) are critically endangered as a result of predation by exotic mammals, particularly ship rats (*Rattus rattus*) introduced by humans to New Zealand. We monitored the survival of bats in four colonies in temperate rainforest in the Eglinton Valley, Fiordland over twenty years. Survival was estimated using multi-state mark-recapture models in Program Mark 7.1 and capture histories of >15,000 bats. Survival was dependent on age, sex, winter temperatures and predator levels. Initially we recorded significant drops in survival of adult and juvenile bats when introduced predator numbers were high and one population went extinct. Matrix modelling indicated that bat populations were declining towards extinction at a rate of 5% per annum. Since 2003, we have experimentally controlled predators during irruption phases and compared survival of bats in treated and untreated forest blocks. Survival has increased significantly in treated areas and matrix modelling indicates treated colonies are now increasing (lambda = 1.12) whereas untreated colonies are still declining (lambda = 0.97). Predator control has now commenced at all sites with bat colonies in the Eglinton Valley in conjunction with a programme that predicts in which years predators need managing (based on monitoring forest seedfall and predator footprint tracking indices) .

Modelling *Geomyces destructans* Distribution in North America and Eurasia Using Ecological Niche Modelling: What Can We Learn?

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White-nose syndrome (WNS), an emerging infectious disease caused by the fungus *Geomyces destructans* (Gd), has been expanding year after year in North America, suggesting a recent introduction of the fungus (probably from Europe). Given the massive mortalities associated with WNS in North America, it is of prime importance to predict areas suitable for its causative agent, Gd. By modelling the occupied niche by Gd in Europe, we predicted its distribution in North America, and which ecological factors could be limiting its distribution. To achieve this, we used a species distribution modelling technique – maximum entropy modelling - that has been proven to accurately predict current species distributions. To reduce uncertainties in models' projections we used the reciprocal modelling approach. This way the full niche of the species is considered (including data from both Europe and North America). We also calculated the similarities/differences in niche occupied by Gd between North America and Europe and highlight potential adaptations of Gd in North America. Finally, we determined potential dispersal routes that Gd could use to expand its current distribution. Results indicated that Gd distribution was limited by temperature variables. Model predictions comprised the currently known distribution of Gd in Europe but also areas where Gd has not yet been detected. Results showed a mismatch between realised niche in Europe and North America. This indicates that Gd is probably not occupying its entire potential ecological niche in Europe or that it recently adapted to North American conditions.

Effects of Habitat Fragmentation and Isolation on Bat Pollinators, Pollen Flow and the Mating Patterns of *Ceiba* Species

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Tropical forest loss and fragmentation isolate and reduce the size of remnant populations with negative consequences to pollinators and the mating patterns of plants. We present long term effects of fragmentation on bat pollination movement, pollen flow and mating patterns of the tropical trees *Ceiba aesculifolia* and *C. pentandra* in two habitats of Mesoamerica. Using allozyme loci and microsatellite genetic markers, we estimated bat pollinator movement, and outcrossing rate (t_m), mean relatedness of progeny (r_p), the genetic structure of pollen pools (Φ_{ft}) and the effective number of pollen donors (N_{ep}) of Ceiba trees. In *C. aesculifolia,* outcrossing rates reflected a strict self-incompatible species with the highest levels of genetic structure of pollen pools in isolated trees. The effective number of pollen donors was greater for trees in undisturbed forest than in disturbed conditions. Relatedness of progeny within trees was consistently greater in fragmented conditions across four years. *C. pentandra* showed a mixed mating system but trees mated predominantly by outcrossing. The progeny of grouped trees was sired by near-neighbors and by few long-distance pollen flow events in isolated trees. Pollen flow distances depend on local tree density as bats apparently concentrate their foraging between near neighbor trees. The progeny of isolated trees in disturbed habitats are sired by a fraction of the pollen donors found in conserved forests. The foraging behavior of bats limits the exchange of pollen between trees, causing higher levels of progeny relatedness in isolated trees and regulating the mating patterns of trees.

Bat Assemblage and Chiropterocory as Evaluators of Ecological Resilience in the Management of the Agro-Ecosystem Landscape (Guanacaste, Costa Rica)

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Most of the Costa Rican tropical dry forest was transformed into livestock and crop areas, diminishing its ecological integrity. The ecological restoration of these areas is a significant action. However the demand for achieving results often ignores the ecological complexity of the systems, and classic biological indicators often fail to evaluate the necessary ecological functions for ecosystem recovery. The aim of this study was to generate basic

investigation about the ecological resilience and resistance of the Laguna Mata Redonda Wildlife Refuge, using bat assemblage and quiropterocory as indicators, in order to generate management actions according to the area's restoration potential. The study was conducted in the Guanacaste province, Costa Rica, between March and August of 2012. Variables evaluated were: diversity, relative abundance and community structure of bats, diversity and ecological traits of the plants being dispersed, and the value of seeds dispersers. Data was analyzed using rank-abundance curves, diversity estimators, goodness of fit tests to abundance models, linear regressions and importance of the disperser index. Sixteen sampling nights (272 hours of capture) were completed. Low bat species diversity and abundance evenness was found. The assemblage falls into a log-series distribution model. There was low diversity of dispersed plant species. The Jamaican fruit eating bat (*Artibeus jamaicensis*) is the most important disperser, but its value is low. According to the variables evaluated the ecological resilience and resistance of the wildlife refuge is low and a passive restoration strategy should not be applied. An active restoration plan must be establish.

Responses of Phyllostomid Assemblages to Land-use Changes, Vegetation Physiognomy, and Seasonality in the Cerrado Biodiversity Hotspot

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In the last decades, more than half of the 2 million km^2 originally occupied by Cerrado were transformed by agriculture and livestock production. Few studies have focused the impact of land-use changes in neotropical savannas on bat assemblages but, if similarly to what happens in forests, habitat degradation in the Cerrado results in changes in the structure of phyllostomid assemblages, essential ecosystem services provided by these bats in this highly threatened hotspot might be disrupted. We hypothesize that the patterns in phyllostomid diversity, composition, and abundance differ among Cerrado phytophysiognomies, disturbance levels and seasons. To test this, we studied patterns of phyllostomid assemblage structure in Central Brazil, core region of the Cerrado biome. Richness, diversity and number of captures were significantly higher in pristine habitats than in mildly modified areas and also higher in these than in severely modified habitats. Forest-structured habitats of the Cerrado biome – Cerradão and Gallery Forests – hold slightly richer assemblages than Cerrado *sensu stricto*, but this typical savanna-structured phytophysiognomy contributes with rare species for the overall diversity of phyllostomids of the Cerrado biome, providing habitat for a range of specialists that are rare or absent elsewhere, in particular nectarivores. The majority of the sampling sites classified as highly modified, which were significantly less diverse, were in the border or in the vicinity of the environmental protected site, core of our study area. This shows the importance of conservation efforts targeted at neotropical savannas, especially considering that these habitats are underrepresented in neotropical reserve networks.

Population Recovery in Greater Horseshoe Bats Is Aided by Pup Sex Manipulation

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A long-term banding study of a wild population of greater horseshoe bats in the UK, at the limits of their geographical range, showed two major population falls. Each was linked to several years of adverse climate. The first occurred in the 1960s; the second in the mid 1980s. Population recovery took about 15 years due to delayed reproduction and single annual births. In 1987 there were only 19 live births from all surviving mature females. Births slowly recovered to 31 in 1997 and 90 by 2011. Matrilines, each starting from a single female that survived the mid 1980s crash, were followed up to 2011. Climate and food supplies after 1997 favoured population expansion. We predicted that successful females should give birth earlier (age 2 years), rather than later (age 3-6 years) and should invest more heavily in female pups than in smaller male pups. Here we describe the sex ratio of pups born to individual females that produced at least 11 pups. We found certain mothers showed significant sex-ratio bias of their pups, with examples of both female-dominated and male-dominated bias. Some matrilines included individuals which showed sex-ratio switching across generations. The outcome of each matriline's life-history and sex-ratio strategies was assessed against predictions by analysing all births in 2011. Earlier births and sex-ratio manipulation favouring females had major long-term impacts. Three matrilines dominated the population, providing over 50% of the pups born in this year. The first-born pups of successful matrilines were also significantly biased towards female births.

Diversity of Paramyxoviruses in Costa Rican Bats

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Paramyxoviruses comprise leading human pathogens, including measles and mumps virus. Recently, bats were proposed to host major mammalian paramyxoviruses. In previous studies it was shown that paraymxoviruses related to human viruses originated mostly from Old World fruit bats (Megachiroptera). In the New World, Megachiropterans do not occur and this ecological niche is occupied by echolocating bats (Microchiroptera), which are highly diversified in the Neotropics. Therefore, studies in the New World tropics are of great importance for the analysis of diversity, distribution and ecology of paramyxoviruses. In this study, neotropical bats from Costa Rica were tested for paramyxovirus RNA. A high diversity and prevalence of Morbilli-related viruses was observed in Costa Rican insectivorous bats. Closely related viruses were detected in a single species (*Pteronotus parnellii*) through three consecutive years and at different locations.

Niche-specific Cognitive Strategies: Object-specific Cues Overshadow Spatial Cues in a Predatory Bat

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We tested the niche-specific cognitive strategies hypothesis using Natterer's bat, *Myotis nattereri*. Specifically, we tested the prediction that, as opposed to frugivorous and nectivorous bat species, predatory bats should rely on object memory over spatial memory to identify potentially profitable prey patches. We observed free-flying Natterer's bats as they took palatable and unpalatable prey suspended below different 3D objects. Bats in Group 1 experienced 4 experimental scenarios, those in Group 2 the last scenario (scenario 4) first. Group 1 bats observed in scenarios 1-3 (object memory) readily associated different shapes with prey palatability but then did no better than chance in scenario 4 (spatial memory). Conversely, experimentally naïve bats (Group 2) associated palatability with position (scenario 4). One of these bats then quickly learned to associate shape with prey palatability (scenarios 1-3). Our results support the niche-specific cognitive strategies hypothesis in bats and birds, and suggest that for *M. nattereri* shape cues overshadow positional cues despite echolocating bats' well-established reliance on spatial memory for other tasks.

Effects of Climate Change on Bat Distributions: What Do We Know? What Can We Do?

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Earth's ecosystems and global biodiversity are facing an escalating decline and in the forthcoming years human-induced climate change (CC) are expected to become one of the major driving forces of such loss. Despite its relevance, and considerable research on other organisms, the potential effect of CC on bats has received little attention. Yet, within this context a considerable research has been devoted on predicting the potential future distributions of bats due to CC. In this talk it will be given an overview on the effects of CC on bat distributions for both temperate and tropical climates and how to develop monitoring networks (MN) that allow a proactive response to the predicted range shifts. Overall, regions currently possessing high species richness are predicted to loose their relevance, especially in the tropics. In temperate climates a general pattern of range shifts towards nowadays cooler regions is predicted. However, there is a higher risk of extinction for species associated to colder climates due to the severe reduction of suitable climatic space throughout the 21st century. Moreover, hibernacula for at least one bat species are also predicted to shift towards cooler latitudes. To validate and detect these potential range shifts the establishment of MN is essential. By sitting monitoring stations in areas sensitive to CC it may be possible to detect species' range shifts whenever they happen. By identifying priority areas for bat conservation and with the establishment of MN it might be possible to react proactively to the potential effects of CC.

Where East (Africa) Meets West: Bat Biodiversity and Biogeography in Southwestern South Sudan

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The new country of South Sudan is larger than Kenya, Uganda, and Rwanda combined, is characterized primarily by moist savanna and montane forests, and is historically known to house a variety of bat species. Along the southwest border of South Sudan with Democratic Republic of the Congo and Central African Republic lies a belt of tropical/subtropical forest. The presence of this tropical zone near the Congo Basin ecoregion sets it apart from the rest of South Sudan, and elements of the faunas and floras of West Africa and East Africa overlap here. As noted by Karl Koopman in his seminal work on the bats of Sudan, the diversity of bats that should be found in this region is vast, yet uncharacterized. Fieldwork was conducted in Bangangai Game Reserve, Western Equatoria State in July 2012, with a follow-up trip to Bangangai and Bire Kpatuos Game Reserves in May and June 2013. Classification efforts are still underway, but bats captured thus far include: Pteropodidae (*Epomophorus*, *Micropteropus*, *Hypsignathus*, *Lissonycteris*); Vespertilionidae (*Scotoecus*, *Scotophilus*, *Neoromicia*, *Glauconycteris*, and the new genus *Niumbaha*); Emballonuridae (*Taphozous*); Nycteridae (*Nycteris*); Hipposideridae (*Hipposideros*); and Molossidae (*Chaerophon*). Bats in the families Rhinolophidae and Megadermatidae are expected, but have not been captured to date. I will present my findings from both the 2012 and 2013 field seasons within the context of the unique biogeography of this region.

Species Richness and Abundance of Bats in the Yungas of the Pampa Hermosa River, Peru

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Despite its great mammal species richness, the central Yungas of Peru have received limited attention for over 40 years. In order to assess the changes in bat richness and abundance in the Yungas of Junin, bats were sampled at seven sites along the Pampa Hermosa river, on a gradient ranging from 700 to 3150 m at 350 m altitudinal intervals. Species richness was expected to decrease monotonically with altitude. Due to the presence of *Sturnira* species along the gradient, changes in their relative abundance were also assessed; the change in abundance was expected to follow the trend observed in the species richness. Sampling was conducted during the dry season (June-July and September-October 2011), between 18:00 and 24:00 hours, using an average of 8 mist nets during 7 nights for each altitudinal belt. A total of 296 individuals were captured, represented by 22 species of the families Phyllostomidae and Vespertilionidae. The greatest and lowest species richness was found between 1400-1750 and 2800-3150, respectively, while the highest relative abundance of *S. erythromos* and *S. oporaphilum* were observed between 2100-2450 and 1400-1750, respectively. Although the species richness in the first belts was lower than expected, richness decreased linearly with respect to altitude, while the abundance was higher at intermediate altitudes.

Bats in Central European Forests

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The flight activity of bats and its temporal changes were studied from May till August in ten selected forests, i. e., floodplain forest (1), pine forest (2), thermophilous oak forest (3), lowland beech forest (4), lowland spruce plantation (5), oak-hornbeam forest (6), ravine forest (7), mountain beech forest (8), bog spruce forest (9), and mountain spruce forest (10). The study season was divided into three parts with respect to the bat reproduction, i. e., pregnancy, lactation and post-lactation periods. The point counting method of automatic bat-detecting was used. The flight activity was recorded in closed, semi-closed and open microhabitats in each studied forest during the first two quarters of the night. In total, 180 recordings were performed during 30 monitoring campaigns. Generally, the level of flight activity of bats detected in six lowland forests (below 300 m a.s.l., 1-6) was significantly higher compared to the activity in four mountain forests (above 700 m a.s.l., 7-10). The highest activity was recorded in the floodplain forest (1) as expected. On the contrary, the mountain spruce forest (10) was utilized by bats only scarcely. In lowland forests, the highest activity was registered in the pregnancy period and it gradually decreased towards the end of the season. In mountain forests, the level of activity was rather well-balanced

throughout the season. In all forest habitats, the flight activity was higher at the beginning of the night than before midnight.

The Influence of Environmental Variables on the Demography of *Myotis lucifugus*

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Given the variety of threats to bat populations in North America and around the world, accurate information on the population dynamics of bat species are necessary to generate effective conservation policies. We have used mark-recapture data from a long-term monitoring study of a maternity colony of little brown myotis (*Myotis lucifugus*) in Peterborough New Hampshire to generate estimates of some of the primary demographic variables (adult survival rates, juvenile survival rates, and reproductive rate) and secondary demographic variables (birth sex ratio, reproductive timing, reproductive synchrony, and post-natal growth rates) necessary to inform population viability analyses and recovery models. These data suggest that adult female survivorship has the highest impact on population growth rates overall, with juvenile survivorship strongly influenced by reproductive timing and environmental conditions. There was no evidence of an overall biased birth sex ratio but strong suggestion that more females were born early in the reproductive season compared to males. The data also suggest that primiparous females give birth significantly later than experienced females and have a male-biased sex ratio. Data collected from this population also suggest that few females reproduce in their first year after birth, and that cohort-specific reproductive rates become age-independent after three years. These data should prove valuable for generating and validating population models in this species, and highlights the value of mark-recapture studies to understand the role of environmental variables on the population growth of long-lived species.

Modelling Bat Mortality Risk on a Railway Using Acoustic Flight Path Reconstruction

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Impact assessments of roads and railways on bats are suffering from poor estimates of mortality and from a lack of knowledge on factors influencing mortality risk. Mortality monitoring is indeed very time-consuming and often of poor reliance because of very short persistence of dead bats. However, recent developments such as high sampling rate unattended recordings and acoustic flight path reconstruction (FPR) opened the way to a large gathering of flight behaviour data and to an accurate quantification of mortality risk. Here, sets of two synchronized SM2BAT (Wildlife Acoustics) plugged to four microphones were used to perform whole night recordings on 15 sites along a 22-km railway of north-eastern France in June 2012. Recordings contained 15 921 bat passes among which 200 were selected on a stratified random sampling basis for FPR. We then analysed the effects of species ecology, habitats and flight response to railway on bat mortality risk. Results showed that body size predicted better species sensitivity than its ecology, both small gleaning and small hawking bats suffering from a much higher risk (> 20% of their flight paths) than every big species (< 5%). Moreover, a majority of flight paths followed the railway instead of crossing it, an overall pattern which was more prevalent in forested parts (> 90 %). Bats seemed indeed to consider the railway much more as a corridor than as a barrier. Thus, bat conservation issues may be more concentrated on creating alternative corridors parallel to railways than on helping bats crossing them safely.

Thermoregulatory and Foraging Patterns in Reproductive *Eptesicus fuscus*

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Reproduction is energetically expensive for mammalian females and seasonality often limits the amount of time available to successfully reproduce. Temperate mammals often have methods to cope with time constraints, such as thermoregulatory and foraging flexibility, but often at a cost. However, foraging and thermoregulation are often studied separately, which leads to limited knowledge about what relationship exists between these two factors. The purpose of this research was to determine how thermoregulation and foraging patterns vary among reproductive stages in big brown bats (*Eptesicus fuscus*) that often switched between building and tree roosts. I equipped pregnant and lactating bats with temperature sensitive radiotransmitters in southwest Saskatchewan, Canada. While transmitters were active, skin temperature data were collected using a datalogger and foraging patterns determined by triangulation. Thermoregulatory patterns remained similar between conditions, but with slightly more heterothermy during lactation, especially when roosting in trees. Bats tended to forage for the same duration in each

condition, but with an altered pattern (i.e. number of trips). When coupled together, I found that foraging duration and torpor duration were not directly related during pregnancy, but had a slightly inverse relationship during lactation. These data provide support that the relationship between thermoregulation and foraging is not constant throughout reproduction, which may be due to the trade-off between slowed development of young through torpor use and risky foraging for the female during suboptimal conditions.

Bat Meta-assemblage Structure in an Anthropogenic Landscape (Coffee Ecoregion, Colombia)

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Using the metacommunity theory to understand the patterns and structuring of assemblages of bats, allows characteristics that were not taken into account from the classical community ecology perspective to be evaluated. The metacommunity approach allows the integration of different spatial and temporal scales, to explain relationships between species, environments and spatial components. The objective of this research was to determine the structure of the bat meta-assemblage immersed in an anthropogenic landscape (The Coffee Ecoregion-Colombia). We reviewed 5279 bat records from the study area found in the most important museums in the country and in international databases. Using tools of GIS, the localities were established. We evaluated the distribution pattern which best describes the location of the different species of bats in the ecoregion. 56 species were recorded in the 26 selected sites; most were family Phyllostomidae. Elevation and structural complexity of the vegetation had the highest association with bat composition. The distribution pattern of the meta-assemblage corresponded to a Clements quasi-structure. This implies that the species distributed throughout the entire range (or most of it) have the possibility of moving throughout the entire region. This shows that there is a spatial connection of the different environments in the ecoregion and species that maintain this connection are the most widely distributed in the area. This analysis illuminates the dynamics and ecological processes that determine spatial variation in species composition of bats in the Coffee ecoregion.

Genetic Consequences of Habitat Fragmentation: Insights from Two Phyllostomid Bat Species in Costa Rica

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Tropical ecosystems are strongly endangered by human impact. Once continuous habitats are converted into mosaic landscapes composed of forest remnants embedded into a matrix of cattle pastures and agricultural lands. A decrease in habitat connectivity may affect the functional connectivity among animal populations. Long-term effects on genetic population structure are becoming clearer for many taxa. However, studies on bat populations are still scarce, especially in the Neotropics. We studied genetic diversity and structure of populations of frugivorous bats on a small geographic scale of approximately 20 km. We focused on the species *Carollia castanea* and *Dermanura watsoni* inhabiting nine forest fragments in an agricultural landscape in Costa Rica. For our study we analyzed DNA sequences of the mitochondrial D-loop. We detected significant levels of population differentiation in *D. watsoni* (F_{ST} = 0.05, $p < 0.001$) but not in *C. castanea* (F_{ST} = 0.008, $p < 0.17$). Matrix configuration accounted for differences in genetic diversity among fragments in *Dermanura watsoni*, not in *C. castanea*. Our results demonstrate that neotropical bats inhabiting fragmented landscapes are not secure against loss of genetic diversity and population differentiation despite their ability to fly and the related high mobility. However, sensitivity towards habitat degradation seems to be species-specific. We assume that differential feeding strategies in our focus species might be an issue here. In detail, *Dermanura watsoni* feeds on a wide variety of fruits from mature forest whereas *Carollia castanea* is strongly specialized on *Piper* fruits from early and late succession. Hence we suppose that *C. castanea* is rather used to matrix habitats and less edge sensitive than *D. watsoni*. This in consequence might affect dispersal ability and hence gene flow among populations. As frugivorous bats play a keyrole as seed dispersers, especially in degraded ecosystems, we want to highlight the need for conservation plans in fragmented habitats.

