

## **Cryptic diversity in Mongolian vespertilionid bats (Vespertilionidae, Chiroptera, Mammalia). Results of the Mongolian-German biological expeditions since 1962, No. 299**

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In contrast to the Eastern Palaearctic region a high degree of cryptic diversity was discovered among temperate bats of the Western Palaearctic region in the last ten years. Climatic oscillations caused severe changes in the distribution of species throughout the Palaearctic region during the Pleistocene. Exploring multiple taxa can help to understand general evolutionary differentiation processes. In the present study genetic variation within and among 94 Mongolian vespertilionid bats of six genera (*Hypsugo*, *Eptesicus*, *Vespertilio*, *Myotis*, *Plecotus*, and *Nyctalus*) was screened by sequencing a 798 bp fragment of the mitochondrial ND1 gene and then subsequently compared with those of Western Palaearctic taxa. This allowed first insights in the differentiation among a wide range of bats across the Palaearctic region. A total of 16 distinct mitochondrial lineages were found in Mongolia. Thirteen lineages differed by at least five percent sequence divergence from Western Palaearctic species. Only three lineages (*Eptesicus nilssonii*, *Vespertilio murinus*, and *Nyctalus noctula*) showed lower divergence values. Our data demonstrate a substantial differentiation between most Western and Eastern Palaearctic vespertilionid bats. Estimations of divergence times showed that most divergence appeared prior to the Pleistocene, but current distributions of bats were most likely shaped by the usage of multiple refugia during glaciations.

*Key words:* biogeography, Chiroptera, Palaearctic region, cryptic species, mtDNA sequence divergence, phylogeny

## ***Nyctalus plancyi* and *Falsistrellus petersi* (Chiroptera: Vespertilionidae) from northern Luzon, Philippines: ecology, phylogeny, and biogeographic implications**

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We report the first records of *Nyctalus plancyi* from the Philippines, on the basis of three specimens taken in high-elevation mossy forest in the Central Cordillera of northern Luzon. We also report three new specimens of *Falsistrellus petersi* in the same areas, previously a poorly known species within the Philippines, and provide the first genetic data on the phylogenetic position of the genus. Analysis of sequence data from the mitochondrial gene cytochrome *b* shows ca. 4% divergence of the Philippine *N. plancyi* from a sample from China. Combined sequence data from cytochrome *b* and the nuclear gene RAG2 confirm that *N. plancyi* is related to *Pipistrellus*. They further show that *F. petersi* is related to *Hypsugo* and *Vespertilio*, and *Philetor brachypterus* is related to *Tylonycteris*, with all of these taxa being members of the Vespertilionini, not the Pipistrellini. *Nyctalus plancyi* is the first mammal species documented to have colonized the main, oceanic body of the Philippines from the north (i.e., Taiwan or mainland China), rather than from the south (Borneo, Sulawesi, or New Guinea).

*Key words:* colonization, cytochrome *b*, RAG2, mossy forest, oceanic islands, Southeast Asia

## **Syntopic occurrence in Turkey supports separate species status for *Miniopterus schreibersii schreibersii* and *M. schreibersii pallidus* (Mammalia: Chiroptera)**

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*Miniopterus schreibersii* is a complex, polytypic species group with a wide distribution ranging from Northern Africa, Southern Europe to Asia, the Solomon Islands and Northern Australia. Two subspecies previously recognized in Turkey, *M. s. schreibersii* and *M. s. pallidus*, differ significantly in nuclear and mitochondrial DNA, and in morphology. Until now, the distribution records of *M. s. schreibersii* and *M. s. pallidus* showed that they were allopatric and hence even though there was clear morphological and genetic differentiation between the two taxa, whether they represented separate species or subspecies was still not determined with certainty. Here we present the first data on syntopic occurrence of both forms in three caves in south-eastern Turkey. We show that the three caves host individuals of both taxa by using mitochondrial DNA, nuclear DNA and morphometric analyses. These findings provide the final line of evidence to date, for designation of *M. s. schreibersii* and *M. s. pallidus* as two separate species, *M. schreibersii* and *M. pallidus*. This will raise the number of species in the Eurobats agreement area from 45 to 46.