Effects of Forest Fragmentation on Central Amazonian Bats

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Neotropical bats constitute a highly diverse and mobile group responsible for pivotal ecosystem services such as pollination, seed dispersal, and insect suppression. Their potential to move over extensive areas of fragmented landscapes combined with their high local abundance and both taxonomical and ecological diversity qualifies them as a well-suited indicator group to examine the effects of fragmentation on tropical forest biota. Over the last two years we have surveyed bat assemblages in eight forest fragments (three of 1-ha, three of 10-ha and two of 100-ha) and nine control plots in continuous forest across the Biological Dynamics of Forest Fragments Project (BDFFP) landscape, Central Amazon, Brazil. Additional sampling was conducted at fragment and continuous forest edges and in the surrounding secondary forest matrix. Preliminary results suggest strong area-related effects on bat assemblages in the smaller (< 100-ha) fragments, with 1- and 10-ha fragments presenting more species-poor and less even bat assemblages. Continuous forest sites and 100-ha fragments showed similar patterns of species richness, composition and abundance. Bat assemblages in continuous sites, fragments, edge and matrix habitats presented comparable levels of species richness but differed in terms of composition and species abundance patterns. Fragments, edge, and matrix habitats were found to accommodate a significant proportion of the BDFFP chiropteran diversity, however, several species (e.g. *Phyllostomus elongatus* and *Phylloderma stenops*) have been found to be nearly exclusive to continuous forest, highlighting that their conservation can only be achieved by the preservation of large expanses of primary forest.

The IUCN Species Survival Commission: a Metanetwork of Expert Networks

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The IUCN Species Survival Commission (SSC) is a science-based network of more than 7,500 volunteer experts from almost every country of the world. More than a simple network, however, SSC is a network of networks, organized into over 125 specialists groups, red-list authorities, sub-committees and task forces. For example, the Chytrid, Zygomycete, Downy Mildew and Slime Mould Specialist Group, whose chair is based in Cuba, has eight members; the Cormorant Specialist Group, co-chaired by a Dutch and an Austrian scientist, has over 500 members, most of them in Europe, Asia and North America; the Marine Conservation Sub-Committee is co-chaired from Argentina and Hong Kong, and their 13 members work globally; the Crocodile Specialist Group is based in Australia and has with 450 members from 52 countries. A quick look at the SSC metanetwork may help identify the characteristics of a successful expert network, applicable to other organizations or institutional contexts. First, they seem to work better if they are demand driven: when the need for networking precedes the creation of a network success is more likely. Second, the presence of a network champion makes all the difference: a highly committed volunteer (or small group) willing to take charge or major organizational responsibilities is essential. Third, no single governance model works best: some specialist groups work in a highly participatory and democratic way, others are benevolent dictatorships, and the rest are everything in between. Fourth, regular communication and group activities create cohesion, encourage participation and build scientific capacity.

The Distribution of Aerial Insectivorous Bat Species in Panama

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Neotropical aerial insectivorous bat species account for up to 30-50% of local bat assemblages, however their occurrence and distribution in the Neotropic generally is poorly described due to methodological constraints. Novel bat detectors that function autonomously help to advance the study of this ecological group by enabling the systematic recording of their species-specific calls across large spatial scales. Here, we described distribution patterns and habitat preferences of 11 aerial insectivorous bat species from three families (Mormoopidae, Emballonuridae and Noctilionidae) in Panama. We focused on species that can be reliably identified by their echolocation calls. We selected 14 areas arranged in a spatially stratified design across the country (app. 60'000

km^2), within which we surveyed four different habitat types three times each with automated high-tech batdetectors. Most Emballonurids and Mormoopids as well as *Noctilio albiventris* were found to be widespread species, mainly in disturbed and open areas; *Pteronotus personatus, Rhynchonycteris naso* and *Centronycteris centralis* occurred continuously from western Panama to the center of the country; the latter mainly occurred in mature forest. Most of the aerial insectivorous bat species included in this study are widely distributed, preferring disturbed. Future studies will analyze the factors affecting these distribution patterns. The results are expected to offer ecological insight into species response to habitat type and anthropogenic changes, especially for the species with limited occurrences.

Current Status of Wind Farms in Latin America and its Relation with Bat Research and Conservation

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The impact to bats from renewable energy developments have become a source of concern in recent years. Fatalities due to wind energy turbines have been well documented in various locations, and the role of solar energy in habitat loss and fragmentation pose a potential problem for wildlife conservation. Wind farms are becoming widespread throughout Latin America where, by and large, no formal protocols have been established to deal with the unexpected environmental costs brought in by this technology. We offer a general survey of the status of Eolic energy throughout Latin America, the major players and the forces behind this development. Special emphasis is given to the establishment of wind farms in Chile, currently with 90 MW of wind energy and 3000 MW planned for the near future, and Puerto Rico with 127 MW currently, 50 MW more preliminarily approved and others under consideration. We present pre and post construction protocols for monitoring impact on bats, and the results obtained at both sites. Such studies just now been conducted in Puerto Rico and Chile suggest a number of unexpected fatalities, e.g., understory phyllostomids. Recent studies suggest that species-specific fatality rates from wind turbines are not consistently correlated with activity levels, and that acoustic surveys do not adequately predict fatalities for all species. Therefore, pre- and post-construction surveys of bat fatalities are an important instrument to help develop conservation strategies.

The Firsts Steps of Bats Conservation through Environmental Education in El Salvador

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The Bat Conservation Program (BCP or PCM in Spanish) of El Salvador was created in August 2011 with the main purpose of knowing, recover and conserve the habitat and population of bats in our country. Therefore we established a strategy through education actions for one of our main threats which is the disinformation. We aim for the people to learn about bats and their importance using talks and presenting our bat theatrical play in several communities. Moreover, the Education committee is in charge of strengthen the members capacities with monthly meetings of discussions about bats researches and planning activities like Christmas bat counts, workshops and visits to communities. As a result in the Education committee so far we have achieve the participation of 450 people in our activities, we have created a theatrical play, identified our national bat, co-organized the Workshop of Divulgation and Environmental Education with bats in Central America, and made workshops with the book "My home in the forest". In a short term we expect to apply our Education plan which includes park rangers and community leaders training in Important Areas for Bats Conservation (IABC or AICOM in Spanish), the activation of a public awareness program, education talks about the common vampire and to produce educational materials. All those activities will help us to achieve our mission to let humans and bats live in harmony in El Salvador.

Central America: Conservation at the Regional Level is a Reality

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The Central American region has the largest amount of bat genera in the world. Habitat loss, direct roosting and population destruction by human beings based on unfounded myths, are the main threats faced by this taxa in the region. Bat Conservation Programs (BCP or PCM in Spanish) established in Latin America developed their model based on species biology and priority areas knowledge, enriched by other tools such as environmental

educational programs and outreach activities, making all this information available to the public. Our objective is to decrease the extinction risk of Central American bat species by strengthening the BCPs in the region and by implementing a joint regional Conservation Strategy for Bat Conservation. We organized the first Central America workshop focused on bat biology where 29 participants from Guatemala, Honduras, El Salvador, Nicaragua and Costa Rica gathered and generated a list of 134 species for the region, and identifying 38 species under risk based on the Method of Species Risk Extinction (MER). Also, 17 priority areas for bat conservation in the 5 countries where also identified from which four of them are binational or trinational areas such as Indio-Maíz (Costa Rica-Nicaragua) and Trifinio (Honduras-Guatemala-El Salvador). In another workshop in El Salvador we identify educational activities that we can help resolve threats. Currently we are working together also environmental education, generating materials for the entire region. Our project is product of a group of Central Americans, which have the knowledge and leadership skills to coordinate and make this effort come true. The contribution is not only related with species conservation, but as the first regional experience where the initiative, coordination and execution of a conservation program are done by locals, enhancing professional skills.

Phylogenetic Signal, Feeding Behaviour, and Evolution of Brain Volume in Neotropical Bats

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Comparative correlational studies of brain size and ecological traits (e.g. feeding habits and habitat complexity) have increased our knowledge about the selective pressures on brain evolution. Studies conducted in bats as a model system assume that shared evolutionary history has a maximum effect on the traits. However, this effect has not been quantified. In addition, the effect of levels of diet specialisation on brain size remains unclear. We examined the role of diet on the evolution of brain size in Mormoopidae and Phyllostomidae using two comparative methods. Body mass explained 89% of the variance in brain volume. The effect of feeding behaviour (either characterised as feeding habits, as levels of specialisation on a type of item or as handling behaviour) on brain volume was also significant albeit not consistent after controlling for body mass and the strength of the phylogenetic signal (λ). Although the strength of the phylogenetic signal of brain volume and body mass were high when tested individually, λ values in Phylogenetic Generalised Least Squares models were significantly different from 1. This suggests that Phylogenetic Independent Contrasts models are not always the best approach for the study of ecological correlates of brain size in New World bats.

Using Molecular Operational Taxonomic Units to Analyze Dietary Differences between Insectivorous Bats

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Molecular approaches, such as DNA barcoding, allow biologists to analyze the diet of insectivorous bats in more detail than conventional analyses, by targeting the DNA of arthropods found within feces. By comparing the DNA from the prey with reference insects in the Barcode of Life Data System (BOLD), biologists can obtain species-level identifications of the insects eaten. Fragments of prey were removed from the guano of 135 Antillean ghost-face bats (*Mormoops blainvillei*) and 86 sooty mustached bats (*Pteronotus quadridens*) from Puerto Rico, and DNA from these fragments was subsequently sequenced and analyzed in BOLD. However, only 54% of the sequences of DNA from the prey of *M. blainvillei* and 16% from those of *P. quadridens* matched a reference insect in BOLD. Because of the paucity of species-level identifications, all sequences (both identified and unidentified) were collapsed into molecular operational taxonomic units (MOTUs), or clusters of sequences that represent the genome from which they are derived, using the program jMOTU. By varying the cutoff value for the clustering algorithm in jMOTU, each unique MOTU in the output can represent a distinct species. A total of 70 MOTUs (i.e. species of insect) were found in the diet of *M. blainvillei* and 63 in guano of *P. quadridens*. Of these 133 species of insect, only 4 were eaten by both species of bat. These MOTUs were used to determine dietary breadth for *M. blainvillei* and *P. quadridens*, as well as the amount of dietary overlap between these two species of bat.

Attacks of *Desmodus rotundus* (Phyllostomidae) on Urban Dogs from São Paulo City, Southeastern Brazil

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Attack of common vampire bats on domestic animals in rural areas is a phenomenon already known in literature, but little is known about bat aggressions on pets in urban areas. On 2012, the Center of Zoonosis Control in Sao Paulo city received a citizen's complain about bats attacking his dogs. Four adult dogs (Boxer) were being bled almost on a daily basis with bites on their feet, legs, back, tail, ear and face. At night, these dogs usually slept around the house or in the kennel and they were bled at both places. Two surveys were performed and five individuals of *Desmodus rotundus* were mist netted around the kennel. All bats were negative to rabies exams (Fluorescent Antibody Technique and Mouse Inoculation Test). As an educational activity, leaflets were distributed to residents of the condominium and we asked them to report similar occurrences. One resident informed us of an abandoned house that had bats inside and 59 vampire bats were netted there. Blood samples from all 64 bats showed that all bats had rabies antibodies with titers varying from 0.16 to 1.3 UI/mL, despite the usual rabies exams being 100% negative. The expressive level of rabies antibodies in these bats indicate that the rabies virus is strongly circulating in the vampire bat population from periurban areas of São Paulo city. Although urban rabies has been under control in the city since 1981, there is a real risk of its reintroduction by infected wild animals such as the common vampire bats.

Barrier Effect: Is Connectivity Affected by Wind Farms? *Nyctalus leisleri* as a Case Study

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The barrier effect caused by wind farms and the relative collision risk they pose to migrating and commuting bats is still little known. We developed a regional-scale analysis for *Nyctalus leisleri* in the Molise region (central Italy), an area currently undergoing a considerable development of wind farms. The specific objective of our work was to investigate whether species-specific connectivity is affected by wind farms development. For our analysis we implemented Species Distribution Models (SDM) and connectivity maps. We developed the SDM using Maxent 3.3.3k algorithm by using 10 variables, 4 topographic and 6 classes of land cover. The best model, chosen using the corrected Akaike Information Criterion (AICc), was the one for which $\beta = 2.0$. Then we developed a map of connectivity for *N. leisleri* using the software UNICOR. Finally overlaying the existing and planned turbines locations we investigated the incidence of wind farms on bat corridors. The SDM was statistically robust (AUC> 0.8). We identified four main corridors for *N. leisleri* from the west to the south-eastern sector of the region. We observed that 14 of the existing and 6 of the planned wind farms fell in suitable areas and interfere with high connectivity routes. To mitigate barrier effect, at wind speeds < 7km/h existing turbines should be stopped and the construction of the planned wind farms should be avoided or subject to restriction in its activity. Our results provide key information to mitigate the impact of further development of wind farm industry in the Molise region.

Species and Rabies Infection in Urban Bats from Piracicaba City, Southeastern Brazil

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Despite the important ecosystem services of bats in nature, their presence in urban areas has caused many problems to the human population. We present the bat species found in the city of Piracicaba (365,000 habs), São Paulo State, southeastern Brazil. Bats were collected while lying on the ground and/or inside the buildings by the health technicians of the Center of Zoonosis Control between 2006 and 2011. In this period 1635 bats were collected and identified as 24 different species belonging to families: Molossidae (91.2% and 9 spp.), Vespertilinidae (5.4% and 8) and Phyllostomidae (3.4% and 7). Among molossids, *Molossus molossus* (N = 882) and *Eumops glaucinus* (N = 396) were the most frequent, whereas among vespertilionids and phyllostomids were respectively *Myotis nigricans* (N = 37) and *Artibeus lituratus* (N = 36). Most bats were found alive (77.2%) by health technicians and during the rainy season (October to March) (74.2%). All bats were submitted to usual rabies exams (Fluorescent

Antibody Technique and Mouse Inoculation Test) and only 28 individuals (1.6%) were positive for rabies. At least six species *Nyctinomops laticaudatus* (N = 9), *A. lituratus* (6), *M. molossus* (3), *M. nigricans* (3), *Eptesicus furinalis* (2) and *Lasiurus ega* (1) were rabies positive. Three other rabid bats with undetermined species belong to the genus *Artibeus, Eumops* and *Myotis*. In Piracicaba region, molossids are the most important bats for public health because of the frequency which they were found fallen on the ground or inside the buildings and their positivity for rabies.

Niche Differentiation of Sympatric Gleaning Bat Species

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Niche differentiation is an often observed phenomenon, especially for bats. The main mechanisms that enable niche segregation in bats are at spatial and/or dietary scale. We studied the niche differentiation of three similar sympatric bat species (*Myotis bechsteinii*, *Myotis nattereri* and *Plecotus auritus*). We hypothesized that niche differentiation of these species will be mainly on the dietary and not on the spatial level. All species forage primarily in deciduous forest by using the foraging strategy "gleaning". *Myotis nattereri* is an active gleaning bat species that uses echolocation to detect prey while *M. bechsteinii* and *P. auritus* are passive gleaning bats listening to prey generated sounds, suggesting differences in prey spectra. To test this hypothesis we investigated the habitat use of all species by radio tracking, examined prey spectrum by DNA-barcoding of prey DNA in feces and used stable isotope analysis of nitrogen and carbon to estimate the trophic level. We could show that the species show a high similarity in regard to their home ranges since the core foraging areas of *M. nattereri* overlapped completely with *P. auritus* and to 97% with *M. bechsteinii*. We were able to identify prey insects mainly on species level e.g. *Limonia nubeculosa* for *M. bechsteinii*, *Curculio glandium* for *M. nattereri* and *Tortrix viridana* for *P. auritus*. Furthermore, we could show that bat species differed in regard to their trophic position. Our results suggest that a differentiation on the dietary scale is sufficient for maintaining stable colonies of three bat species within the same forest.

Is the Correct Education about Bats Working in Paraguay? A High School Survey Case

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Knowledge related to the importance of bats is still scarce, mainly because they are linked to negative aspects and false believes. Environmental education is a keystone in bat conservation, and for that reason we are developing the "Bat Conservation Program" in Paraguay with the mission to extend the knowledge of bats focused on its conservation. In this work we measure the bat's knowledge of students of an age group between 15-17 years old (upper high school). The sample size was of 149 students from three schools: one from Asunción (capital country), and other two from countryside: Tobatí and Canindeyú. Results show that in the whole sample only one student thinks that bats are insects and 8.05% think that bats are birds, 16.1% think bats suck blood, and 5.37% said bats are venomous. Almost half of the sampled population said that bats could transmit rabies. Finally, 36.9% recognizes that bats are important for the environment, but 30.2% knows the true ecological role. An important fact is that school with emphasis on environmental education has the lowest rate of knowledge. In that case being several students that think bats transmit other diseases as cancer and yellow fever, and 4.7% think bats are venomous (one student in the other schools). Nevertheless, a half of student with correct knowledge about bat ecological role is very amazing. We have not found any difference between capital and countryside levels, so we assume that 80's-90's new trends about biodiversity conservation has been rooted in those students.

Various Machine Learning Techniques for Acoustic Classification of Neotropical Bat Species Based on the Complete Echolocation Call Repertoire

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Recent years saw the development of various methods for the acoustic identification of bat species based on echolocation calls, where machine-learning algorithms were used to train predictor models. However, these methods are restricted to search phase echolocation calls, and also only few Neotropical bats are currently included. We developed and evaluated an automated classification method for calls from 29 Neotropical bat species

(Emballonuridae and Molossidae) using calls from all echolocation phases. First, we compared the performance of five machine learning algorithms for prediction of species identity. We tested 4 different data sets comprising either exclusively search phase calls or various combinations with approach and/or terminal phase calls. For most data sets the predictor models trained with the Random Forest algorithm were the most accurate. We found that the prediction accuracy did not decline when non-search phase calls were included into the training and prediction tasks. Additionally, we estimated the importance of different echolocation call features for the prediction of species and genera using a feature importance calculation based on the Random Forest algorithm. Using this method we were able to identify which features of the non-search phase echolocation calls may provide relevant information for species and genera discrimination. Based on our results we provide some recommendations for designing robust and accurate predictive models for software-aided identification of Neotropical aerial insectivorous bats of the families Emballonuridae and Molossidae.

Cautionary Tales in Reconstructing the Evolutionary History of Island Bats

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Bats represent some of the most dramatic natural dispersal events among mammals, with representative taxa inhabiting most continental and oceanic islands. Within these island systems, commonly-asked phylogeographic questions investigate aspects of the evolutionary history of populations: Where did the island populations disperse from? How many dispersal events occurred and when? What was the direction of dispersal? Questions of conservation relevance may also be of concern in many island systems: To what extent do island populations exchange alleles with source population(s) or with other island populations? How diverse are island populations? Coalescent-based phylogeographic analyses have been applied to answer these questions in several systems. These powerful analyses demand judicious application, as they can be positively misleading when misused. Here, we review some cautionary tales learned from analyses of Hawaiian lasiurines, Caribbean *Pteronotus*, and Malagasy *Triaenops* and *Myzopoda*. These studies demonstrate that model choice is extremely important. The flexibility permitted by approximate Bayesian computation (ABC) approaches makes available a wealth of diverse models, but also demands that researchers think creatively when considering models to test and that we collect sufficient data to test parameter-rich models. In island systems, it is also important to sample multiple source populations and to consider the possibility that the direction of dispersal might not be easily predicted. These examples illustrate the power of this approach, but also illustrate the need for a thoughtful application of analyses.

Detection and Characterization of Bat Hotspots: a Fusion Test of Local Spatial Autocorrelation

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Mammalogists commonly seek to identify spatial autocorrelation in their capture datasets; in some instances to negate its effect on design or analysis, in others to elucidate the processes behind the phenomenon itself. Although there are several tests of local spatial association, each has different strengths and weakness and hence tends to capture different aspects of the data. Here we present a fusion approach to characterize clusters in spatially-explicit capture data of rainforest bats from Malaysia, using three disparate, but commonly-used tests of local autocorrelation: a traditional spatial analytical approach (*G* statistics); a permutation method designed for ecological count data using distance indices (SADIE); and a cluster detection test that uses a moving window of variable size to identify sets of points or regions (SatScan). We demonstrate that the fusion approach significantly improves hotspot detection and characterization; provides explicit representation of confidence for individual clusters; and generates an integrated map that incorporates spatial autocorrelation of the data.

Directed Seed Dispersal of *Piper* by *Carollia perspicillata* and its Effect on Understory Plant Diversity and Folivory

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Directed dispersal occurs when seeds are differentially deposited to sites where offspring survivorship is higher than at randomly chosen sites. Traditionally, characteristics of the dispersal target sites that could increase survivorship of the dispersed plants are thought to be intrinsic to the sites. Here we report patterns of *Piper* diversity (richness, equitability and similarity) and *Piper* folivory within plots near natural or artificial roosts of *Carollia perspicillata* versus similar plots without bat roosts. Plots with bat roosts, both natural and artificial, had significantly higher *Piper* species diversity. Furthermore, we found that plots with a higher *Piper* species diversity showed less specialist folivory, higher generalist folivory, and lower total herbivore leaf damage than plots with low *Piper* diversity. Finally, plots with bat roosts also showed less specialist folivory, lower generalist folivory, and lower total folivory when compared to plots without roosts. Additionally, parallel metabolomic and phylogenetic analysis also showed that plots near bat roost had significantly different levels of *Piper* chemical diversity and phylogenetic structure. We propose that non-random patterns of seed dispersal can change the local ecological characteristics of target sites via changes in plant diversity, and that these changes are likely to reduce the local rates of folivory and community assembly and therefore, increase seed and adult plant survivorship.

The Role of Geography and Digestive Capacity in the Diet of Neotropical Frugivorous Bats

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Understanding the structure and evolution of ecological communities requires the evaluation of factors that influence biotic interactions. From zoocentric perspective plant-animal interactions are affected by extrinsic factors such as plant diversity, and intrinsic as digestive capacity of animals to exploit the available resources. Using meta-regressions we investigated the direction and strength of the relationship between geographic predictors of plant diversity and the proportion of core plant taxa in the diet of *Sturnira* and *Artibeus* frugivorous bats. In addition, we investigated if *Sturnira* and *Artibeus* bats had different digestive capacity, an intrinsic factor that could promote the use of different core plant taxa. Our results show that the use of core plant taxa is positively related to latitude for *Sturnira* (*Solanum* consumption), and negatively with altitude for *Artibeus* (*Ficus*-*Cecropia* consumption). This is due to changes in the diversity of plants which they fed along a geographic gradient. Digestive capacity was lower in *Sturnira ludovici* compared with *A. jamaicensis*, this result explains the preference of *S. ludovici* for plants with high percentage of sugars. This work will enable us to understand, from a digestive point of view, the partition of diet resources at local scale and at continental scale the weight of plant diversity in the diet of frugivorous animals.

Ectoparasite Diversity in Five Bat Species from San Panchito Island, Jalisco

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Parasitism is one of the most relevant biotic interactions due to its impact on the community structure through its effects on the host. Parasites represent a great part for the world biodiversity; it has been calculated that 50% of the species of plants and animals use this strategy at least once during their life cycle. It is known that most organisms, including parasites, are influenced directly or indirectly by ambient variables. Unfortunately, few studies have quantified the effects of the environmental conditions on host-parasite communities. Bats represent an ideal habitat for several species of parasites, and each part of their body can be a microhabitat for many arthropods. Here, we show the preliminary results of a study of the load ectoparasitary found in five bats species from a Mexican dry forest with a highly seasonal environment: *Mormoops megalophylla*, *Pteronotus parnellii*, *P. personatus*, *P. davyi* and *Leptonycteris yerbabuenae.* The collected material will be employed to investigate changes in ectoparasite species diversity throughout the year. Eighty and 212 ectoparasites (bat flies and mites) were collected in late dry season (June; n=6 bats) and in the transition season (November; n=72 bats), respectively. Parasite prevalence was 83 and 78%, mean abundance was 13 and 3 parasites/host, and intensity was 16 and 4 parasites/host in the dry and transition seasons, respectively.

The Southernmost Tip of the Yungas Forests: Their Bats and a Threatened Colony

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The Yungas eco-region reaches its southern limits in the province of Tucumán, Argentina, where the Escaba Dam is located. For many years, the dam attracted the attention of biologists due to the presence of a huge colony of *Tadarida brasiliensis*, probably the largest in a manmade construction, with approximately 10 million individuals. Early studies leading to define the population number of the colony were conducted by our group in 1992 and 2000. Years later, several anthropic actions have impacted negatively and affected the health of the colony. To define the current status of the species composition of the area, and attempting to reverse the damage to the colony, we developed studies between September 2012 and March 2013, at different sites around the dam; the bats were captured using mist nets active for six hours after sunset every netting day. Our results have permitted to add 10 species of bats to the area, and evaluate that the original number of individuals in the colony has dropped dramatically due to manmade blockades. Additionally there have been actions in education, given lectures at community centers and schools in the area which, together with the development of brochures, are useful tools for the future of conservation actions of the site. The results will be used to propose the Escaba dam as a SICOM (Site of Importance for Bat Conservation) and the region as an AICOM (Area of Importance for Bat Conservation), thus advancing in the process of protection of species and their shelters.

Bats as Novel Potential Reservoir Hosts of *Leishmania* sp in Mexico

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Leshmaniasis is one of the most important emerging diseases in the world, and in the last decades its incidence, geographic range, and reservoir host has increased. Due to this the aim of this work was to identify bats as potential reservoir hosts of *Leshmania* sp. To do this, we sampled 22 localities in Tabasco, Chiapas, Jalisco, Michoacan, Nuevo León and Monterrey, covering different habitat conditions from sylvatic areas to domestic ones. Once bats were caught we sacrificed them and collected selected tissues in order to analyse by PCR to identified *Leshmania* sp parasite. In total 420 bats of 36 different species were caught. From these, 41 individuals of 14 species were positives to *Leshmania* sp. Results showed that Phyllostomidae bats had the higher infection rate, for example: *Choeroniscus godmani* (23.07%), *Glossophaga commissarisi* (75%), *Glossophaga soricina* (26.92%) and *Sturnira lilium* (11.11%). In this work we reported 11 new potential reservoir host bat species, which in the context of Leshmaniasis gives important insights about the disease cycle. Bats ecology is the main explanation to these results. For example, feeding and roosting behaviour could turn out bats as blood source for sand flies. Although experimental evidence is necessary, data suggest that bats can be important reservoirs host to *Leshmania* sp in Mexico, and potentially elsewhere were there exist the geographic coincidence of Bats - Sand flies - *Leshmania* sp, and consequently the likelihood of ecological interaction between them.

Siboney-Juticí Ecological Reserve: an Area of Importance for Cuban Bats

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The Siboney-Juticí Ecological Reserve is a protected area of 2,075 ha, which is located in south eastern Cuba in the province of Santiago de Cuba, Cuba. The reserve shelters a huge array of underground ecosystems (33 caves), some of them are heated up by energy provided by the thousands (millions?) of bats that are roosting there. Actually 14 different species are known to roost in the caves. The species found in the caves show different feeding habits: 10 are insectivorous; four of them are nectarivorous, and one species is frugivorous. Three of the species roosting at Siboney-Juticí are species endemic to Cuba, one of them is the Cuban flower bat (*Phyllonycteris poeyi)* that forms the greatest colonies in Majáes Cave and is responsible for the high temperatures (38°C) and relative humidity that exceed 90%. Majáes Cave (with 11 species) and Cantera Cave (with 6 species) harbor between them 87% of the bat species recorded in the Reserve. These cave ecosystems, and their component species, are in great

need of study and conservation. Siboney-Juticí Ecological Reserve is an Important Area for the Bat Conservation (AICOM with code A-CU-002) because the reserve protects over 50% of the Cuban bat species and therefore is very important for the conservation of Cuba's bat fauna, with important populations of species of West Indian endemic lineage. This category is conceded by the Red Latinoamericana para la Conservación de los Murciélagos (RELCOM). We want to create a conservation strategy for the bat populations in this area and already developed conservation activities and environmental education in the Reserve.

Links among Morphological, Functional, Performance and Lineage Diversity in Bats

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Ecomorphology is one of the most active research areas in biology, and it focuses on understanding how morphology maps onto function and performance, and ultimately how adaptations in these traits may allow lineages to diversify. Bats constitute an excellent system for investigating these connections because it is possible to explicitly quantify cranial traits and functional properties that are relevant to biting performance in this group, and they exhibit an outstanding diversity of dietary specializations within a relatively simple anatomical template. We present a comprehensive, quantitative dataset on the cranial morphology, muscle function and *in vivo* bite forces across several families of bats. We use these data in phylogenetic comparative analyses to determine how morphological diversity maps onto functional and performance diversity, and assess which and how morphological and functional traits are related to diversification within bat lineages. Our results indicate a strong influence of body mass on the functional and performance diversity across feeding strategies in bats. Upon removing the effects of body size and phylogeny, disparity in some morphological variables exceeds the disparity in functional and performance measures. Similarly, changes in rates of character evolution seem to be more dynamic in morphological than in functional and performance traits. These results provide support for many-to-one mapping hypotheses of cranial anatomy to bite function, and could be linked to differences in the patterns of lineage diversification within bats.

Three Tales of Six Bats: Factors Shaping Cryptic Bats Distribution in Iberia

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Cryptic species pose a challenge to conservation by leading to biodiversity underestimations, may conceal threatened taxa within the cryptic complex and also bring the need to redefine what was classified as a single species distribution and environmental requirements. There is evidence that 20% of Iberian bat species harbour cryptic complexes and in this study we analyse the distribution patterns of three cryptic complexes in Iberia: *Plecotus auritus/a. begognae*, *Eptesicus serotinus/isabellinus* and *Myotis mystacinus/alcathoe*. We aimed to determine the distribution patterns of each species in Iberia, the ecological factors limiting these patterns, the identification of contact zones between sister species and the potential overlap between their ecological niches. Species identification was validated genetically by sequencing a fragment of the mtDNA cytochrome *b* gene. Maxent was used to build species distribution models, employing 15 variables relevant for bat occurrence. Most species distributions seem to be shaped by climatic factors and the presence of some linear features such as slopes, however *E. isabellinus* and *M. alcathoe* also showed affinity to the presence of forests. Moreover, niche analyses showed that the niches of *P.a. begognae* and *M. mystacinus* encompassed those of *P. auritus* and *M. alcathoe*, respectively. In the case of *E. serotinus/isabellinus*, both species seem to be competing for similar resources, as their niche overlap is high but their contact zone is restricted to a few locations in central Iberia. Here we show that combining genetic analyses with species distribution modelling provides important insights on the dynamics of the distribution of cryptic species.

Applying a Software-assisted Identification Method of Echolocation Calls in a Panama-wide Acoustic Survey

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Bat detectors that record echolocation calls of aerial insectivorous bats automatically have revolutionized ecological studies of bats. While such recording devices lead to the collection of highly standardized information, large amounts of species-specific call data need to be adequately processed. To analyze these large datasets, several software programs specifically focused on automated identification of echolocation calls have been developed for different world regions. Due to a lack of reference calls, software-assisted identification of aerial insectivorous bats in the Neotropics has so far been lacking. Here, we expanded the software 'Batscope', established originally for European species (www.batscope.ch), to analyze calls from Central America by including reference recordings of 41 Neotropical aerial insectivorous species. Batscope is both a database and a classification tool which uses three classifiers (Support Vector Machine, k Nearest Neighbour, Discriminant Analysis) to attribute calls to species. We used the software's classification suggestion as a first step in species identification, followed by manual verification. We applied this approach in a Panama-wide acoustic survey to study habitat use in the entire country of Panama. We obtained presence and absence data for 17 species and sonotypes from 56 geographically stratified sampling points in four habitat types along an anthropogenic disturbance gradient. Occupancy analyses that include habitat-specific detectability revealed species-specific patterns as a function of land-use change, dependent on species mobility and habitat requirements. Software-assisted identification methods prove to be an efficient tool for acoustic surveys also in the Neotropics and are expected to obtain wide use in basic and applied research.

Bat Malaria – a Focus on *Hepatocystis* in African Epauletted Fruit Bats

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Bats are known as important reservoir hosts for numerous emerging and highly pathogenic viruses. It is less well known that they also host a diverse set of malaria parasites species (family Haemosporida). To date, eight different genera (out of 14) of Haemosporida are described from the chiropterans, with all except two of these genera restricted to bat hosts. *Hepatocystis* is one of the latter genera that in addition to bats, uses rodents, artiodactyls and primates as vertebrate hosts. This genus is distributed in the Old World tropics and features a slightly modified life cycle compared to *Plasmodium* and lacks the parasite stages that are associated with the typical malaria symptoms. We report infections with *Hepatocystis* from West and East African bats, almost exclusively epauletted fruit bats (Pteropodidae), which feature high prevalences. We used a combination of microscopy and molecular methods to characterize the infections. The detected *Hepatocystis* parasites show a remarkable phylogenetic diversity and group with mammalian *Plasmodium* species. Some evidences indicate multiple infections in this host group. We conclude that these infections are almost universal in several African pteropodid bats, indicative of continuous and highly efficient transmission cycles.

Operational Mitigation Strategies to Reduce Bat Fatalities at Wind Turbines: a Synthesis of Existing Studies

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Widespread and often extensive fatalities of bats have increased concern about impacts of wind energy development on bat populations. Minimizing these fatalities is critically important to both bat conservation and public acceptance of wind energy development. Recent studies indicate that a substantial portion of bat fatalities occur during relatively low-wind conditions during late summer-fall bat migration. We synthesized information from 10 different operational mitigation studies to assess the effectiveness of altering turbine operations when bats are most at risk. Most studies demonstrated a 50% reduction in bat fatalities when turbine cut-in speed was raised by

1.5 m/s. Other studies that reported mixed or non-statically significant results could be explained by the lack of treatments being implemented during the study (i.e., winds were either too low or high to enable comparison), and the relatively low reduction in bat fatality (approximately 20–38%) at one study may be explained by the high percentage of Brazilian free-tailed bats (*Tadarida brasiliensis*), a species known to fly at higher wind speeds. Data available suggest that <1% of total annual output would be lost if operational mitigation strategies were employed during high risk periods for bat fatalities. Although additional studies are needed to optimize operational mitigation (e.g., incorporating temperature, time of night, bat activity patterns into treatments), we believe increasing cut-in speeds and feathering blades offers an ecologically sound and economically feasible strategy for reducing bat fatalities at wind energy facilities and should be implemented broadly.

Calls in Transition: Evidence for a Communication Function of Landing Strophes in *Megaderma lyra*

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Bat sonar calls are shaped by the functional requirements of the respective echolocation situation. As is typical for many bat species, *M. lyra*, when close to a target, usually emits groups of short calls with a steeply downward frequency modulated contour at a high rate. During approaches to a perch, however, individuals may gradually switch to a different type of vocalisations of longer duration, higher amplitude, and a different spectral composition and frequency-time contour, termed landing strophe. To test the hypothesis that the landing strophe has a communication function, we separately trained nine bats kept in a group to land on a specific perch when released into a flight room. We analysed the behaviour and call patterns in three release situations: bat alone, group mate present in a cage placed next to the perch, and group mate hanging at the perch. The occurrence of landing strophes differed significantly between situations. Most landing strophes were emitted when the perch was already occupied by a group mate. Moreover, landing strophes occurred more often if the bat at the perch showed an aggressive display towards the approaching bat, corroborating a communication function of landing strophes. The structural similarity of the landing strophe to the response call in agonistic interactions suggests an appeasing function of the landing strophe. The present data provide evidence that bats are able to switch from an echolocation to a communication context within a call sequence. Supported by the DFG (SCHM879/6-3).

Sympatric Horseshoe Bats Differ in Flight Performance in Confined Space

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In south Eastern Europe all five European horseshoe bat species occur sympatrically, and are presumed to compete for insects during periods of low insect abundance. They are known to forage within or close to vegetation, e.g. within woodlands. In this habitat maneuverable flight is essential for effective prey pursuit and avoiding collisions with vegetation. We hypothesized that resource partitioning in these species is effected by differences in their ability to maneuver within dense vegetation and tested 2 - 6 individuals of each species in an obstacle course simulating standardized vegetation. The course comprised three rows of vertical rods with inter-rod distances set from 45 - 10 cm at 5cm increments, within a flight tunnel. The rods had a diameter of 6 mm ensuring that detection of the obstacles was not a limiting factor. Individuals were presented with each inter-rod distance during six consecutive trials on three separate occasions, and were scored on their success (based on number of touches, falls, rejections and invalid trials). All individuals managed to negotiate inter-obstacle distances of as little as 30 cm. At the smaller spacings, the smallest species, *R. hipposideros,* and one of the middle-sized bats, *R. euryale*, performed best. The largest species, *R. ferrumequinum,* showed the poorest performance. It therefore seems that the size of the different bat species plays an important role for their niche differentiation but other factors seem to be important as well. Therefore our next step will be to compare the performance with the wing morphology of these species.

Ecological Co-variates of the Immune System in Neotropical Bats

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Ecological and social factors are central in the emergence and transmission of infectious diseases, thus bearing the potential for shaping a species' immune functions. Although previous studies demonstrated a link between social factors and the cellular immune system for captive mammals, it is yet poorly understood how ecological factors are connected with the different branches of the immune system in wild populations. We tested how variation in aspects of the constitutive cellular and humoral immune system of free ranging bats is associated with two ecological factors that likely influence the putative risk of species to become infected by parasites and pathogens: diet and shelter. We found that white blood cell counts of 24 syntopic Neotropical bat species varied with the species' diet and body mass. Bats that included at least partially vertebrates in their diet exhibited the highest white blood cell counts, followed by phytophagous and insectivorous species, which is consistent with the assumption that the immune system varies with the pathogen transmission risk of a trophic level. The soluble part of the constitutive immune response, assessed by an *in vitro* bacterial killing assay, decreased with increasing roost permanence. Our results suggest that the ecology is an important factor in the evolution of the immune system in bats and probably also other mammals.

Species Interactions during Diversification and Community Assembly in *Miniopterus* Bats in Madagascar

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Ecological differentiation may occur rapidly in clades undergoing adaptive radiation. Closely related, ecologically similar species often have adjacent distributions, suggesting competitive exclusion may influence community assembly. To determine whether the 11 endemic *Miniopterus* species in Madagascar could potentially compete with one another for habitat, we used ecological niche modeling to assess similarity of potential habitat use, both for current and last inter-glacial climates. We then used null models to examine dispersion patterns of sympatric species in terms of their phylogenetic relatedness and phenotypic and sensory characters – body size, skull morphology and echolocation - with the goal of understanding whether the assembly of 21 *Miniopterus* ensembles, sampled across Madagascar, was non-random. Of the four sister species pairs, we only found statistical support for ecological similarity between one sister species pair. Similarly, the overlap in potential habitat use was significantly high in < 15% and significantly low in > 65% of all possible species pairs (n = 54 pairs), implying that competition for habitat between most species pairs is unlikely. In 87% of the observed combinations of sympatric *Miniopterus* species, we found significant signal for overdispersion of phenotypic and sensory characters, or phylogenetic branch length. The most commonly sampled *Miniopterus* ensembles displayed non-random patterns in multiple skull, body size and echolocation characters associated with the trophic niche. Collectively, our results suggest that selective processes associated with the adaptive radiation of *Miniopterus* species in Madagascar favoured bats to diversify first into habitat specialists (e.g., mountain versus lowland) and later into dietary specialists within a given habitat.

Supply Determines Demand: Influence of Partner Quality and Quantity on the Interactions between Bats and Pitcher Plants

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Interspecific relationships such as mutualism and parasitism are major drivers of biodiversity. Because such interactions often comprise more than two species, ecological studies increasingly focus on complex multispecies systems. However, the spatial heterogeneity of multi-species interactions is often poorly understood. Here, we investigate the unusual interaction of a bat (*Kerivoula hardwickii hardwickii*) and two pitcher plant species (*Nepenthes hemsleyana* and *N. bicalcarata*) whose pitchers serve as roost for bats. *Nepenthes hemsleyana* offers roosts of higher quality, indicated by a more stable microclimate compared to *N. bicalcarata* but occurs at lower abundance and is less common than the latter. Whereas *N. hemsleyana* benefits from the roosting bats by gaining nitrogen from their feces, the bats' interaction with *N. bicalcarata* seems to be commensal or even parasitic. Bats stayed longer in roosts of higher quality provided by *N. hemsleyana* and preferred them to pitchers of *N. bicalcarata*

in a disturbance experiment. Moreover, bats roosting only in pitchers of *N. hemsleyana* had a higher body condition and were less infested with parasites compared to bats roosting in pitchers of *N. bicalcarata*. Our study shows how the local supply of roosts with different qualities affects the behavior and status of their inhabitants and—as a consequence—how the demand of the inhabitants can influence evolutionary adaptations of the roost providing species.

Echo-acoustic Adaptation in a Bat-Pitcher Plant Mutualism

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The Bornean woolly bat *Kerivoula hardwickii hardwickii* is symbiotic with the carnivorous pitcher plant *Nepenthes hemsleyana*. This plant captures less arthropods than closely related *Nepenthes* species. However, this nutrient deficiency can be compensated by harboring bats whose feces provide one third of the plants' nitrogen intake. Because both partners depend on each other, co-adaptations facilitating the interaction are likely. Therefore, we firstly investigated the bats' echolocation system. The vocalizations start with frequencies far above 250 kHz, which is the highest call frequency ever found in bats. These starting frequencies and the bandwidth of the echolocation calls even increase when they approach a pitcher compared to calls emitted during normal flight. We assume that the high frequency calls enable the bats to detect the pitchers even in dense clutter. Secondly, we measured the echo impulse responses of *N. hemsleyana* pitchers with a biomimetic sonar head and compared them to those of a closely related pitcher plant species, which does not serve as a bat roost. In fact, *N. hemsleyana*'s catchment volume—the amount of echo detectable by the bats—was significantly higher than that of the compared species. The reason is an echo-reflecting parabolic structure at the back of *N. hemsleyana*'s upper pitcher wall. This structure is likely to advertise the pitcher to woolly bats. Our study provides evidence that the close bat-pitcher plant-interaction is supported by adaptations in the bats' sensory system and morphological adaptations in the pitcher plants' capturing structures. This is the first example in a plant that has developed a prime acoustic cue for roost finding in bats.