**Key words:** Chiroptera, *Miniopterus schreibersii*, speciation, Anatolia, mitochondrial DNA, microsatellites

## **Taxonomic position of the Bobrinski's serotine (*Eptesicus bobrinski*, Vespertilionidae, Chiroptera)**

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The taxonomic position of Bobrinski's serotine (*Eptesicus bobrinski*) is still unclear. In the present study the relationships between *E. bobrinski* and other small Palaearctic serotines were examined based on morphometric and molecular evidence. Both mitochondrial (cytochrome *b*) and nuclear (THY) sequence data indicate that *E. bobrinski* is closely related to Gobi serotine (*E. gobiensis*). The difference between these two forms is significantly lower than between either of them and any other Palaearctic serotine. The results of morphometric analysis suggest that morphological differentiation between *E. gobiensis* and *E. bobrinski* is to a large extent accounted for by size difference. It is concluded that the species status of Bobrinski's serotine is doubtful and this bat should be treated as a subspecies of *E. gobiensis*.

*Key words:* *Eptesicus*, taxonomy, morphometrics, *cytb*, *Eptesicus gobiensis*, Central Asia, geographic variation

## **Taxonomic status assessment of the Mexican populations of funnel-eared bats, genus *Natalus* (Chiroptera: Natalidae)**

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Due to its morphological conservatism, the American funnel-eared bats of the genus *Natalus* have had a complex taxonomic history. In Mexico only one species, *N. stramineus*, has traditionally been recognized. But recently a new endemic species, *N. lanatus*, was described in the region as a sympatric sibling species of *N. stramineus*. *Natalus stramineus*, with a geographic distribution extending from Mexico to Panama, was subsequently reassigned to *N. mexicanus*. In this study, we analyzed morphological and molecular characters to determine if two distinct species of funnel-eared bats (*N. lanatus* and *N. mexicanus*) occur in Mexico. We found that the proposed diagnostic morphological characters that separate the two taxa are not consistent and rarely differentiate between the two forms. Likewise, phylogenetic analyses do not support the separation of *Natalus* into two species in Mexico, but there is clearly geographic structure when all Mexican haplotypes are combined. The genetic distance between the haplotypes that could be ascribed to *N. lanatus* and *N. mexicanus* was typically within the range of conspecifics and not distinct species. To summarize, the results of both morphological and molecular analyses point to the presence of a single species of *Natalus* in Mexico.

*Key words:* bats, cytochrome *b*, Mexico, sibling species, taxonomy

## **Quantification of morphological variation within species of *Anoura* from Ecuador, with an emphasis on *A. fistulata* (Chiroptera: Phyllostomidae)**

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The original description for *Anoura fistulata* (long-lipped bat) was mostly qualitative in nature. Here we make a quantitative reassessment of morphological variation in skull shape for this and other Ecuadorian species. Our goal is to provide a perspective into morphospace for understanding the boundaries and extent of variation within and among species of *Anoura* occurring in Ecuador. Our results show that, besides its singular differences in soft-tissue anatomy, the distribution of samples in morphospace for *A. fistulata* suggests this species occupies an intermediate space between *A. geoffroyi* and *A. caudifer*. *Anoura geoffroyi* and *A. caudifer* share opposite regions of morphospace, where size is the largest factor contributing to variation, and along the shape vector both species are distinguished mostly by a contraction of the maxilla and a contraction of the braincase, respectively. Although size is the main factor determining boundaries among species, for *A. cultrata* shape seems to be more relevant, as its geometric configuration of the skull is remarkably different. The other species are similar in shape when size is factored out. An unusual group of specimens may require further study as they may represent an unknown species, as these occupy unexpected areas of morphospace. A discussion of why we do not think there is evidence to assign this unusual group to any of the small species of *Anoura* (i.e. *A. caudifer*, *A. aequatoris*, and *A. luismanueli*) is also included. Populations of *A. geoffroyi* from the western and eastern slopes of the Andes show statistically supported differences in most of the measured morphological traits, however this is not true for *A. caudifer*. The effect of western and eastern habitats on the geometric configuration of the skull is different and inverted between both species. This results in a statistical interaction between the two slopes of the Andes and the two species. Eastern populations of *A. geoffroyi* and *A. caudifer* are morphologically closer than western populations in both species. *Anoura geoffroyi* possesses a larger altitudinal range and a larger body size, a positive correlation that may concur with the hypothesis of body size serving as a buffer to extreme or highly variable environments. The frequency distribution of character states in morphospace and their differentiation across the various species of *Anoura* is discussed in the context of diet and habitat.