Strategies for Examining Immune Responses of Bats

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Examination of immune responses in bats has been challenging, principally because of the great multitude and diversity of bat species, and the lack of reagents and methodologies for conducting meaningful immunological research. However, recent advances in transcriptome analysis can be leveraged to assess the host response in vertebrates, regardless of species. While transcriptome data have interpretive limitations, primarily post-transcriptional and post-translational events, they provide pathway activation information that can shed light on how the immune response engages specific pathogens. We are examining the host response of Jamaican fruit bats (*Artibeus jamaicensis*) to Tacaribe arenavirus (TCRV) by transcriptional profiling using a PCR array of 94 immune and antiviral genes. Splenic and kidney expression profiling detected elevation of many genes involved in the type I interferon pathway, apoptosis, lymphocyte migration and homing, proliferation, T and B cell activation, Jak/STAT signaling, and Notch signaling, suggesting a complex host response occurs during TCRV infection of Jamaican fruit bats. Despite this mobilization, disease progressed rapidly with death occurring within 24 hours after disease onset. The rapidity of disease progression suggests the immune response may contribute to pathogenesis; however, further work characterizing the response is required to clarify such a role. The software we developed for designing the array is currently linked to several mammalian genome and transcriptome datasets, including four bat species, and can be similarly used to examine gene expression profiles during infection of these species.

Developmental Controls of the Diverse Palate Shapes of New World Leaf-nosed Bats

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New World leaf-nosed bats (Family Phyllostomidae) display extensive craniofacial diversity that is associated with their broad range of dietary preferences. Highly frugivorous phyllostomids have short and broad palates, and nectarivores long and narrow palates. Although the functional correlates and evolutionary history of

shape variation in phyllostomid palates are beginning to be understood, the contribution of development remains largely unknown. This study uses morphometrics to investigate: (1) the impact of development on palatal variation in three phyllostomids with different diets (*Artibeus jamaicensis*, *Carollia perspicillata* and *Glossophaga soricina*) and on a diverse group of 34 phyllostomids, and (2) the specific developmental alterations that underlie the diverse palate shapes of seven phyllostomids (*Anoura geoffroyi*, *A. jamaicensis*, *C. perspicillata*, *G. soricina*, *Micronycteris megalotis*, *Sturnira lilium*, and *Uroderma bilobatum*). In regard to the first, the overall symmetrical component of palate variation is conserved during ontogeny and within and among adults. In addition, symmetrical and asymmetrical palate variances are strongly correlated in each species. In regard to the second, although initial palate shape (i.e., width versus length) varies among species, the pattern of this variation does not match that observed in adults. In contrast, the relative growth of palate width and length in developing phyllostomids and the ratio of these axes in adults are significantly correlated. Taken together, results are generally consistent with shared developmental constraints governing phyllostomid palate variation, and with the diverse palate shapes of phyllostomids resulting from relatively subtle evolutionary changes in later (i.e., growth) rather than earlier (i.e., initial formation) development events.

Island Bat Diets: Does it Matter More Who You Are or Where You Live?

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It has been suggested that differences in body size, echolocation call frequency and geographic location may result in diet partitioning among bat species; however, very little data exist that explicitly test these hypotheses in the context of island biogeography. We used next generation sequencing methods to conduct a species-level analysis of the diet of three *Rhinolophus* species and one *Hipposideros* species on the Philippine islands of Cebu, Bohol and Siquijor. Overall, we identified 504 prey Molecular Operational Taxonomic Units (MOTUs) in the guano from 76 individuals. Moreover, there was a high degree of overlap among species' diets on Cebu Island despite large differences in body size and call frequency. For example, the diet of the 3 g-*Hipposideros pygmaeus* (mean CF = 98 kHz) exhibited a diet overlap higher than would be expected by chance with the 13 g-*Rhinolophus inops* (mean CF = 53 kHz). Despite high endemicity exhibited by fauna across islands in the archipelago, we found a significant overlap in the diets of *H. pygmaeus* on Cebu and Bohol Islands. Interestingly, the smallest bat, *H. pygmaeus*, consumed the widest diversity of prey, had the largest niche and overlapped strongly in niche between islands and species. These data suggest that size and echolocation call differences do not translate into prey partitioning among some CF bat species and raises questions about the foraging strategy and adaptability of *H. pygmaeus*.

Summer Distribution and Movement Patterns of *Myotis lucifugus* and *M. septentrionalis* in Fragmented Habitat

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Anthropogenic alteration of species' habitat can have a major impact on local organisms dependent on that area. Wind power generation is a rapidly growing industry for which natural habitats are changed. At most studied wind farms bat fatalities have been detected, locally causing up to thousands of casualties per year, but secondary impacts of wind farms on bats are poorly understood. Specific movement patterns and changes in behavior of bats as a result of wind farm development and habitat alterations need to be investigated. We hypothesized that bat activity at a wind farm in a forested area is the result of attraction and avoidance behavior caused by deforestation and its related geographical features. Data collection consisted of an acoustic study, radio tracking and a trapping survey in disturbed and undisturbed areas. A multi criteria evaluation was used to characterize suitable habitat before and after fragmentation using radio telemetry fixes of nine *M. lucifugus* and ten *M. septentrionalis*. None of these bats were observed inside the boundaries of the wind farm despite being captured near or immediately adjacent to it. Acoustic data and trapping surveys indicate a significantly higher bat activity outside the wind farm. Overall, preliminary results indicate that the local bat populations use the disturbed landscape of the wind farm much less than the surrounding landscape and, hence suggest that bats show avoidance behavior towards the altered landscape of a wind farm.

Using a 16 Microphone Array to Study the Scanning Behavior of *Pipistrellus pipistrellus* in the Field

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Until now only a few studies investigated scanning behavior in bats. Most of them were conducted in the laboratory with trained bats during approach flights. Single microphone recordings of bats in the field often show alternating signal amplitudes during search flight. We were interested whether these amplitude variations indicate scanning behavior or whether they can be explained by changes in signal amplitude. To answer this question we made sound recordings in common pipistrelle bats (*Pipistrellus pipistrellus*) flying in the field. We used a planar vertical 16 microphone array to determine the sonar beam direction of succeeding pulses and to characterize the three dimensional scanning behavior at three different recording sites. Time of arrival differences (TOAD) were used to position the bats at the moment of pulse emission. Pipistrelle bats searching for prey and orienting in space kept their source levels fairly constant. However, they moved their sonar beam in all directions, often alternately back and forth. They also produced sequences with irregular or no scanning movements. When approaching the array, the scanning movements were much smaller and the beam was moved over the array in small steps. Differences in the scanning pattern at the recording sites indicated that the scanning behavior depended on the echolocation task that was being performed. Similar scanning behavior was also observed in other bat species. Through the use of scanning movements, bats are capable of finding and exploring targets in a wide search cone centered along flight direction.

Bat Species Richness and Abundance in the Biosphere Reserve Ria Lagartos, Yucatan, Mexico

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The establishment and maintenance of protected areas is considered a key strategy for conserving biodiversity. However species diversity present, which is essential to evaluate the effectiveness of the protected area, is not always known. This study estimates the diversity and abundance of bats inhabiting tropical dry forests in the Ria Lagartos Biosphere Reserve, representing the first study carried out in this protected area. We set 10 ground level mist nets and recorded ultrasonic bat calls in three different dry forest types (medium, low and flooded forest) each month over one year. Mist nets were open for 7 hours from dusk. We caught 609 bats of 19 species, belonging to three families. The most abundant family and genus were Phyllostomidae and *Artibeus*, respectively. We found higher species richness and abundance in medium dry forest (S=14, N=254), while in the low forest lower species richness and abundance was found (S=13, N=155). We recorded calls of 12 species and 4 families, and using sound analysis identified 8 additional species, making a total of 27 species found during this study. This represents more than 72% of bats species found in the Yucatan region. Bat species richness was related to plant species richness and bat abundance to tree height. We suggest that the higher availability of resources and roost sites in the medium forest compared to the other forest types attracts more species and individuals to this habitat. Flooded forest might be used by bats as a corridor for commuting.

Beyond Size--Morphological Predictors of Bite Force in a Diverse Insectivorous Bat Assemblage from Malaysia

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Bite force is used to investigate the maximum feeding performance in a wide variety of vertebrates. In all taxa studied, bite force is strongly correlated to body and head size. However, studies of bats are largely from the Neotropics and focused on species that maximized differences in diet. Little is known about the bite force of bats from the Old World tropics, nor of variation in bite force within a diverse assemblage of obligate insectivores. Moreover, the role of factors other than size is poorly known, but these may be important in driving interspecific differences in bite force, and hence diet. From the combined action of the jaw muscles and muscle-bone mechanisms, bats generate mechanical advantage that explains the amount of pressure during biting. Here, we examine the correlation between morphological variation and bite force capacity of 35 species of insectivorous bats from a single paleotropical assemblage. We confirmed the overall relationship between size and bite force, but find

that bite force is predicted more strongly by head length than body mass or forearm length. Mechanical advantage was calculated by dividing the moment arm by the corresponding lever arm for each of five muscle-bone complexes and three function points. When controlling for body size, the mechanical advantage produced by the moment arm of the suprazygomatic portion of the temporalis muscle at the molar function point was the only significant variable for predicting bite force. The consequences of these findings for structuring mechanism in diverse insectivorous bat assemblages are discussed.

Phylogeographic Structure and Unaccounted Diversity in *Micronycteris* (Phyllostomidae)

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The Neotropical bat genus *Micronycteris* comprises ten species, partitioned into four subgenera. Despite all the research effort devoted to this group in the past, its systematics is not yet resolved; the molecular data shows evidence of paraphyletic relationships within several species, and authors have indicated that the genus probably contains a number of undescribed species. The first molecular analysis of the genus was performed five years ago and included 45 specimens of 8 species. The most recent analysis, based on previous work, focused only on the description of a new species. The aim of this project is to increase sample size, to include all species recognized, and to expand the geographic coverage. For the analyses we used the sequences found in Genbank (42 individuals), and we also extracted DNA and sequenced the entire cytochrome-*b* gene (1140 bp) and partial Fibrinogen beta chain (~700 bp) for 70 individuals. Maximum likelihood, timescale of diversification, and Bayesian analyses were performed and genetic distance values were estimated using the Kimura 2-parameter model. Our results support previous analyses and indicate that species-level clades are present within at least three species. However, in this analysis the picture is clearer and the clades are statistically supported. Additionally, *M. minuta* and *M. megalotis* show a clear phylogeographic structure, separating individuals from Amazonia, Guianan Shield, Eastern and Western Ecuador, and Central America. *M. megalotis* also presents the most complex tree topology, with at least 7 clades, two of which include specimens identified as *M. microtis*.

Clutter Rejection, Attention, and Inattention in Bat Biosonar

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Big brown bats (*Eptesicus fuscus*) emit widely-beamed multiple-harmonic FM echolocation sounds covering 20 to100 kHz that have a high bandwidth (~75 kHz). They attend to objects by aiming their broadcast beam and tracking the object's movements. Echoes from targets located on the broadcast beam have the full emitted spectrum except for local interference nulls caused by target geometry, which the bat perceives as a focused spatial image containing reconstructed glints. Echoes from objects (clutter) located off to the sides have lowpass spectra due to frequency dependent beaming. Lowpass filtering affects a wide frequency span of the echo spectrum (>25-50 kHz), which lies beyond the narrower spectral-feature region of nulls (1-12 kHz) that the bat uses for glint reconstruction. Lacking an unambiguous reconstruction of target geometry, the bat instead perceives numerous glints that blur, or defocus, the images of clutter. Defocused images do not mask focused images. Big brown bats suppress clutter by defocusing clutter images, leaving only the target of immediate interest or the critical empty space to the front depicted in focused images. The principle is to remove background objects through deliberate imposition of inattention on undesired clutter. [Work supported by ONR, NSF, JSPS]

Noctilionoid Bat Diversity: How Many Fossil and Living Species Are There?

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The superfamily Noctilionoidea includes seven families of bats: Myzopodidae, Mystacinidae, Thyropteridae, Furipteridae, Noctilionidae, Mormoopidae, and Phyllostomidae. These groups vary tremendously in diversity, with Phyllostomidae having 100 times the number of species as the smaller families (e.g., Furipteridae or Myzopodidae). Although the fossil record of noctilionoids is not particularly rich, it is nevertheless clearly important. Recent studies suggest that all seven families were distinct by the end of the Eocene, Oligocene and Miocene fossils are known from five families, and the geographic ranges of some families (e.g., Myzopodidae and Mystacindae) and genera (e.g., *Mormoops*) were much greater in the past than they are today. In the last decade

many new species have been recognized based on newly discovered fossils and studies of extant populations. Newly recognized species generally fall into two categories: (1) species new to science that have never before been collected or recognized, or (2) species previously thought to be subspecies or population variants but shown to be distinct based on genetic data. Rather than decreasing gradually over time, the pace of discovery of new species has actually increased in the last decade. As of early 2013, the following species diversity in Noctilionidea (15 fossil species/222 extant species) can be recognized: Myzopodidae (1/2), Mystacinidae (3/2), Thyropteridae (0/4), Furipteridae (0/2), Noctilionidae (1/2), Mormoopidae (2/10), and Phyllostomidae (8/200). There are also aware of many fossil and extant species awaiting description. In total, noctilionoids currently comprise approximately ~5% of known fossil bat diversity and ~17% of extant bat diversity.

Echo-acoustic Signaling in Bat-pollinated Flowers

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Angiosperm plants and their animal pollinators have co-evolved into mutualistic relationships. The plants depend on and compete for the animals' pollination services and, as a consequence, have evolved sophisticated floral signals to attract their pollinators. Bat-pollinated flowers even show echo signals to attract their echolocating pollinators. However, only few plant species have been studied so far in this regard. To get an idea on how frequently such acoustic adaptations occur in bat-pollinated flowers, and to find out if there are different mechanisms involved we investigated flowers of more than 60 different plant species regarding their echo acoustic reflection properties. We not only measured echoes of bat-pollinated flowers, but also of flowers belonging to other pollination syndromes. We found effective echo reflectors in some plant species, where the majority of bat-pollinated species showed no floral structures specifically evolved to acoustically attract pollinating bats. Nevertheless, all bat-pollinated flowers showed a tendency to reflect echoes of higher intensity than bird- or insect-pollinated flowers and they could be classified down to species level only by using echo spectral information. Among the flowers with special acoustic adaptations there are not only different kinds of reflectors, but also plants that embed their flowers in sound absorbing structures, to enhance the acoustic contrast and make them more conspicuous to bats.

The Earliest Bats from Europe

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Chiroptera is one of the few modern mammal orders for which no fossil record has been associated with the Paleocene-Eocene Thermal Maximum that happened 55.8 million years ago. With the exception of complete skeletons from the early Middle Eocene of the Messel Formation in Germany and the late Early Eocene Green River Formation in Wyoming, all early bats are only represented by isolated elements, mainly teeth and fragmentary jaws, making the diversity and taxonomic affinities more difficult to establish. Here we revise all of the Early Eocene bats from Europe based on dental features, including digitally reconstructed teeth using micro-CT scanning technology of some complete skeletons. The diversity of European early bats is composed of the families Onychonycteridae, Icaronycteridae, Archaeonycteridae, Palaeochiropterygidae, and some of undetermined affinities. Dental features and synapomorphies of each family are characterized for the first time. The earliest bats are dated from the early Early Eocene and are all of small size with lower molars less than 1.3 mm in length. They are represented by: *Eppsinycteris anglica* from Abbey Wood, east London, England, an onychonycterid with reduced lower p4 and long molars; *Archaeonycteris*? *praecursor* from Silveirinha, Portugal, an archaeonycterid with long postcristid on wide lower molars; a new archaeonycterid genus and species from Meudon, North France with long trigonid and shorter postcristid on wide lower molars. These results indicate that the diversity of European Early Eocene bats is higher than previously recognized and that diversification began early in the Early Eocene.

Evolutionary Origins of the Neural Substrate for Echolocation Pulse Production

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Echolocating bats are not unique in their ability to produce ultrasonic vocalizations, but are exceptional in their ability to finely manipulate the timing and acoustic properties of their vocalizations to meet the constantly changing demands of their sonar behavior. While much is known about how the bat's auditory evolved to support echolocation, little is known about how the bat's brain was adapted to support flexible echolocation pulse production. The descending vocal motor pathways producing echolocation pulses are likely derived from the same limbic motor circuits that generate the largely inflexible social calls used by all mammals, but important neuroanatomical differences between the pathways producing pulses versus social calls have been identified at every level of motor control. Yet explaining precisely how these changes in bat brain architecture contributed to the evolution of progressively more sophisticated echolocation behavior remains an elusive goal. Through the integration of comparative physiological data and computational modeling of vocal motor circuitry a novel hypothesis emerges to explain how an expansion of specialized neural networks in the bat's medial prefrontal cortex accommodated the more flexible fine control of echolocation pulse shape needed for adaptive biosonar behaviors. Specifically, the proposed model offers testable mechanistic hypotheses about how subtle changes in network activity dictates outgoing pulse acoustics and points towards key molecular innovations that may delineate the cellular and genetic origins of this distinctively chiropteran vocal behavior.

A Geographic Assessment of the Diversity of Colombian bats

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Colombia harbors the highest bat richness in the Neotropics; at least 198 species have been recorded so far, this is well above Brazil (174 spp.), or Peru and Venezuela (165 spp. each). This diversity is included in nine families (10 out of 11 Phyllostomid subfamilies) and 67 genera. The most diverse family is the Phyllostomidae (40 genera, 123 species), and the three most speciose genera belong to this family (*Platyrrhinus*: 14 spp., *Sturnira*: 11 spp., *Anoura*: 10 spp.). Seven species are endemic to the country; three of them are known from a single locality, and only one has a wide distribution through the country. Because of its location, at the northwestern corner of South America, the presence of three cordilleras, plus Pacific and Caribbean coasts, and lowland forests on its eastern half, the geographic component becomes a critical factor to explain this species richness. Five ecological regions can be recognized within Colombia: Amazon, Andean, Caribbean, Orinoquia, and Pacific (Chocó). Although 55 species have wide distributions through the country, more species are restricted to the Andean region (38 spp.) than to others (18 Amazonian, 15 Pacific, 11 Caribbean, 3 Orinoquian). Influence of the Andes over nearby regions is evidenced by the combined 62 species in Andes plus Pacific, and 58 species in Andes plus Amazon. For Colombian species, the average altitudinal range was 1190 m. In regard to altitudinal extension, up to 166 species occur below 600 m whereas only 53 reach over 1800 m

Riparian Corridors, Bat Seed-Dispersal, and Cloud Forest Regeneration in a Pasture Matrix

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In a pasture-dominated landscape with forests present mainly along riparian corridors, we tested the hypothesis that most of the regeneration potential (source of seeds and bat and bird seed disperseral) of forest resides in these corridors compared to adjacent pastures. We worked with phyllostomid bats in the foothills of the Cofre de Perote volcano, in central Veracruz State, Mexico, in 10 localities located between 1300 and 2000 m. Data on abundance of chiropterochorous fruit, bat richness and evenness, bat-dispersed seed deposition and viability was collected in three distinct seasons. Paired-wise comparisions were perfomed using riparian strips and adjacent pastures. The abundance and richness of phyllostomid bat species was greater in riparian corridors (9 species, 919 individuals) than in pastures (5, 54). A similar pattern was observed for species of bat-fruit. The most common bat species were *Sturnira ludovici, Carollia sowelli, Artibeus jamaicensis,* and *Glossophaga soricina*. Sixteen species of seeds were recovered from 176 bat droppings. The most abundant bat-dispersed seeds were *Solanum aphyodendron, S. schlechtendalianum, S. nigricans, Piper hispidum, P. lapathifolium* and *Hedyosmum mexicanum*, for both vegetation types; the majority belonged to shrubs of early succession stages. However, more seeds were recovered

in riparian forest than in pastures, particularly in the rainy season. We discuss how maintaining and connecting riparian forests in this fragmented landscape can foster the regeneration potential of cloud forest, since riparian corridors are a last and crucial reservoir of forest seeds and dispersers.

Chromosome Rearrangements and Diversity in New World Leaf Nosed Bats

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The family Phyllostomidae is a speciose group with unprecedented morphological and ecological diversity. Yet, specific processes and mechanisms leading to their diversity are still not well understood. Rapid diversification rates and morphological and ecological variability in phyllostomids are coupled with high rates of chromosomal change, which makes them an ideal model system to study the role of chromosomal rearrangements to speciation and morphological/ecological variation. The first step to test the hypothesis that chromosome rearrangements have played a role in diversification of phyllostomid bats is to define regions of chromosomal homology among species. Therefore, we have generated whole chromosome paints from a phyllostomid with a proposed basal karyotype (*Macrotus californicus*) to create comparative chromosome maps on other phyllostomid species. We have successfully detected homologous chromosomal regions on the karyotypes of phyllostomid bats from 6 subfamilies and 4 outgroup species and determined the sequence of chromosomal rearrangements during the evolutionary history of Phyllostomidae, as well as the primitive karyotype for the family. Overall chromosomal data show phylogenetic signal, with similar patterns as those recovered by molecular markers. *Macrotus* bears the primitive condition for most of the linkage groups. The high number of ancestral chromosomes at the basal node of each subfamily suggests the presence of a conserved chromosomal landscape before the radiation of ecologically unique monophyletic taxa. Increased rearrangement activity, however, is observed in specific groups within each subfamily. These unique syntenies remain as candidates for adaptive rearrangements that facilitated directional selection for new ecological niches.

Extinction and Phylogeography of Caribbean Bats during Late Quaternary Climate Change

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Recent studies have addressed the probability of current gene flow among Greater Antillean bat populations. However, the ability to infer the historical events that caused changes in these bat populations is essential to understand range-wide phylogeographic patterns. Late Quaternary climate change is characterized by multiple glaciation events that affected the size and shape of West Indian islands. We are testing the hypothesis that glacial-interglacial cycles likely influenced historical demographic processes, such as migration and extinction, which produced the phylogeographic signature observed in today's Greater Antillean bat populations. We used radiocarbon dated bat fossils to validate ecological niche model (ENM) projections of species under past climate and to determine the effect of climate change on bat distributions over time. Additionally, we used ENM past projections to develop *a priori* hypotheses of evolutionary history taking into account historical demographic events of an endemic nectarivorous bat (*Monophyllus redmani*). These hypotheses were tested using coalescent simulations analyzing five population-level summary statistics. Radiocarbon dates show that local extinctions were more recent than previously hypothesized. We also found that populations of *M. redmani* on Puerto Rico and Dominican Republic diverged around 700ky, which coincides with the onset of Late Pleistocene glacial cycles, and that population migration preceded Last Glacial Maximum (ca. 21 ky) climate change. The coupling of ENM, fossils, and coalescent simulations is a powerful approach that allows us to evaluate past occurrence patterns and genetic variation under alternative evolutionary hypotheses that contribute to the contemporary phylogeographic patterns observed in Caribbean bats.

Estimating Genetic Diversity, Migration, and Population Structure across Multiple Biogeographic Barriers in Mexican Free-tailed Bats

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Within the West Indies, the Bahamas provide a unique system where dispersal can be evaluated in a relatively controlled setting when compared to mainland communities. Previous research indicates that the oceanic channel separating the Great and Lesser Bahama Banks acts as a barrier to gene flow between bat populations. This break is interesting because it is unclear whether characteristics specific to the oceanic channel or habitat and resource differences between the Great and Lesser Bahama banks are most important in deterring dispersal. To identify factors influencing gene flow and test the effects of this barrier on an excellent disperser, we examined the population structure of *Tadarida brasiliensis* within islands, between islands of the same bank and across banks of islands. We collected tissue from a total of 160 individuals from localities on Grand Bahama and Abaco of the Lesser Bahama Banks, and Eleuthera and Long Island of the Great Bahama Bank. We amplified 9 variable microsatellite loci, which were analyzed using Structure to test for population cohesion and Migrate to estimate movement between populations. Preliminary mitochondrial sequence data shows *T. brasiliensis* populations are distinct across the Great and Lesser Bahama banks. By characterizing dispersal within islands and between islands of the same bank, we can potentially identify attributes important in maintaining structure across these banks. These attributes may provide novel information for elucidating key mechanisms underlying biogeographic processes (e.g. colonization, speciation, extinction).

Abiotic and Biotic Factors Affecting the Foraging of Bats over Wetland Habitats

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Foraging animals face decisions about when and where to forage based in part on factors such as prey availability, which can fluctuate temporally as well as spatially. For temperate insectivorous bats, wetlands are important forage habitats because they contain high abundances of insects. My overall objective is to identify abiotic and biotic factors that influence bat foraging activity over wetlands in the channeled scablands of eastern Washington. I surveyed 12 wetland sites at Turnbull National Wildlife Refuge in Cheney, Washington, 3 times during summer 2012. Ten stations were set up at each site to measure insect abundance using floating aquatic emergence traps, sticky traps, and pan traps. Bat feeding activity was measured using ultrasonic recording devices. I measured vegetation abundance, water temperature and depth, presence/absence of fish, and hydroperiod at each site. Eight bat species were detected overall with an average of 6.4 species per site (range 5-8). The nightly species count ranged from 0 to 8 with an average of 4.5 species present at a site each night. Feeding buzzes were recorded at all 12 sites during at least one sampling period. A stepwise regression showed a positive correlation between feeding buzzes and both reed canary grass and bullrush abundance. I have identified 1,336 insects to date. The majority belong to the order Diptera (78%) with 6 other orders at < 10% each. By evaluating the factors influencing bat foraging, my study will help identify quality habitat for conservation purposes.

Are We Seeing the 'Big Picture'? A Look at Home Range Size by Day for Two Species

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Due to weight restraints, home range methodology needs to be examined for Microchiropteran bat species. We examined how the number of days tracked and locations tracked per day affected estimations of home range size. Since radios are on bats for a small window of time (2-21 days in this study depending on species), are we actually getting a good view of the spatial use necessary to accurately estimate home range size? We looked at home range size for the eastern red bat (*Lasiurus borealis*) and the Indiana bat (*Myotis sodalis*) in Missouri. We chose these species because of different weight restraints (0.58 g radios on eastern red bats and 0.43 g radios on Indiana bats). In addition, spatial area use is generally more constrained for Indiana bats than red bats because of morphological and life history characteristics. Here, we present the range of each species of bat by day until the range size reached its limit. Using this data, we can help researchers maximize efficiency of equipment by optimizing battery use and radio signal strength.

Will Heterothermy Increase the Chance of Survival of Bats During Climate Change?

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Animals will be exposed to new thermal challenges caused by climate change and it is predicted that as a result some species will shift their distribution poleward or to higher altitudes. However, not all species will be able to change their geographic location and will have to use other mechanisms to deal with the climatic changes in their environment. Many bat species are opportunistic heterotherms and, by using torpor, are able to adjust their thermal biology and thus energy requirements seasonally and regionally. To determine how temperate bats might respond to climate change we examined how the use of torpor, an important survival strategy of small bats, is affected by temperature in the tropics as these bats are already exposed to warm conditions. Over two mild winters, the skin temperatures of tropical free-ranging bats (*Nyctophilus bifax*, 10g, n=13) were monitored via temperature-telemetry in northern Australia. Bats used torpor on 95% of study days and were torpid for 33.5±18.8% of 113 days measured. As torpor duration was temperature-dependent we estimated that a temperature increase of 2ºC, as predicted on average for the 21st century, would decrease time in torpor by one third. However, it appears that regional phenotypic plasticity of *Nyctophilus* populations actually will minimise the effect of temperature on torpor patterns. Our data suggest that even in warm conditions heterothermy is an important aspect of energy budgeting in bats and that during climate change the flexible use of torpor will increase bats' chance of survival.

Phyllostomid Assemblages in Atlantic Forest of South America: Phylogenetic, Phenetic and Functional Perspectives along Biodiversity and Environmental Gradients

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Biodiversity is considered a complex and multidimensional concept that characterizes variation of life on earth. Nonetheless, most studies have examined only a few if not just one dimension in isolation when trying to understand spatial or temporal variation in biodiversity and underlying determinants. Herein we develop new analyses that explicitly incorporate correlations among different components and account for the actual dimensionality of biodiversity. We characterize the phenetic, phylogenetic and functional structure of a large number of bat assemblages from Atlantic Forest of South America and examine degree of redundancy among these sets of descriptors. Second, we examine dimensionality of community structure and quantitatively determine if these different suites of descriptors represent three unique dimensions of community structure. We examine if dimensionality measured from real sites is different than that based on randomly assembled assemblages. Finally, we examine if different kinds of community structure metrics respond differently to environmental gradients spanning Atlantic Forest in South America. Atlantic forest bat assemblages are highly variable in terms of phenetic, phylogenetic and functional structure. Different sets of structure metrics exhibited substantive correlations. Accordingly, dimensionality was lower than the three sets of descriptors and six individual metrics. Nonetheless, observed dimensionality was greater than that expected from a null model. Only abundance based measures of phylogenetic diversity exhibited significant environmental gradients. Temperature seasonality was the strongest predictor of structure with overdispersed assemblages characterizing more seasonal environments and underdispersed assemblages occurring in areas of less variation in temperature. Dimensionality of community structure is low with phylogenetic structure exhibiting the strongest patterns, probably because phylogeny reflects many different ecological aspects of the phenotype that are not restricted to just one measure of structure. Temperature seasonality is an important determinant of phylogenetic structure of bat assemblages in Atlantic Forest in particular and likely in general.

Intraspecific Differences in Immunocompetence of European Bats

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Knowledge about the immune system of European bat species is scarce, although is essential for interpreting the occurrence of parasite infestations and diseases. The immunocompetence (IC) is the ability to raise an immune response following a pathogen contact. It has been shown that it is influenced by many factors; however these factors are untested for the European chiropterans. This study investigated if IC is influenced by 1) energy demand 2) sex or 3) age of *Myotis daubentonii* individuals. We collected blood samples from *M. daubentonii* in

periods of high and low energy-demand, from males and females, as well as juveniles and adults. All samples were analyzed using a multiparametric test which included bacterial killing assay, hemolysis-hemagglutination assay and quantification of immunoglobulin G levels to get overall information of the bats' IC. Our results showed that the IC of bats depends on several intraspecific factors and demonstrated the need to balance the allocation of energetic resources (trade-off relation) between growth, reproduction and the energy-demanding IC. Additionally, the IC in females and males differed significantly. To conclude, when comparing IC between species, it is important to include these co-founding factors in the respective study design to get comparable results.

Containment of Potential Mates in Bonin Flying Foxes: Exploitation of Female Ball-shaped Warming Clusters

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Social thermoregulation is a significant adaptation to cold environments, which is especially important for animals having high surface-to-volume ratios. Huddling behavior can influence animal dispersion pattern. However, little attention has been paid to the relationship between huddling behavior and social organization, including mating systems. We investigate whether the ball-shaped bat clusters formed in arboreal roosts of Bonin flying foxes, *Pteropus pselaphon*, have a social thermoregulatory function and whether clusters are involved with the species' mating systems. Field observations showed that *P. pselaphon* clusters were roughly separated into three groups: males, females, and subadults. Statistical analyses showed that ambient temperature had significant negative effects on the proportion of individuals that formed cluster among all groups. Cluster size decreased significantly with increasing ambient temperature in female and the sub-adult groups. Some female clusters were composed of a single male and multiple females. Marked males excluded other males from the periphery of female clusters and monopolized copulations with clustering females, exhibiting a so-called female-defense harem structure. Our results suggest that Bonin flying fox males exploit female clusters for mating, although clustering behavior a fundamental warming role.

The Thermal Preference and the Hibernation Period in Seven Cave-dwelling Bats in South Korea

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In the temperate region, the interspecific variation in temperature preferred by the species will reflect a difference among bat species in the hibernation period. We estimated the hibernation period of seven species bats by monitoring presence and absence of bats in major hibernacula from 2007/8 to 2009/10 and examined a hypothesis that species-specific thermal preference affect to hibernation strategy such as the onset and termination of hibernation and hibernation period. This study showed that the temperature preferred by each species and the hibernation period was differed among 7 species; *Rhinolophus ferrumequinum* (average temperature = 7.9±0.8°C, hibernation period = 146 days), *Myotis petax* (5.1±0.6°C, 137 days), *Myotis formosus* (13.6±0.8°C, 216 days), *Plecotus auritus* (2.7±0.6°C, 110 days), *Hysugo alaschanicus* (3.4±0.4°C, 125 days), *Murina leucogaster* (2.9±0.3°C, 110 days), and *Miniopterus fuliginosus* (6.6±0.4°C, 123 days), respectively. The period of hibernation in each bat species might be strongly influenced by fluctuations in the external temperature. The external temperature fluctuation curves and the species-specific thermal preference were regularly overlapped in early-winter and early-spring. The first and second crossing periods were coincident with the time of beginning of hibernation and arousal of the bat species, respectively, and the duration between two crossing points coincided with the hibernation period of seven bat species. We suggest that the hibernation period of bats is influenced by the combination of species-specific thermal preference and external temperature at the region.

Bats' Spatial Perception through Echolocation in the Natural Habitat

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Echolocating bats perceive the world through the echoes of their sonar sounds reflected from objects and background in their vicinity. They adjust frequency and duration of their calls to the habitat and behavioral context. New techniques have enabled us to determine the emitted intensity and directionality of the sonar beam. Those two

sound features define the search volume of the echolocation, i.e. the volume ahead of the bat ensonified with sufficient sound energy to reflect detectable echoes. Not surprisingly bats control the intensity and emit more intense (longer) sound beams when focusing at objects far away and reduce the intensity the closer to the object they get. Elisabeth Kalko pioneered the study of bats in their natural environment, and we examined control of intensity in the wild. The results clearly showed flexibility and adaptation, such that intensity often is reduced much more steeply in the field than in the laboratory, depending a.o. on the detection distance. Surprisingly, directionality also turned out to be under the bats' control. Vespertilionid bats of different sizes and species adjust their sonar beams to similar shape and width in the lab. There, the beams are fairly broad. When in the last phase of insect pursuit, they broaden the beam even more, presumably to keep erratic flying insects within their acoustic field of view. Again, field data differ, since a much narrower beam is emitted in the search phase in the field. This, once more emphasizes the importance of studying bats in their natural habitat.

Solitary Turbines and Bats: Preliminary Results from a Case Study in Lewes, Delaware

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We are conducting a post-construction assessment of bat activity at a solitary wind turbine located along the shoreline near the Delaware Bay and Atlantic Ocean in Lewes, Delaware. For this initial report, we present the preliminary results from the 2012 flight/migratory season. Our objectives were to determine if the turbine is an attractant/repellent for bats, assess the turbine's impact on local and migratory bats by monitoring bat activity, and examine correlations between turbine rotation, bat activity, and bat mortality. To measure bat activity, we set two Wildlife Acoustics SongMeter SM2BAT 384Khz passive recorders at similar heights near the turbine: one recorder 15 m away from the turbine and the second 200 m away. We analyzed calls and classified species with Sonobat v3.01. We also conducted carcass searches during the flight period using standardized protocols. Overall, we recorded 17301 passes from 10 May to 19 October 2012, with the majority recorded at the detector 200 m from the turbine. However, at mid-July there was an uptick in passes recorded at the near detector, with a subsequent decline at the far detector. At this time, it is not clear if this difference results from a change in bat behavior due to migration, mating, or is an artifact. Furthermore, the majority of bat fatalities occurred after an extended shutdown of the turbine during July. Fatalities totaled 32 for the year and extended into October, with the majority being *Lasiurus borealis*. Our data suggest a potential for mitigation through limited curtailment.

Bat Conservation Africa: a Voice for Our Friends in the African Night Sky

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Africa is home to 20% of the world's bat species. However, this rich diversity of over 220 species faces increasing threats from habitat destruction, persecution and the bush-meat trade. Meanwhile African bat researchers frequently study in isolation, working with scant resources and limited support. Thus, to date, when viewed from a global perspective, much of Africa appears to be a bat research and conservation void. To meet this challenge, in February, 2013, Bat Conservation Africa was launched in Naivasha, Kenya. With a leadership drawn from the six sub-regions (Central, East, North, Southern, West Africa and Western Indian Ocean Islands), it aims to provide a network for all (students, experts, African or international) interested in Africa's bat fauna. Its model for integrating research, education and conservation involves working in-country to raise capacity, recruit new members, raise public awareness, update national species lists, identify important bat areas, and influence local decision makers to promote pro-bat conservation policies. At a regional level, overarching threats and challenges to bat conservation will be addressed. On a continental scale, the network will develop projects that involve assessments of species status and field based trans-national projects. So far, the network has submitted two grant proposals. Other outputs include members working on collaborative reviews and research papers. Membership has grown steadily since the launch and each week, on e-mail, there is a lively exchange of views on an eclectic range of subjects. Clearly, this budding network will define the future of bat conservation in Africa.

Acoustic Identification of Insectivorous Bats of the Ria Lagartos Biosphere Reserve, Yucatan, Mexico

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Bats are considered as parameter group that can be used for monitoring biodiversity due to many species are indicators of disturbance and/or loss of habitat in tropical regions. Although most studies have employed capture methods such as mist-netting for biodiversity assessment it has been stated that not all species are recorded with this method, making necessary the use of additional methods, such as bat detectors. In this study we estimated species richness, using an ultrasonic bat detector in dry forest in the Ria Lagartos Biosphere Reserve, Yucatan, Mexico. Monthly records were made in three types of forests, recording echolocation sounds with an ultrasonic detector Pettersson D240-X in time expansion mode. The sounds were analyzed using the software BatSound Pro. Sound features as high frequency energy, maximum and minimum frequency, pulse duration, pulse interval, were analyzed to identify the species recorded. 130 acoustic recordings were obtained throughout the year, 36 records in low forest, 55 records in the tropical forest and 39 records in flooded forest. In August we had the highest number of records (22) and the largest number of species (8). We identified 11 species: *Pteronotus parnelli, P. davyi, Molossus rufus, Eptesicus furinalis, Lasiurus ega, L. intermedius, Rhogeessa aeneus, Saccopteryx billineata, Eumops underwoodi, Promops centralis, Nyctinomops laticaudatus* and one phonotype: *Eumops sp*. Eight bat species were added to those mist net bat species captured, which demonstrates that using ultrasonic sensors is a efficient method for recording insectivorous bats species.

Climate Change, Global Water Stress, and the Conservation of Insectivorous Bats

Daniel Taylor, Trish Badeen, and Mylea Bayless
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Climate change is adversely affecting the global distribution and availability of water sources. Due to inherent physiological traits, insectivorous bats–which comprise nearly 70% of all species–may be especially vulnerable as they obtain less metabolic water from their food than non-insectivores, especially in arid and semi-arid environments. Research on myotis bats in a semi-arid region of the United States found that reproductive fitness declined significantly with diminishing surface water. To better understand which species and regions may be most vulnerable, we conducted a global gap analysis to identify where high bat species diversity, endangerment, and water stress intersected. Species data were obtained from the International Union for the Conservation of Nature and water data were obtained from a Nature Conservancy model derived from both physical and anthropogenic parameters such as temperature, precipitation, trends in water use by sector, and population density. Countries and regions with the highest vulnerability included Mexico, the Pacific Coast of Peru and Ecuador, Southern Africa, and Western India. Despite overwhelming evidence of negative climate-induced changes to global water availability and the importance of free water to insectivorous bats, limited research or conservation focus has been directed towards this emerging threat. Bat Conservation International will further refine our analyses and prioritize regions where we can work with local partners to raise awareness about water's importance to bats, support research on bats and water, and promote proven mitigation strategies such as watershed restoration and the incorporation of bat water needs into industrial, agricultural and livestock water management.

Bats as Biocontrol Agents Suppressing Nocturnal Flying Pests in Macadamia Orchards in Limpopo Province, South Africa

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Bats are major predators of crop pests. Regular acoustic transects (using ANABAT bat detector), mist-netting and harp-trapping of bats and dietary analyses of four bat species was conducted on two macadamia farms in the northern Limpopo Province between 2010 and 2013. Based on ANABAT call files recorded over seven months throughout the year, 16 species of bats were recorded of which five common species were recorded across three habitats (macadamia orchards, riparian bush and homesteads). Bat activity peaked during February and May, corresponding with high stinkbug (Hemiptera: Pentatomidae) numbers generally recorded at that time (stinkbugs are the major insect pest of macadamia nuts). Activity during winter was negligible. Faecal pellets and culled prey remains from slit-faced bat (*Nycteris thebiaca*), Angolan free-tailed bat (*Mops condylurus*), African pipistrelle

(*Pipistrellus hesperidus*) and yellow house bat (*Scotophilus dinganii*) revealed important components of bugs (Order Hemiptera), higher than recorded in previous studies conducted in natural habitats. Future work will focus on a DNA bar-coding approach to probe the diet of bats. Gene sequences ("Bar-codes") have been obtained for 13 species of stinkbugs collected from the study area. A collaborative project between University of Venda and the Centre of GeoGenetics, Copenhagen (Denmark) will conduct Next Generation Sequencing of bat fecal pellets from day and night roosts in macadamia orchards to establish the detailed insect diet of bat species foraging in macadamia orchards and to determine the frequency of stinkbug prey in the diet of at least six species.