*Key words:* *Anoura*, geometric morphometrics, morphology, morphospace, shape, size, species boundaries

## **Dietary composition, resource partitioning and trophic niche overlap in three forest foliage-gleaning bats in Central Europe**

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A diverse syntopic bat community was studied in Central Europe. The study was primarily aimed at forest bats utilizing a foliage-gleaning foraging strategy (*Myotis nattereri*, *M. bechsteinii* and *Plecotus auritus*). The results indicated the foliage-gleaning foraging strategy and the effective resource partitioning. Once a certain diet item comprises an important food resource for one bat species, it is usually exploited much less by the other two bat species, and despite important seasonal dietary changes this pattern lasts throughout the entire season. Dietary composition varies more among the entire guild of forest foliage-gleaning bats than it does between these species and their morphological siblings or evolutionarily related species (e.g., *Plecotus auritus* vs. *P. austriacus* or *Barbastella barbastellus*, *Myotis nattereri* vs. *M. emarginatus*). The results are not fully consistent with the predictions of sensory ecology, which presume that bats with longer ears feed more frequently on prey that generates sound. The results do not support the hypothesis that rare bats exploit a narrower range of prey. The relatively rare *M. bechsteinii* has a wider trophic niche, whereas the more common *P. auritus* exploits a narrower range of prey. Comparison of dietary composition and morphological and echolocation parameters indicates that larger species feed on harder prey, species with longer ears are moth-eating specialists and species with a higher call intensity exploit small dipterans, probably in uncluttered habitats.

**Key words:** gleaning bats, foraging strategy, trophic niche overlap, *Myotis nattereri*, *Myotis bechsteinii*, *Plecotus auritus*

## **High trophic similarity in the sympatric North European trawling bat species *Myotis daubentonii* and *Myotis dasycneme***

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Most European bat species are insectivorous and share foraging areas to some extent. Where similar species rely on similar resources in the same foraging habitat, they are likely to interact. This study addresses the trophic niche of the Northern European trawling bat species *Myotis dasycneme* (Boie, 1825) and *Myotis daubentonii* (Kuhl, 1817), occurring in the same habitat, and possible interactions or differences within their dietary behaviour. Dietary data of both species were analysed to draw conclusions on their ecology, possible dietary overlap, hints for coexistence mechanisms and community structure. In this study, *M. dasycneme* and *M. daubentonii* fed mainly on Chironomidae (*M. dasycneme*: 44.4%; *M. daubentonii*: 32.8%) and Trichoptera (*M. dasycneme*: 20.4%; *M. daubentonii*: 22.2%), showing a high trophic niche overlap and similar niche breadth. Nevertheless, there were differences in the diet of the two species concerning the predation of chironomids. Differences also occur regarding the prey types, referring to the terrestrial or aquatic life-cycle of prey groups. This could be evidence for different foraging habitats and a spatial segregation of both species. High resource abundance is also likely to allow the coexistence of both species within the same hunting habitat.

*Key words:* *Myotis dasycneme*, *M. daubentonii*, diet analysis, faecal samples, trophic niche, coexistence

## **Seed dispersal among three different vegetation communities in the Huasteca region, Mexico, analyzed from bat feces**

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Seed dispersal is a key process for plant colonization and for the establishment of many plant populations in tropical environments. A large proportion of all tropical woody plants with fruits and seeds depend on frugivorous vertebrates for their dispersal, and frugivorous bats are essential for the dispersal of seeds from many tropical plants. Many of these plants are important for vegetative regeneration after disturbances. Our main goal was to document the process of seed dispersal through feces-seed analysis by the bat community among semi-deciduous, evergreen, and secondary forests in the ‘Huasteca’ region of San Luis Potosí, Mexico. We hypothesized that bats would disperse seeds among all three forest types, and thus predicted that we would find seeds from both early and late successional stages in bat feces in all three forest types. In each of three replicate sites representative of each of these forest types, we trapped bats with mist-nets and collected their feces with seeds. A total of 558 individuals from eight frugivorous bat species were captured. The most abundant species were *Sturnira ludovici*, *Glossophaga soricina* and *Artibeus jamaicensis*. We documented seeds in bat feces from 16 plant species belonging to four families: Moraceae, Piperaceae, Solanaceae, and Myrtaceae; 43% were pioneer species, and thus important for the initial stages of regeneration, and 37% were species of late successional stages. Seeds in bat feces were found in similar proportions in all forest types, thus contributing to the regeneration of highly deforested habitats in the Huasteca region. To maintain the entire mutualistic network between bats and plant species, diverse bat communities are important.