Phylogenomic and Population Genetic Studies Eludicate the Evolution and Functional Roles of Echolocation in Bats

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The sensory drive theory of speciation predicts that populations of the same species inhabiting different environments can differ in sensory traits, a process that can ultimately drive speciation. Of all mammal species, bats are the auditory sensory specialists. They use echolocation (sound) to orient and detect prey in complete darkness, relying on the echo of their ultrasound calls to develop an acoustic image of their environment. Bat echolocation is considered to be one of the most fascinating yet least well understood modes of sensory perception. Owing to the central role of echolocation in orientation and foraging in bats, it is commonly assumed that echolocation has been shaped by ecology via natural selection alone and only a few studies have investigated its role in communication and mate choice. Here we review the molecular population genomic studies that have suggested the role that echolocation frequency plays in mate choice, potentially acting as a 'magic trait' driving sympatric speciation. We highlight the phylogenetic advances that illuminate but yet still question its evolutionary trajectory in bats. To test if echolocation can play a role in mate choice and ultimately drive sensory speciation in bats, we used a mulitidisciplinary approach combining ecological, behavioural and genomic data to elucidate whether information encoded in echolocation calls is used in mate choice by bats and if this can influence the evolution of the echolocation signals. We show in our novel integrative study, combining ecology, genomics and behaviour, that bats are using echolocation to choose a mate, the higher the frequency of the call the more attractive the male. Indeed, echolocation calls act like a 'peacock's tail', the higher the frequency the more attractive the call; however the less efficient the call is for foraging, ultimately an attractive handicap. This evolutionary 'trade-off' between efficiency and attractiveness moulds and constrains bat echolocation and echolocation can indeed act as 'magic' trait in sympatric sensory speciation.

The Sensory Ecology of a Predator-Prey Community: Neural Representation of Bat Predation Risk in Moths

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The ears of noctuid moths contain only two auditory receptor cells (A1 and A2) that are tuned to the ultrasonic sound frequencies used by predatory bats for echolocation. We tested the hypothesis that the frequency-dependent A-cell thresholds allow moths to detect bat species calling at different frequencies at distances at which they pose a similar threat. First, we show that bat call frequencies are tightly correlated with four bat characteristics related to the danger posed to moths by bats. Second, we measured auditory receptor thresholds in 12 moth species for the echolocation calls of 13 sympatric bat species in the lab and compared them with data collected for several species in the field. Third, we modeled temporal and spatial safety margins before detection by the bat for moths initiating directional flight at A1 threshold. In general, moths detect bats long before bats can detect the moth. For moths almost directly in front of an approaching bat, A1 activity translated into similar temporal safety margins across all bat species. At greater angles away from the bat, the safety margins varied greatly, often resulting in unnecessary directional flight. This suggests that the A1 cell has adapted to the worst-case scenario for the moth. In contrast, the less sensitive A2-cell starts to fire at approximately the same time as the bat detects the moth for bat species calling at 30 kHz and greater, suggesting that A2 activity informs moths that they have been detected by a bat.

Understanding Collective Behavior of *Tadarida brasiliensis* Using Computer Vision and Multi-target Tracking

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Tadarida brasiliensis form large, cohesive formations as they emerge from the caves in which they roost. Though intriguing, it is challenging to study the behavior of individual bats within the emergence column due to the technical limitations of imaging and tracking technology. In simulation models of collective behavior, it is assumed that certain minimum distances between conspecifics are maintained. We provide observational evidence of this presumed behavior in *Tadarida brasiliensis*. Using thermal infrared cameras and multi-target tracking algorithms, we have reconstructed the flight paths of more than 1,000 bats over 36,000 frames (4.5 minutes) of video during the early part of an evening emergence. With these data, we are able to study the patterns of the behavior of bats in the emergence column in unprecedented detail. We found that more than 98% of the time, a minimum distance of at least 30 cm is maintained. Among the bats that do not maintain this minimum distance, we have found interesting, unexpected maneuvers that point the way to new questions about how bats interact socially while in flight.

Bat-mediated Genetic Connectivity of *Crescentia alata* Populations

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Bats are important pollinators of flowering tree species in the tropics. Tropical forests are facing increasing threats from fragmentation, but it is unclear how this affects bat pollinators, or gene flow in bat-pollinated trees. The goal of this study was to evaluate the impact of forest fragmentation on contemporary pollen flow in a bat-pollinated tropical tree species, *Crescentia alata* in Jalisco, Mexico. We hypothesized that populations of *C. alata* have low pollen pool genetic structure resulting from high gene flow due to the potential long distance foraging movements of bats. Secondly, because bats are capable of visiting many trees, we hypothesized that genetic diversity among populations and among fruit within trees is high. We genotyped 203 seedlings from 16 adult trees in continuous forest populations (CF) and 198 seedlings from 15 adult trees in fragmented forest populations (FF) using 7 microsatellite markers. We found unexpectedly high genetic structure of the pollen pools, and higher structure from continuous forest maternal trees ($\Phi_{ST\ cont} = 0.191$ vs. $\Phi_{ST\ frag} = 0.163$) indicating more restricted pollen movement in the continuous forest landscape. However, we also found that the majority of the diversity in pollen gametes is among seeds within fruit, which may indirectly be confounding the genetic structure estimates. These findings contradict the idea that pollen flow is limited, and suggest there are many bats pollinating each flower, and/or bats are carrying genetically diverse pollen loads to each flower, and bats are moving pollen widely across the landscape.

Seasonal Occupancy in a New Mitigation Area for the Endangered Hawaiian Hoary Bat

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The State of Hawaii has mandated a clean energy initiative that strives to have 70% renewable energy by the year 2030 in an effort to reduce the consumption of fossil fuels. In response to this initiative six wind-energy facilities have received operational permits and seven additional facilities are in the planning stages in Hawaii. Bat fatalities at wind farms are increasingly recognized as an important environmental concern in the United States and elsewhere. In an effort to mitigate take while continuing to meet substantial state alternative energy goals, Hawaii's Division of Forestry and Wildlife created Kahikinui Forest Reserve Conservation Area encompassing 4,986 ha on the southeast slope of Haleakala Volcano on the island of Maui. We here present the results of acoustic surveys (July 2012 to present) across a 1500 m elevation gradient in order to identify seasonal trends in occupancy of Hawaiian hoary bats (*Lasiurus cinereus semotus*). Bat detectability was highest during the months of July and August, corresponding to the annual period of hoary bat lactation and declined thereafter. Low elevations within the reserve (1200-1700 m) had the highest cumulative detectability although bat vocalizations were recorded throughout the year at our high elevation sites (2400-2700 m). Results from this study will provide information to assist efforts to better manage endangered Hawaiian hoary bats through improved mitigation and habitat restoration.

Ecological Niche Modeling of the Mating Roost for the Conservation of the Mexican Long-Nosed Bat

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A single mating roost is known for the migratory Mexican Long-nosed bat: La Cueva del Diablo, located in Tepoztlán, Morelos. This species is considered as threatened in Mexico and endangered in the United States. A Recovery Plan was writen in 1994 and it identifies conducting additional surveys to locate unknown roosts as one of the key recovery actions. The main objective of this project was to model the potential distribution of other mating roosts using ecological niche modeling (ENM) and an analysis of ecological distances with a posterior directed field validation. We compiled all available information in literature and scientific collections about the localities in which this species has been recorded and then we modelled the ecological niche to predict the potential distribution of other mating roosts using three modeling tools: Maxent, GARP and Bioclim. For the analysis of ecological distances we look for the closest ecologically areas to the localitie where La Cueva del Diablo is. We then identified areas in which all three models coincided in addition to the areas obtained in the latter analysis. Field validation was carried out during the mating season in the winter. We visited a total of 16 caves in the region and found one winter colony that is likely to be a mating roost. However, our visit occurred in late winter, so at this point we are unable to confirm that this is a mating roost. This hypothesis will be validated next winter, together with additional fieldwork to identify other additional mating roosts.

Evidence for Lek Breeding in Lesser Short-tailed Bats, a 'Rare' Mating System

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Lek breeding is characterised by aggregations of sexually-displaying males visited by females that select mates based on the quality of those displays. Rare in mammals, leks are thought to form when males can defend neither females nor resources. The rarity of leks may arise through a relative lack of mobility in mammals, making it uneconomical for females to search out male aggregations. Bats, however, do not suffer from reduced mobility and yet lekking remains virtually undescribed in the Order. I hypothesize that New Zealand's lesser short-tailed bat (*Mystacina tuberculata*) is a lekking species, and will use my findings as a case study for the conditions necessary for the evolution of lekking in other temperate species. I have studied short-tailed bats in the Pureora Forest Park using walking transects of the forest, video footage, remote monitoring using PIT-tags, and radio-telemetry. During the summer months males occupy solitary roosts in trees from which they sing structurally-complex songs. These roosts are clustered, with 49 roosts aggregated within 0.6 km^2 of forest, and are occupied and defended by the same male each night. Female behaviour likely promotes male clustering as females possess large (>500 ha) home ranges and change roosts frequently, making them indefensible by males. Short-tailed bats appear to fit the criteria for true leks, and conditions imposed by temperate climates may promote lekking in other species but remain unstudied. Lekking entails unique conservation considerations and thus the identification of lekking characteristics in bats is an important concern for future research.

Trophic Niche Analysis of the Bat Community at Laguna Lachuá National Park, Guatemala: an Ecomorphological Approach

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Wing morphology and food items consumed were related in order to explore interspecific morphological and ecological relationships within an assemblage of 21 bat species at Laguna Lachuá National Park, Guatemala, during the rainy season of 2012, based on the hypothesis that niche partitioning allows the coexistence of sympatric species. We grouped the species in four functional ensembles supported by foraging strategies and diet: narrow-space aerial insectivorous (4 species), gleaning insectivorous (4 species), carnivores (1 species) and frugivorous (12 species). The resource partitioning in the frugivorous species is mainly given by the food consumption; all the species in this group have similar characteristics and capability of flight, with smooth differences on flight speed and maneuverability. Most of the species fed primarily on four plant genera: *Piper*, *Ficus*, *Cecropia* and *Vismia*. Fruit consumption reveals a group of species that fed mainly on *Piper* and *Vismia* and another group that fed mainly on *Ficus* and *Cecropia*. In contrast, the resource partitioning in the insectivorous species is mainly given by the

foraging strategy; the food consumption in this group does not reveal any particular pattern. Most of the species fed primarily on coleopterans, supporting their diets with other less common items. The results indicate that different foraging strategies and trophic selection allows the coexistence within species and plays a great role in the structure of local bat communities.

Integration of Local Culture in Flying Fox Conservation Strategies in North Sulawesi, Indonesia: a Preliminary Framework

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Hunting of flying foxes has contributed significantly to their recent decline in Southeast Asia. Conservation of bats in Sulawesi, Indonesia is desperately needed, but previous initiatives fail to consider local culture as part of the solution. Semi-structured interviews of locals (31 vendors and 40 buyers) were conducted in 8 markets near Manado, North Sulawesi, where bat trade is most intense. Bats were relatively uncommon in the markets and sourced primarily from South Sulawesi. Peak consumption of bats coincided with religious holidays in December, intensifying consumption by 3 to 6 times more than in other months. Most locals between the ages of 19 to 45 in Manado consumed bats at least once a month but felt that it was not an essential part of their daily cultural practices. None of the locals were concerned about disease transmission, an issue that needs to be addressed through community education efforts. To control consumption, local governments should set maximum take and import laws and churches can act as local enforcement and educators since they are the center of the community. Educational programs in primary schools will be essential to long-term conservation efforts, as age cohorts divide consumption. The substitution of bats with snakes, cats, and dogs should be considered. Wild boars and pigs are not suitable substitutes due to associated conservation concerns and local perceptions, respectively. These suggestions would enhance efforts not only in bat conservation, but of other protected mammals, such as macaques and kuskus, as well.

Flowers and Bats – A Not Always Easy Partnership

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Many different interactions have evolved between New World leaf nosed bats (Phyllostomidae) and flowering plants, ranging from mutualistic pollination to mild forms of parasitism, where the bats do no direct damage but opportunistically use floral resources without providing any service in return to the plant. Flowering plants interacting with bats reach from columnar cacti to trees, shrubs and herbs. Specialized nectar-feeding bats (Glossophaginae, Lonchophyllinae) occur in a wide range of habitats from rain forests to dry forests and deserts and show characteristic specializations to their nectar diet. Adaptations involve behavior and morphology, and range from a unique hovering flight style that permits the access even to small and fragile flowers, to enormously long tongues that aid in extracting the nectar from deep within a flower. An extremely high energy turnover causes specialized nectar-feeding bats to be very flexible and use opportunistically any resource available to them, regardless whether these are co-evolved with them or with other organisms. The presentation will cover main ecological adaptations of flower-visiting bats, offer some insights into community ecology and present selected interactions between chiropterophilous flowers and their pollinators. While many interactions between bats and flowers seem to be rather straightforward, they are often more complex than visible at first glance and merit closer investigation.

Flexible Echolocation Behaviour of Trawling Bats during Approach of Continuous or Transient Prey Cues

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Trawling bats use echolocation to detect and classify acoustically continuous cues originating from insects at and above water surfaces and are also able to detect transient prey cues from aquatic animals briefly breaking the water surface. Due to the diversity of prey cues they use in hunting, we expect trawling bats to be highly flexible in their echolocation behaviour, and to adjust it to the specific task on hand. To test this hypothesis we studied the behaviour of *Noctilio leporinus* when approaching either a continuous cue or a transient cue target, using high-speed video with synchronized ultrasound recordings. The bats responded to both cue types with their typical capture

behaviour and dipped their feet in the water at the cue location. In continuous cue trials bats started to adapt their calling behaviour at a mean of 410 ms before prey contact. In the case of transient cues bats responded as shortly as 177ms before reaching the transient cue location and minimum reaction time was 50.9 ms. In both tasks call emission always continued after the end of the approach phase approximately until prey contact. The use of spatial memory was indicated by bats dipping their feet at the original location of the transient cue, even after its disappearance. Our results suggest that trawling bats possess the ability to modify their generally rather stereotyped echolocation behaviour during approaches within very short reaction times depending on the sensory information.

Mining Company Preserves Critically Endangered Bat in the Andean Desert of Southwestern Peru

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The southwestern Peruvian desert, located in the northern extreme of the Atacama Desert, is one of the most arid in the world. Columnar cacti provide one of the different kind of habitats available to endemic biota in this area. These columnar cacti have key functions to the maintenance of this arid ecosystem. In these environments, located on the western foothills of the Andes, minerals can be found. Sociedad Minera Cerro Verde (SMCV) exploits copper there and, as part of its environmental commitments, has hired Knight Piésold to prepare Environmental Impact Assessments for its current and future operations, in addition to the biological monitoring. Within the EIAs, the Peruvian Long-snouted Bat (*Platalina genovensium*) has been identified as an important species, not only because it is critically endangered (Peruvian legislation), but also because it is a keystone species for the survival and reproduction of an important population of the columnar cactus *Weberbauerocereus weberbaueri*, a structural species within the desert. The measures to protect *P. genovensium* considered in SMCV Biodiversity Management Plan are the following: 1) Protection of holes exposed to plundering for popular medicine, 2) habitat improvement by relocating cacti and its propagation, 3) Induction of flowering to increase availability of food offer, 4) permanent monitoring including the use of PIT-tags, remote sensing, capture nets; which has provided a great deal of information regarding this poorly known species, as well as 5) fostering activities that involve acknowledged scientists in environmental education, and management plans with regard to threatened bat species.

The Origin and Evolution of Nectarivory in Phyllostomid Bats

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The specialization of phyllostomid bats in feeding vegetal items varies greatly. The attempts to elucidate the evolution of nectarivory (feeding on nectar and/or pollen) among these bats have provided contradictory results. Here, based on a molecular phylogeny, we tested different hypotheses of the evolution of the nectar feeding habit in Phyllostomidae. We found a strong support for a direct dietary diversification of the phytophagous habits from insectivory. In addition, the estimates of divergence times of phyllostomids and the Bayesian reconstruction of ancestral states support a parallel evolution of nectarivory in two lineages during the Miocene. According to this, during the evolution of phyllostomids, the switches to new feeding mechanisms allowed the access to abundant and⁄or underexploited resources. This could provide selective advantages for the appearance of ecological innovations in different lineages of the family. We did not find evidences to support or reject the hypothesis that the insectivorous most recent common ancestor of all phyllostomids was also phytophagous. In parallel, we examined whether specialization for nectarivory is associated with diversification rates, and how this pattern differs between the mainland and the West Indies. The relation between specialization for nectarivory and diversification rate depends on the biogeographical context. Among mainland linages, predominant nectarivorous clades showed higher diversification rates than the rest of the genera. This pattern was not observed when the Antillean genera were included in the analysis. This suggests that specialization for nectarivory has not had a significant effect on diversification of Antillean phyllostomids.

Bats as Key Indicators of Habitat Quality – Assessment through Acoustic Monitoring in Kalakad Mundanthurai Tiger Reserve, India

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Microbats are a key component of healthy ecosystems and are therefore ideal indicators of habitat quality and climate change. The diverse forests of Kalakad Mundanthurai Tiger Reserve (core area of 'Agasthyamalai Biosphere Reserve' and UNESCO treasured part of Asia) are considered as a hotspot for biodiversity and are known to be rich in bat species diversity. Acoustic surveys (Anabat SD1) were used to assess bat activity patterns in different habitats (Agro ecosystem of the foot hills, dense forest, forest near water body, Human settlement at 1000 ft elevation and above 2000ft elevation) of the Kalakad Mundanthurai Tiger Reserve (KMTR). An ANOVA was performed to assess overall differences in bat activity among the different habitats; while multiple regression analyses were applied to assess the impact of different habitat variables on bat activity. Results showed that even a small change of habitat quality – especially through anthropogenic activities - constituted a significant effect on bat assemblages as well as their interactive activities.Bat conservation in the KMTR is essential to maintain the ecosystem services which assist in the preservation of the forest ecosystem. In this study we showed that ultrasonic surveys are an effective method in the assessment of habitat quality which will be not only beneficial for bats but also for other wildlife in the KMTR.

Comparative Population Genetics of Bechstein's Bat and Two of its Ectoparasites

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At a local scale the coadaptation between hosts and their parasites is strongly influenced by the genetic population structure of both species. For parasites, genetic population structure is dependent on the life history of both interacting species. However, the relationship between individual parasite life history variables and genetic population structure are often unclear as they are confounded by host effects. Comparative studies on multiple parasite species infecting a single host can be used to disentangle the influence of host and parasite life history. In this study we compare the genetic population structure of two ectoparasites of the Bechstein's bat (*Myotis bechsteinii*): the mite *Spinturnix bechsteini* and the bat fly *Basilia nana*. Both species are specific to the Bechstein's bat, but differ significantly in several key life history traits, including their mode of reproduction and generation time. Using mtDNA sequences and nucDNA microsatellites, we found strongly differing genetic population structures in the two parasite species. The mite (*S. bechsteini*) was highly differentiated between host maternity colonies, whereas the fly (*B. nana*) was panmictic across the same host maternity colonies. These results can be attributed to differences in effective population size, which are caused primarily by differences in generation time and dispersal opportunities between the two parasite species. Such differences in genetic population structure have substantial implications for the evolutionary potential of the parasites, thereby also affecting the risk and evolutionary pressure exerted by each parasite on its host.

Wing Shape Divergence Among Taxa, Strata and Feeding Behavior: a Geometric Morphometrics Approach

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Chiroptera is highly diversified in phylogeny, and resource and habitat use. Variability is fundamental for natural selection that results in evolutionary process and development. The relation between ecology and shape is the basis for phylogenetic diversity and morphological specializations. Taxonomic diversity is related to the ability to explore a great diversity of habitats and resources. The exploitation of diversified habitat and resource depends on flight dynamic, which is directly related to morphology, especially wing shape. The present research was conducted in the Parque Estadual do Rio Doce, southeastern Brazil, a remnant semi-deciduous Atlantic Forest. Using geometric morphometric task, wing shape variability among taxa, habitat and resource exploitation were analyzed through Canonical Variate Analysis and Discriminant Analysis (MorphoJ). Captures summed 412 individuals, represented by 28 species, 18 genera and four families, in three strata: ground level, lower canopy and higher canopy. Stenodermatinae and Carolliinae were most representative, respectively with 143 and 194 captures (44%

and 96% in ground level). *Artibeus lituratus* were very abundant in all strata and the wing shape differed slightly among the strata (p=0.057). Phyllostomidae totalized 382 captures and the wing shape differed between canopy and ground level (p=0,0052). Molossidae were captured exclusively in canopy and Thyropteridae in ground level. We observed that wing shape diverged specially in wing width and tip, and the position of fourth and fifth digits, the latter the main factor to most wing dimensions. Our results confirm that phylogeny is closely related to wing shape, therefore to ecological factors and flight dynamic characteristics.

Seasonal Digestive Plasticity in the Nectar-feeding Bat *Glossophaga soricina* in a Mexican Dry Forest

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Understanding how animals respond to environmental changes is crucial to predict their responses to different aspects of global change. Studies about the digestive plasticity of animals help us to understand their ability to adapt to changes in the quality and quantity of their food, something that occurs with anthropogenic habitat alterations or under global warming processes. The climatic and phenological seasonal contrast present in the dry forests makes this ecosystem and ideal system to look for digestive plasticity associated to changes in food resources. We compared seasonal changes in digestive morphology of the nectar-feeding bat Glossophaga soricina in west Mexico. The weight and length of the intestine increased significantly (38.55% y 8.15% respectively) during the wet season in comparison to the dry season. Our findings demonstrate that G. soricina is plastic at digestive level, because it is able to increase the absorption surface of its gut, altering nutrient retention time during the wet season, when incorporates fruits and insects to their diet.

New Record of an Ectoparasite Insect (Diptera: Streblidae) for *Platalina genovensium* Thomas, 1928 (Chiroptera: Phyllostomidae) from Perú

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The genus *Platalina* is known from few localities west of the Andes in Peru and northern Chile, with the exception of two records from the department of Huánuco in central Peru. Its elevational range goes from near sea level up to 2,566 m.a.s.l. Its only species *Platalina genovensium*, the largest Lonchophyllinae, is a highly specialized phyllostomid bat that feeds primarily on columnar cacti. *Platalina* is listed as Near Threatened by the IUCN. The main threats to this species are: decline of columnar cacti populations, mainly due to the expansion of the urban areas; disturbance of caves (roost sites) along its entire distribution; and increase in hunting pressure for medicinal purposes. Here we report a new record of an ectoparasite insect from a specimen of *Platalina genovensium* obtained from a bat inventory carried out in northwestern Peru: Piura, Talara, La Brea, 12.9 km N of Tamarindo. From that inventory, four specimens of *Speiseria ambigua* Kessel, 1925 (Diptera: Streblidae) were collected, which is only the second known ectoparasite reported for *Platalina*. The only other ectoparasite reported for the species was *Phalconomus puliciformes* Wenzel, 1976 collected from a specimen from Arequipa, Peru. *Speiseria ambigua* is known to parasitize several species of bats (Mormoopidae, Natalidae, Phyllostomida, and Vespertilionidae) in the Neotropics. In this study we present the northernmost record of *Speiseria ambigua* in Peru.

Foraging Movements of *Uroderma bilobatum* at Tirimbina Biological Reserve, Costa Rica: the Dilemma of Tent-defense for Males

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Peters' tent-making bats, *Uroderma bilobatum*, at Tirimbina Biological Reserve commonly construct and occupy pinnate tents in coconut palms (*Cocos nucifera*). Group size was 2-5 individuals per tent in July 2012, but solitary individuals also could be found in coconut palm tents. Groups always were composed of one adult male, with variable numbers of adult females and subadults. We report core-use and foraging range minimum area probabilities for five radio-tagged individuals. Adult males frequently returned to their tent during the night, often

with fruits for consumption; whereas adult females and subadults were more broadly ranging and did not return to the tent until foraging ceased each night. From flight cage studies we observed handling behaviors including time to consume fruits of identified size and species as well as total wet weight consumed. Finally, we report on the species of fruits and seeds found under tents in this region. We conclude that *U. bilobatum* 1) constructs tents in disturbed areas where the tent is exposed to sunlight and warm temperatures during the day; 2) that adult males defend tents by remaining at the tent through much of the night, 3) that all individuals will traverse both closed canopy forest and highly disturbed areas such as pastures to forage thus this bat species may be an important link in dispersing rain forest seeds for regrowth of highly disturbed areas.

Foraging Behavior of *Ectophylla alba* (Chiroptera: Phyllostomidae), an Extreme Food and Habitat Specialist

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Distribution of resources has a great influence on activity of animals. For bats, availability and spatial distribution of food and roosts are limiting factors, especially for species with specialized requirements. *Ectophylla alba* is a tiny bat with a very limited distribution, that only feeds of fruit of one fig species (*Ficus colubrinae*, Moraceae). For the construction of its tents roosts it requires leaves of a specific size of certain plant species (mostly *Heliconia* sp.) and prefers forests of an intermediate stage of secondary succession. Based on its specialized ecology and its small body size, we hypothesize that movement patterns and foraging behavior will be strongly related to the distribution and availability of food resources and roosts. We followed nine bats with radiotelemetry techniques in the lowland rainforest of Costa Rica and determined the spatial location and availability of *F. colubrinae* trees and tent roosts. Home range size varied greatly among individuals (mean: 8.9 ± 7.0 ha). Foraging activities were mainly restricted to an area of 3.6 ± 2.7 ha. Roosts were located 27.3 m to 1949.6 m from fruiting trees where the bats foraged (mean: 617 ± 280.2 m). Using the 'Kcross' function we found that tents were spatially associated with fruiting fig trees. Our results show that home range size of *E. alba* varies greatly depending on the spatial and temporal distribution of fruiting fig trees. The localization of roosts close to the fig trees indicates that roost selection is also influenced by the proximity to the food resources.

Never Cry "Wolf": the Need for a Holistic Approach on Zoonotic Diseases and Bat Conservation

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Recent studies have reported many previously unknown bat-borne pathogens; these "new species" have had a vast impact in the general public and decision makers with bat culling campaigns, bats officially declared as vermin, and progressively greater economic incentives to continue crying "wolf" with bat-borne pathogens. It is urgent to set the record straight: these pathogens are far from new. The discovery of previously unknown pathogens is only due to new, much more sensitive technologies. Infection to humans is highly unlikely and extremely rare, and the crucial, beneficial ecosystem services bats provide grossly outweigh any potential incidental infection from bats to humans. Although the finding of "new" pathogens is scientifically interesting, caution is necessary in drawing conclusions about the gravity and implications of bat-borne pathogens. Warning people to "stay away" from bats is as empty as warning people to stay away from all wild animals. It is common sense and there is no need to take extra measures to control or contain bat populations. A much more proactive approach instead of simple fishing expeditions to look for those "new pathogens" above all other issues is needed. With the current inventory of pathogens questions should focus on those most likely to create a credible, measurable risk, and study and model their pathogenic potential. If this simple precept is not followed, results will be misinterpreted and will trigger a global hostile response against bats. It is impossible for bats to suddenly become a risk to humans. In fact, greater bat diversity buffers disease prevalence and contagion.

Bat activity in the northern Central Valley of California as determined by long-term acoustic data

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The Sutter Buttes are a unique geological formation in the Central Valley of California that consists of multiple volcanic peaks arranged in a circular pattern measuring 16 km in diameter. This area provides extensive contiguous natural habitat for many mammals including bats. A total of thirteen species of bats have been documented by mist netting studies from the Sutter Buttes. Long-term acoustic monitoring using solar-recharged Anabat detectors has been on-going since 2011 in multiple locations in this small mountain range. Acoustic data from one of these detectors (located at a ponded water feature) was examined to determine activity levels in 1-hr blocks after sunset. The data was calculated for a period of 1-yr to determine peak activity levels on an hours-after-sunset and monthly basis from the acoustic detector location. As expected, peak activity levels were experienced shortly after sunset with gradual peaks and declines throughout the night and bats were detected throughout the entire year (including the winter months).

Characterization of Seasonal and Stress-related Immunity in Pteropodid Bats

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Bats represent critical species: they are physiologically and ecologically unique and are recognized as significant reservoirs for zoonotic diseases. Yet, little is known about their immune responses and how they vary by sex, species, social processes, and environmental conditions. Maintaining a robust defense system at all times is energetically costly and the relative benefits versus costs of this protection vary with life-history state, seasonal shifts in resource availability, and disease risk. In order to better understand the seasonality of immunity, blood samples from male and female captive fruit bats (*Pteropus vampyrus*, *P. pumilus*, *P. hypomelanus*, and *Rousettus aegyptiacus* (males only)) were collected in March, June, September, and December. Additionally, a subset of male *P. vampyrus* and *R. aegyptiacus* were sampled 3 hours post-handling in December. Total antibody (IgG), cortisol, corticosterone, testosterone (males only), and complement hemolytic ability were measured in plasma samples. Blood smears were analyzed for total and differential white blood cell counts. Data presented will characterize within and between Pteropodid species differences across seasons and in response to stress. Identifying how and why immune defense varies in this taxonomic group is fundamental to understanding infection dynamics, both within bat communities and between bats and other mammals.

How Much Variation in Flight Behaviour is Explained by Metabolic Costs?

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Flight is central for the ecological and evolutionary success of Chiroptera. Here, I review studies on how flight energetics (and wing morphology) may have shaped the feeding habits of bats. Particularly, I will focus on experiments with the ^{13}C-labeled Na-bicarbonate method. Aerodynamic theory predicts that metabolic power is highest at low and high speeds and lowest at intermediate speeds. Recently, we confirmed the U-shaped power curve quantitatively for bats flying in a wind tunnel. Our experiments also revealed that metabolic power of some individuals increased linearly with increasing speed, highlighting a large potential for intra-specific variation in flight energetics. We further confirmed that echolocation does not add energy costs to the metabolic requirements of flight. Since wild bats rather engage in complex curvaceous flight than in linear flight, we tested how species-specific differences in wing loading and aspect ratio translate into metabolic differences of maneuvering flight. We demonstrated for two congeneric bat species that a 20% difference in weight translates into a 50% increase in metabolic power for the heavier species, supporting that body morphology largely influences flight energetics. Further, we investigated if centrifugal forces impose additional costs on bats when flying curves. Indeed, metabolism of fast flying bats, such as *Molossus currentium*, even doubled when flying in circles. This may make narrow-spaced habitats unattractive for fast-flowing bats, because the net gain of foraging may become marginal. I conclude that a better understanding of the factors influencing flight energetics may help in explaining context-dependent flight and feeding habits of bats.

Working Together to Save Latin America's Bats

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The conservation of Latin America's bats requires that we work together; researchers, conservationists, educators and others have important roles to play if sustainable conservation is to succeed. The *Red Latinoamericana para la Conservación de los Murciélagos* (RELCOM) is a powerful model that provides a strong foundation for bat conservation throughout Latin America. In 2012, RELCOM and Bat Conservation International (BCI) signed an agreement to work together for these priorities: 1) advancing bat conservation through the RELCOM network; 2) advancing the capacity of students and conservationists in Latin America; 3) developing key educational materials; 4) establishing a rapid response program for crisis situations (e.g. rabies outbreaks); and 5) advancing the conservation of Important Bat Areas/Sites. Since early 2012, BCI and RELCOM have successfully worked together on most of these priorities, and we remain committed to expanding the impact of our partnership in the future. As BCI enters its fourth decade working for the conservation of the world's bats, we are proud to have a new collaborative relationship with RELCOM. The challenges are great and the threats to Latin America's bats continue to grow. Thus, BCI and RELCOM must continue taking steps to strengthen our relationship under a common understanding that we are partners and collaborators in all areas of conservation: research, fieldwork, education, and fundraising. Fittingly, just as 2012 marked the International Year of the Bat, it also ushered in a new era for expanded collaborative bat conservation in Latin America and around the world.

Birdies, Eagles, and…Bats? Bat Activity and Bat Conservation Efforts on Golf Courses in Delaware

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Habitat destruction poses a major threat to biodiversity, and therefore habitat preservation is a top conservation priority. Bats in the Northeastern United States are key components of an ecosystem serving as biological pest controls and indicators of ecosystem health. With continuous land development, new approaches to habitat conservation must be considered. Usually regarded as an environmental nuisance, golf courses may offer an innovative opportunity of using developed land in conjunction with conservation goals by using features on the altered landscape as possible wildlife habitat. Hard-edges and water hazards present on golf course are two elements that encourage foraging bats, and forested patches may offer suitable roosting habitat. As pest predators, bats should be considered beneficial by golf course managers. Using ultrasonic detectors placed at five different microhabitat locations on golf courses, I analyzed bat activity and habitat use as it relates to small scale landscape change. Additionally, in the course of this research several unexpected public outreach opportunities were presented, an integral part of bat conservation efforts. Results indicate that seven of the eight Delaware bat species are present on golf courses and the highest amount of activity is focused near water-hazards and areas with a maintained lawn and high canopy. Open grass areas and unmaintained forest patches showed no significant differences in activity levels. The implications of my study can be used in making more informed decisions in designing new and managing existing golf course landscapes that are both beneficial to the game of golf and bat populations.

Stereotypy and Variability of Social Calls among Huddling Female Big-footed Myotis: Implications for Individual Recognition

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Individual recognition (IR) in animals is required for almost all social behavior, and recognition capabilities differ greatly between species. Previous studies have focused on the recognizer (receiver) and mainly explored the individual recognition ability of single animals; relatively fewer investigations have examined the signaler (the individual being recognized). Bats have an advanced auditory perception system, predominantly using acoustic signals to communicate with each other. Bats can emit a rich range of social calls in complex behavioral contexts. This study examines the vocal repertoire of five pregnant big-footed myotis bats: *Myotis macrodactylus*. In the process of clustering, the last individual to return to the colony (LI) emitted social calls that correlated with the bats' behaviors, as recorded on a PC-based digital recorder. These last individuals could emit 10 simple monosyllabic and 27 complex multisyllabic call types, composed of four syllable types. We show that the social calls are composed of

highly stereotyped syllables, hierarchically organized by a common set of syllables. However, intra-specific variation was also found in the number of syllables, syllable order and patterns of syllable repetition across call renditions. Data were obtained to characterize the significant individual differences that exist in the maximum frequency and duration of calls. The time taken to return to the roost was negatively associated with the diversity of social calls. Our findings indicate that differential access to individual recognition plays an important role in the association between the richness of social calls and success of reunion in female big-footed myotis.

Does Host Exposure or Parasite Establishment Determine Helminth Burdens of *Eptesicus fuscus*?

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In most host-parasite systems, variation in parasite burden among hosts is a major driver of transmission dynamics. Heavily infected individuals introduce disproportionate numbers of infective stages into host populations or the surrounding environment, this, in turn, may cause sharp increases in frequency of infection. Parasite aggregation within the host population may result from both heterogeneous exposure to infective propagules and heterogeneous establishment of parasites in the host. We sought to quantify the relative roles of exposure and establishment in producing variation in parasite burdens in order to predict which hosts are more likely to bear heavy burdens using *Eptesicus fuscus* and its helminths (parasitic worms) as a model system. We captured bats from seven colonies in Michigan and Indiana, assessed their helminth burdens, and collected data on variables related to both exposure (capture location, capture date, water contact) and establishment (host sex, age, body condition, immune function, genetic heterozygosity). Structural equation modeling revealed the best-fitting *a priori* models (AIC=11.704) for all parasite taxa and trematodes alone included host genetic diversity and distance of colony to nearest body of water. The best-fitting model for cestodes and nematodes (AIC=10.64) included month of capture and host genetic diversity. Differential host exposure and differential parasite establishment both appear to play significant roles in creating heterogeneous helminth burdens. However, variables that impact trematode burdens differ from those that impact cestode and nematode burdens. Thus, transmission dynamics are not one-size-fits-all and we must carefully consider biology of host and worm when attempting to predict helminth burdens.

Bat Conservation in Kenya: Challenges and Opportunities

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Public perception of Kenya's wildlife is dominated by charismatic megafauna (e.g. lions and elephants). However, bats hold equal or even greater overall importance by performing vital ecological services that benefit agriculture, forestry, and public health. Comprising of 108+ species and a major part of Kenya's biodiversity, bats play vital ecological roles, influencing forest regeneration through plant pollination and seed dispersal and indirectly affecting all other forest biota. Despite such Kenya's amazing species diversity and valuable ecosystem benefits, bats are severely threatened from the disturbance of crucial roosts, persecution and destruction or fragmentation of their roosting and foraging habitats. Many are known only from type specimens and from habitats that are deteriorating at alarming rates. To minimize or reverse threats facing bats and their habitats, address emerging bat conservation challenges and to demystify some negative beliefs, misinformation and myths about bats, Kenyan representatives at a recent African Bat Conservation Summit in Kenya agreed to establish an active Bat Conservation Network for Kenya, KenBAT, as an NGO to provide a platform for sharing and coordinating bat research and conservation activities in Kenya. Through KenBAT, priorities will be identified for bat conservation (including identifying important bat areas) in Kenya through measures such as mapping key bat roosting sites, identifying local Kenyan species "redlist" for their protection, and robust public outreach and environmental educational programmes. Current key research initiatives are highlighted.

Personality and Ectoparasite Prevalence in *Myotis lucifugus*

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Animal personality has been linked to variation in numerous physiological, behavioural and energetic traits. Some aspects of personality, such as exploration or boldness, also correlate with use and exploration of space which

can increase risk of exposure to parasites or pathogens. Ectoparasite exposure may also be affected by degree of coloniality and age-related variation in grooming ability. We tested the hypothesis that individual personality, sex, and age correlate with ectoparasite loads in little brown bats (*Myotis lucifugus*). We predicted that: 1) individuals with bold, explorative and active personalities would exhibit relatively high ectoparasite prevalence; 2) females and juveniles would have greater ectoparasite prevalence than males because of colonial roosting; and 3) juveniles would have greater ectoparasite prevalence than adults due to their inexperience grooming. Throughout the autumn swarm period, we used infrared video to record behavioural responses of individuals in a novel-environment test during ten-minute trials and subsequently sampled each individual for ectoparasites. We identified the same personality dimensions previously observed in rodent and bat studies but found no evidence of a link between personality and ectoparasite prevalence in little brown bats. Interestingly, however, we found an interaction between demographic and date throughout the swarming period which was driven by an increase in parasite prevalence for male bats as swarming progressed Although, individual variation in personality has been predicted to influence parasite exposure, my study suggests that highly social species, with many frequent contacts between individuals, may differ from other model species used in personality studies.

Spring Time Ecology of Virginia Big-eared Bats in North Carolina

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While there is some information about the ecology of Virginia big-eared bats (*Corynorhinus townsendii virginianus*), we lack information on seasonal movements, foraging habitats and ranges, and locations of maternity roosts for some populations. In particular, there is no information on the spring/summer ecology of female Virginia big-eared bats in North Carolina, which is one of five states where the subspecies occurs. Our goals were to identify temporal and spatial patterns in migratory movements, quantify the size of and measure the characteristics of foraging ranges, and identify factors important in roost habitat selection for the NC population. From late March to early April 2013, 19 female Virginia big-eared bats were radio tagged and tracked to locate roosts and foraging areas. We recorded elevation, aspect, dimensions, outside clutter, and distance to water for each roost found. Roosting and foraging ranges were calculated using the programs Locate III and Geospatial Modeling Environment, then plotted in a Geographic Information System. Bats moved up to 22.7 km from the hibernaculum to a primary maternity roost and several secondary roosts, which were all at lower elevations than the hibernaculum. Large caves, relatively open rock structures, as well as buildings were used as roosts. Identifying movements, foraging areas, and roost characteristics of Virginia big-eared bats in North Carolina will give managers precise information about critical foraging and maternity habitat, and may guide efforts to mitigate for habitat loss.

Echolocation Behavior of Hoary Bats During Migration Provides Insights into Their Disproportionate Fatality Rate at Wind Energy Facilities

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Hoary bats (*Lasiurus cinereus*) are the bat species most impacted by wind energy development in North America. Fatalities of hoary bats peak during autumn migration but the reasons remain enigmatic. Among hypotheses posed to explain this pattern are 1) season-specific behaviors render hoary bats more susceptible during autumn and 2) migrating bats are less likely to echolocate. Using ground-based observations in an area of migration concentration we demonstrate that increased susceptibility could result from a combination of these behaviors. During autumn 2011 and 2012 we captured large numbers of, predominantly male, hoary bats in forests of northwestern California. Bouts of pursuit were frequently observed and hoary bats were often captured in pairs using mist nets. Although hoary bats emit high intensity echolocation calls and are generally considered easy to detect, we captured more individuals than we recorded with echolocation detectors. On multiple occasions, we observed, or recorded video footage of, hoary bat activity well within range of a detector, but no vocalizations were recorded. Clearly some hoary bats were not using echolocation during flight, at least part of the time. It follows that bats engaged in pursuit behaviors, especially while suspending use of echolocation, will be at higher risk of collision. Documentation of these behaviors, or the lack thereof, in different settings and at other times of year may provide a partial explanation for the susceptibility of hoary bats to fatality by wind turbines and why susceptibility appears to peak in autumn.

Interactions between Tent-roosting Bats and Roost Plant Abundance Catalyze Seed Dispersal and Seedling Regeneration during Tropical Forest Succession

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Phyllostomid tent-making bats construct tent roosts in over 75 plant species in wet tropical forests. Tent-bats eat over 62 species of fruits, and can deposit seeds at tent roosts. The plant communities of regenerating tropical forests change over time, affecting availability of food and roosting resources needed by tent-making bats. In northeastern Costa Rica, we examined tent abundance during forest regeneration in 21 one-hectare plots ranging from 15 years to old-growth, or selectively logged. The main objective was to assess effects of changing abundance of tent roost plants and canopy fruiting trees on tent abundance and seed dispersal by tent-making bats in regenerating forests. We monitored seed traps at tents and control plants 5 m from tents, and surveyed canopy tree phenology monthly for one year. Seedling abundance of large-seeded species consumed by tent-bats was surveyed around tents and controls located 25 m from tents. Total average tent abundance increased significantly with forest age category; however, within site variation was important and varied by tent type. Tent-plant surveys in each hectare showed that average abundance of the 9 most commonly used species increased with forest age, and canopy tree fruits commonly eaten by tent-bats were more abundant in older forests. Bat tents were associated with 50% higher seedling abundance of focal species and higher species richness of seeds. Tent plant abundance and canopy fruit resources act interdependently to facilitate tent colonization. As roosting sites increase during forest succession, so do the importance of bat dispersal and regeneration of bat-dispersed species.

Winter Activity of Four Bat Species at Three Desert Hibernacula in Idaho

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Documenting activity patterns of hibernating bats in western North America is important for understanding the behavioral ecology of these mammals, especially before white-nose syndrome potentially affects some of these species. Activity patterns of bats during winter in western North America, however, are poorly understood. We acoustically monitored 3 caves (Middle Butte, Rattlesnake, and Aviator caves) that are important hibernacula (up to 705 hibernating bats) in southeastern Idaho during winter (November to March) from 2011 to 2013. At those caves, AnaBat detectors were set for 234 sampling nights during 2011 to 2012 and for 320 sampling nights during 2012 to 2013. We used filters in AnaLookW to quantify bat passes (sequences ≥ 2 calls separated by ≥ 1 second), and documented western small-footed myotis (*Myotis cilolabrium*), Townsend's big-eared bat (*Corynorhinus townsendii townsendii*), big brown bat (*Eptesicus fuscus*), and the little brown myotis (*Myotis lucifugus*) flying outside of caves during mid-winter. Activity was highly sporadic and differed among species, with western small-footed myotis being most active during winter (bat passes = 2,303), followed by Townsend's big-eared bat (bat passes = 694). We recorded the highest diversity (4 species) and the most activity (3,051 bat passes) at Middle Butte Cave. Our study documents activity patterns outside of caves for several species of bats during hibernation. These results improve our understanding of the behavioral ecology of these species in western North America prior to the potential arrival white-nose syndrome, and the possibility of this disease altering winter behavior of these mammals

Crucial Hibernacula for Bats in Southern Idaho: Implications for Conservation and Management

Jericho Whiting, J. Lowe, S.t Earl, A. Earl, B. Doering, D. Englestead, J. Frye, R. Cavallaro, T. Stefanic, and B. Bosworth
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Bat populations are being impacted by human disturbance and modification of hibernacula. Identifying important hibernacula and counting hibernating bats are effective ways to conserve these mammals. We compiled periodic counts of hibernating bats during winter (November to March) in 36 caves from 1984 to 2013 to document the number of caves used by bats, as well as to investigate if the number of bats hibernating varied by colony size. Researchers counted 24,919 bats representing 6 species. Townsend's big-eared bats (*Corynorhinus townsendii townsendii*) comprised 95.8% (23,874 individuals) of those bats and used 35 caves, and western small-footed myotis (*Myotis ciliolabrum*) comprised 4.1% (1,014) of those bats and used 19 caves. Twenty caves were substantial

hibernacula (≥ 20 individuals) for Townsend's big-eared bats, and five caves were substantial hibernacula (≥ 5 individuals) for western small-footed myotis. The largest hibernating colony of *C. t. townsendii* occupied Kid's Cave ($\bar{X}$ = 1,446, *SD* = 516.3, range = 619 to 1,994 individuals). The largest hibernating colony of *M. ciliolabrum* occupied Fool's Wading Pool ($\bar{X}$ = 87, *SD* = 51.4, range = 32 to 146 individuals). Smaller hibernating colonies varied more in the number of bats counted than did larger colonies. We document one of the largest densities of caves used by hibernating bats in the western USA, as well as possibly the largest reported hibernacula for Townsend's big-eared bats and western small-footed myotis in their distributions. This information provides important context regarding hibernating bats prior to major threats (i.e., white-nose syndrome) occurring in southern Idaho.

The Effect of Personality on Pre-hibernation Food Intake in Little Brown Bats

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Consistent individual differences in behaviour (i.e., personality) influence many aspects of animal ecology including foraging behaviours such as the tendency to investigate and accept novel food sources. Hibernators must accumulate large energy stores during autumn to survive the winter. Individuals vary in both fall body condition and hibernation energy expenditure, and personality could help explain this variation. We tested this hypothesis using captive *Myotis lucifugus*. We predicted that individuals with active and explorative personalities would learn to accept mealworms more quickly during initial captivity and gain mass more quickly prior to hibernation. In late summer 2012, we captured 41 juvenile male *M. lucifugus* in Manitoba, Canada and held them in a flight cage for six weeks prior to hibernation. Beginning on the second day of captivity, we used a hole-board test (i.e., 57 x 42 cm vertically oriented arena with 3 cm diameter holes spaced at varying distances from the walls) to quantify personality. We quantified the length of time required for each individual to take mealworms on their own and, once each individual could self-feed, we recorded its body mass at weekly intervals to quantify pre-hibernation fattening. Analyses are currently ongoing, but our findings will improve the understanding of the relationship between personality and pre-hibernation fattening of bats, which has critical implications for survival of hibernation.

Phylogeography of Little Brown Myotis Using RAD-Seq: Genome-Wide Patterns of Genetic Diversity and Divergence

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Myotis lucifugus is among the most widespread and well-studied bat species. Information on its demographic history and possible adaptive differences among regional populations is particularly valuable, given the precipitous decline of populations in eastern North America due to white-nose syndrome (WNS). We used restriction site-associated DNA sequencing (RAD-Seq) to generate thousands of short sequences scattered throughout the genome from individuals sampled across the species' range. Clustering analyses distinguish eastern and western populations with admixture east of the Rocky Mountains. West of the Rockies, *M. lucifugus* exhibits an isolation-by-distance pattern in which genetic similarity declines with geographic distance; east of the Rockies, genomic data suggests that the population is essentially panmictic (or has been in the recent past). This pattern at autosomal loci contrasts with that of the maternally inherited cytochrome *b* gene, which is geographically structured in both the East and West, suggesting male-biased dispersal. We fit several candidate demographic models using δaδi, a program that simulates the expected allele frequency spectrum (AFS) under a given model. The observed AFS best fits a model where, early in the Pleistocene, part of the ancestral population split off and then expanded in the East. A genome scan using RAD loci identified ~125 "outlier" loci that may differ between East and West due to divergent selection. Potentially unique adaptations to the WNS-threatened region warrant further exploration because preservation of functional diversity is critical to species conservation, and adaptive differences may have important implications for repopulation of WNS-affected regions by migrants.

Bats in Tropical Agroecosystems: Impacts on Production and Implications of Changes in Agricultural Management for Bat Conservation

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Land use in the tropics is dominated by agricultural production. Tropical bats provide a variety of ecosystem services, from seed dispersal to pollination to limitation of insect populations, and many investigators have documented bat populations in different kinds of tropical agroecosystems, although information is limited on how different kinds of agricultural production affect bat populations. Similarly, there is little quantitative information describing the impacts of tropical bats on agricultural production or how change in agricultural systems affects their provision. In this talk, I briefly review current knowledge about how bats impact agricultural production in the tropics. Using the role of bats in controlling insect pests of coffee, I explore how changes in agricultural intensification affect bat diversity, abundance, and provision of the ecosystem service of pest control. Although in these systems bats demonstrate little change in species richness across different habitat types, their abundance decreases with increasing agricultural intensification, and high-shade coffee plantations support species assemblages similar to those found in forested areas. In high-shade, traditional polyculture shade coffee, bats provide effective limitation of herbivorous arthropods and feed on the most devastating insect pests of coffee. Bats that feed on coffee pests are forest specialists whose activity declines with increasing agricultural intensification. Other investigations in more intensive coffee systems have failed to demonstrate an effect of bat predation on insect pests. These results suggest that agricultural intensification may limit the ability of bats to provide services in agroecosystems. Changes in agricultural management in the tropics affect both bat populations and the degree to which bats enhance agricultural production.

Consistent Behavioral Differences between Individuals of the Nectar-feeding Bat *Glossophaga commissarisi*

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Humboldt-University, Germany

In natural populations of animals and humans a whole range of individual differences in behavior have been found. These differences are consistent over time and/or across contexts and have been referred to as animal personality, behavioral syndrome or temperament. The long-term goal of our project is to get a better understanding why and how different behavioral traits within one species have been retained during the course of evolution. One hypothesis is that these individual differences have been maintained via frequency-dependent selection because they are adaptations to slightly different environments. To further substantiate this hypothesis with empirical data we aim to investigate how behavioral traits influence the fitness-relevant foraging efficiency of the nectar-feeding bat species *Glossophaga commissarisi* in different environmental conditions. The first step to reach this goal is to characterize behavioral traits in this species. Therefore we conducted a series of experiments over two months in the controlled environment of flight cages in Costa Rica. With this setup RFID marked bats could visit a field of artificial, computer-controlled flowers. We measured different behavioral parameters and found consistent individual differences with high repeatability and correlations between them. These results show that behavioral traits also exist in this bat species and they provide the basis to further investigate the influence of behavioral traits on the foraging efficiency of these bats under different ecological conditions.

How Malaria Gets Around: the Genetic Structure of a Parasite, Vector, and Host Compared

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Parasites with complex life cycles have two host species shaping their genetic structure, but the traditional view posits that the parasite's structure will be mainly determined by the most mobile host species. Malarial parasites are a prime example of parasites with a complex life cycle, needing both a dipteran and vertebrate host to complete their life cycle. In both hosts they impose selection pressures. Yet, how vertebrate and dipteran host

populations shape the parasite's genetics has been little studied. The relative contribution of each host to the parasite's population structure has therefore never been satisfyingly determined. Being the most mobile host, we predict that the vertebrate host will show the most similarities with the structure of the malarial parasite. We compare the genetic structure of all three actors in a parasite-vector-host system: the vertebrate host, the long-fingered bat (*Miniopterus schreibersii*); the vector/dipteran host, the wingless bat fly *Nycteribia schmidlii*, and the malaria parasite *Polychromophilus melanipherus* using traditional microsatellite markers, cyt*b* DNA sequencing and a SNP library obtained by ddRAD sequencing. We found relatively high structure in the bats. In contrast, the haplotype distribution of *P. melanipherus* shows little geographic differentiation. We investigate the role of the dipteran host in generating the observed patterns and conclude that the vertebrate host alone is not affecting the genetic structure of the haemosporidian parasite, but that it is probably the high dispersal rate of the vector that shapes the geographical structure of the parasite populations.

Summer Home Range Size of Female *Myotis sodalis* in Missouri

Kathryn Womack, Frank Thompson III, and Sybill Amelon
University of Missouri; U. S. Forest Service, USA

We radio tracked 13 pregnant and 12 lactating *Myotis sodalis* (Indiana bats) during the maternity season in northern Missouri. We hypothesized that home range size and nightly distance traveled would be smaller for lactating bats since pregnant bats are able to night roost in foraging areas. Mean (± SE) home range area based on the fixed kernel method for the 50% and 95% probability contours was 203.6 ± 26.0 ha and 1116.7 ± 129.3 ha, respectively. Home range size did not differ significantly by reproductive condition; although, data suggests some spatial trends as the mean 95% probability contours for lactating individuals was 1367.0 ± 267.2 ha versus 930.5 ± 109.6 ha. The mean maximum distance individuals were observed from the roost while foraging was 4.9 km (range: 2.2–9.4 km) for lactating and 3.7 km (range: 1.9–5.1 km) for pregnant individuals. We did not find support for our hypothesis, which might be a reflection of date since parturition. Our estimates of home range size and maximum distance traveled are substantially greater than previously reported for Indiana bats during the maternity season.

Use of 3D Flight Path Reconstruction in Bat Social Behavior Research

Genevieve Spanjer Wright, Chen Chiu, Wei Xian, Gerald Wilkinson, and Cynthia Moss
University of Maryland, USA

Understanding social interactions and communication between individuals can help illuminate many aspects of bat behavior. Gathering detailed information about the flight behavior and vocalizations of individuals can be an arduous task, but collecting this information can allow the researcher to address many previously unanswered questions. In a series of experiments, we examined the use of social information in learning a foraging task, the use of communicative vocalizations to mediate interactions, and the behavior of big brown bats (*Eptesicus fuscus*) in a competitive foraging situation. We used synchronized high-speed video and audio recordings to recreate flight paths of bats, assign vocalizations to individuals, and quantify flight patterns and inter-bat distances. Through these analyses, we determined that bats display increased following/chasing behavior and decreased inter-bat distance when social learning is occurring and that emission of some social vocalizations varies by sex, age, and foraging context. One specific call type (social sequence) was emitted only by males and in a foraging setting and was associated with an increase in diverging flight and inter-bat distance, along with greater prey capture success for the calling bat. This collection of findings offers new insight into the behavior of foraging bats and highlights the utility of position data and flight path reconstruction in studying social behavior and communication in a nocturnal flying animal.

Foraging and Roosting Behavior for a Male and Female Western Red Bat (*Lasiurus blossevillii*) in the Northern Central Valley of California

David Wyatt, Daniel Neal, Chandra Jenkins, and Kathleen Norton
Sacramento City College, USA

One adult male and one adult female western red bat were radiotagged and tracked over multiple nights in the northern portion of the Central Valley in California. The Sutter Buttes are a small volcanic mountain range and are one of the few large, contiguous areas of undeveloped habitat remaining in the Central Valley. The bats were tracked to their roost sites and to their foraging areas. The male was using a day roost of multiple vine species

consisting of a mixture of California wild grape, poison oak, and pipe vine. This vine cluster was suspended in the canopy of an oak. The male was also found night roosting in a mixture of Fremont cottonwood and Goodding's willow. The female consistently day roosted in a maternity roost in the canopy of a large Valley oak and was found returning to the same roost to night roost. This maternity roost had two adult females and up to five juveniles present. Both the male and female bats were radiotracked to their foraging areas over multiple nights. Both bats traveled a considerable distance from their day roosts (up to 10 km from their roosts) during windless nights but stayed close to their day roosts when windy conditions prevailed. During the windless nights, they had remarkably consistent nightly foraging core areas over the wetlands at the Gray Lodge Wildlife Area. The distances traveled by the bats suggest that wetlands are critically important for these bats and, if energetically feasible (e.g. windless nights), they will travel great distances to reach these wetlands.

A Field Key to the Bats of Costa Rica and Nicaragua

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Buena Vista University, USA; University of Kansas, USA; Universidad de Costa Rica and Asociación Theria, Costa Rica; Medical and Scientific Illustrator, USA, The Bat Jungle at Monteverde, Costa Rica

We present a new, well-illustrated, dichotomous field key to the bats of Costa Rica and Nicaragua. This key allows for the unambiguous diagnosis of 123 species known or suspected to occur in these countries and features a large number of revisions to previous keys, including taxonomic updates, the addition of more than 30 illustrations, and major revisions to the layout of couplets and to the descriptions of field characteristics designed to facilitate use. The key is to be published at KU ScholarWorks, the online digital repository of the University of Kansas, which allows full open access to the document. The page layout and use of line drawings renders printed and reproduced copies easy-to-use in the field. The development of an interactive digital app for iOS and Android systems is in-progress.

Envisioning a Global Data Network for Bats

Bruce Young, Lori Scott, and Mary Klein
NatureServe, USA

As interest in bat conservation has increased, so has the volume of research on bats. The resulting proliferation of data and management guidance creates the possibility for tremendous gains in local capacity, through sharing of information and expertise. The question, then, is how best to organize this wealth of information so it can be most useful to the conservation community? NatureServe has 40 years of experience working with a geographically-dispersed network of data centers to implement data systems that support information sharing and the ability to roll up data to address conservation challenges at national and international scales. This system already includes taxonomic and conservation information for 366 bat species spanning nearly 50 nations. NatureServe will share its experience working with a decentralized data network and describe a vision for a global bat data network that could be developed and deployed in collaboration with Bat Conservation International.

Citizen Scientists and Acoustic Technology Team Up

Anna Zack, Sybill Amelon, and David Riggs
University of Missouri; U. S. Forest Service; MYOTISOFT; Master Naturalists, USA

Bats are currently faced with a suite of threats, including roost disturbance, habitat loss, wind development, white-nose syndrome and other diseases, as well as, synergistic and interacting effects. Localized bat mortality from these threats is well-documented in some cases, but long-term changes in regional populations of bats remain poorly understood. Acoustic detectors are a tool available for assessing bat status on the landscape and can provide indices of change over time at large spatial scales. Various approaches are currently being used, including driving and walking transects and point monitoring. Evaluation of tradeoffs in spatial and temporal distribution, sampling investment, logistics and potential for statistical analysis associated with these methods is needed by natural resource managers. Our study includes each of these acoustic methods and teamed researchers, software developers and citizen scientists to quantify the tradeoffs associated with each and to provide a visual interpretation of the results. The Miramiguoa Chapter of Missouri Master Naturalists (MMN) conducted acoustic surveys within the Ozark Highlands ecological region of Missouri while researchers conducted acoustic surveys across a larger geographic area. Equipment and training were provided by USFS Northern Research Station and MMN volunteered

their time. MYOTISOFT software was used for the visual interpretation. Our team approach resulted in 10 walking, 10 driving transects, 10 driving with point counts and 32 passive points of monitoring data each repeated a minimum of 2 times to assess detection probability. Each transect or monitoring station can be accessed visually in Google Earth or ArcMap© using MYOTISOFT Transecticizer or TransectPro. We discuss tradeoffs associated with sample design, analysis, occupancy status and how this team approach offers multiple benefits for a regional bat monitoring program.

Activity Patterns of the Pond Bat *Myotis dasycneme* from a Maternity Colony

Aneta Zapart, Mateusz Ciechanowski, and Karolina Iwińska
University of Gdańsk, Poland

Despite the fact, that in some regions of Europe, numerous and easily available populations of pond bat *Myotis dasycneme* still occur, research on ecology and ethology of that threatened, trawling vespertilionid is relatively scarce. The aim of this study was to examine patterns of emergence, return and associated behaviour of pond bats from the nursery roost in Poland. We compared activity patterns in pregnancy and lactation, as the female bats are known to reveal different energy demands in those two periods. The study was conducted from 21.05.2010 to 26.09.2010 and from 08.05.2011 to 11.09.2011. All bat movements through the entrances were monitored using 2 infrared (IR) cameras OPTIVA, while data on weather conditions (air temperature, pressure, wind speed, precipitation) were recorded with automatic weather station La Crosse Technology, model WS 3650 IT. The number of events (departures, arrivals or hidings) per every 15 minutes were converted to % of events during particular nights. Percentages were included in the RDA model, to check if nightly pattern of roost use is affected by weather conditions or only by time. In the first season loft was occupied by bats until the beginning of July but in the second one until the second half of August, with the peak number in the first half on June. The time of emergence did not differ significantly between seasons and occurred in average 26 minutes (2010) and 24 minutes (2011) after sunset. The significant changes in the behavior of pregnant and lactating females were recorded.

Nightly Movements and Changes in Habitat Selection During Pregnancy and Lactation in a Threatened Habitat Specialist, *Myotis dasycneme*

Aneta Zapart, Mateusz Ciechanowski, *Tomasz Kokurewicz, Marcin Rusiński, and Magda Lazarus
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Pond bat *M. dasycneme* is a trawling vespertilionid that hunts insects over larger water bodies and occupies mostly anthropogenic roosts during daytime. It is considered near threatened globally and endangered in Poland. Data on its foraging patterns and habitat preferences based on radiotracking are almost lacking. In 2012 we attached radio transmitters (Holohil Systems) to 8 females during pregnancy (early May) and 8 females with signs of lactation (late June) and tracked them with Australis 26k receivers (Titley Electronics) and Y-3 directional antennas. Their communal home range in May was 6 229 ha, while in June was only 3 818 ha (90% Kernel). During pregnancy, most animals switched to alternative roosts (buildings), located 7.5-19 km from tagging site, but the majority of lactating females remained in the original nursery roost, i.e. old forester's lodge. Pregnant females visited many foraging sites (almost exclusively lakes) spending a short time in each of them, whereas during lactation 1-2 foraging sites (both lakes and relatively short sections of rivers or canals) were visited and bats spent up to 2 hours, foraging there. The furthest foraging site during pregnancy was located 22 km from roost (mean 8 km), on contrary to the lactation when the foraging sites were located up to 9 km from colony (mean 5 km). This switch in foraging strategy likely made possible to avoid the intraspecific competition in early spring when food resources were limited and allowed multiple returns to the colony at night in early summer, presumably to feed offspring.

Nycteribiidae of Croatia

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Since 1937, when Z. Karaman published her work on Nycteribiidae of Yugoslavia, where she described species sampled on bats collected throughout Yugoslavia, there hasn't been any systematic research on Nycteribiidae in Croatia. The aim of this research is to compile a basic list of Nycteribiidae for further research of ectoparasites of bats in Croatia. The study was conducted in the period from 2008 to 2011, where 161 bats were

sampled and it deals with 110 Nycteribiidae specimens sampled from 11 species of bats from several sites within Croatia. Out of eight collected species, two were recorded in Croatia for the first time, *Basilia italica* and *B. nana*, sampled from *Hypsugo savii* and *Miniopterus schreibersii.* Additional studies are necessary to complete the list of Nycteribiidae, as well as of other ectoparasites recorded in Croatia.

Flying or Sleeping: Influence of WNS on Flight Activity of Bats during Deep Hibernation

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Several bat species are threatened by White-nose Syndrome (WNS) in North America and Europe. WNS affected bats typically have visible white cover on the muzzles, wings and ears, and exhibit abnormal hibernation behavior. Our objective was to test the influence of WNS on hibernation behavior and flight activity of European bats. We predicted that affected bats will exhibit abnormal flight activity (higher level and sooner onset of activity) and different general pattern of hibernation. Hibernation behavior of bats was studied in a limestone cave during two winter seasons 2006/07 (before WNS detection) and 2010/11 (after WNS). Only data from „deep hibernation" period were analyzed. We realized biweekly visual monitoring of hibernating bats and observation of bat flight activity in the cave with a night-vision scope. Bat movements through the hole in the gate were monitored continuously by a custom-made IR barrier. We did not registered abnormal changes in bat hibernation behavior, activity level or its seasonal pattern after WNS occurrence. Flight activity was generally low and temperature remained the best predictor of its level. The higher ambient temperatures increased flight activity of bats, made its onset more desynchronized and bats were leaving the cave even during January. Low prevalence of WNS registered at locality under study combined with stable hibernation behavior support the hypothesis that the fungus has been present in Europe for a long time and has only recently invaded North America. This study was supported by the grant of GACR No. 506/12/1064 and institutional support RVO:68081766.

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