*Key words:* diet, frugivorous bats, frugivory, lowland tropical forest, Phyllostomidae, regeneration, San Luis Potosi, succession

## **Diet of mormoopid bats on the Caribbean island of Puerto Rico**

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Dietary differentiation can be a key mechanism for the coexistence of syntopic species with similar niches. On the Caribbean island of Puerto Rico, three species of bat from the family Mormoopidae — the Antillean ghost-faced bat (*Mormoops blainvillei*), sooty mustached bat (*Pteronotus quadridens*), and Parnell's mustached bat (*Pteronotus parnellii portoricensis*) — are aerial insectivores that roost in the same caves. To investigate the possibility of dietary differentiation, we estimated the percent volume and percent frequency of occurrence of the orders of arthropods consumed by these three species of bat, using standard fecal analysis. We also compared dietary diversity among species, as well as the amount of dietary overlap, with respect to season and habitat. Lastly, this study used canonical correspondence analysis (CCA), a method of ordination, to assess the effects of species, sex, age, reproductive condition, season, and habitat on intraspecific differences in the diet of the Puerto Rican Mormoopidae. Eight orders of arthropods were found in the diet of these mormoopids, with Lepidoptera, Hymenoptera, and Coleoptera being major staples. The CCA revealed differences in diet among the three species, suggesting that dietary differentiation is at least one mechanism for coexistence. In addition, the variables habitat and season correlated significantly with the diet of *M. blainvillei* and *P. quadridens*, whereas habitat and sex correlated with the diet of *P. p. portoricensis*. Thus, our study shows dietary differences among the three species of Mormoopidae living in the same caves on Puerto Rico, as well as intraspecific differences within the diet of each species.

*Key words:* bats, diet, Mormoopidae, *Mormoops blainvillei*, niche partitioning, Puerto Rico, *Pteronotus parnellii portoricensis*, *Pteronotus quadridens*

## **Fly-and-forage strategy in the bat *Pipistrellus nathusii* during autumn migration**

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Populations of *Pipistrellus nathusii* (Nathusius's bat), an insectivorous aerial-hawking species that breeds in north-eastern Europe, perform long-distance migrations between breeding sites and hibernation areas in central and southern Europe. The feeding strategy of migrating *P. nathusii* was investigated in Latvia on the east coast of the Baltic Sea, exploring evidence for and against two non-mutually exclusive predictions that i) the bats feed shortly after dusk at highest aerial insect activity and continue to migrate thereafter or ii) apply a 'fly-and-forage' strategy and frequently interrupt their migration flight to feed. Echolocation calls and feeding buzzes of *P. nathusii* were recorded throughout the night from August until September on a known migration flyway over coastal dunes and at potential foraging sites in adjacent woodlands, over meadows and wetlands. The results indicate that *P. nathusii* applies a fly-and-forage strategy along the Baltic coast. However, a threshold in aerial insect availability may exist, below which no foraging occurs and migration continues.

*Key words:* Baltic Sea, feeding strategy, Latvia, Pape Ornithological Research Station

## **Ranging patterns and habitat use of a solitary flying fox (*Pteropus dasymallus*) on Okinawa-jima Island, Japan**

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Most flying fox species (genus *Pteropus*) exhibit strong coloniality. They are highly mobile animals and commonly forage over vast areas. Only a small number of species are solitary, and their foraging and roosting patterns are not well understood. Here, we examined ranging patterns and habitat use of Orii's flying fox, *Pteropus dasymallus inopinatus*, a solitary fruit bat, using radio-tracking from April 2002 to January 2006 on Okinawa-jima Island, Ryukyu Archipelago, Japan. The daily home range size for this species was very small (mean 52.5 ha) compared to other *Pteropus* species, although home range size was highly variable among individuals and seasons. The distance between a day roost and feeding trees was 621 m on average, with a maximum of 6,875 m. Day roost site shifted frequently (every  $1.6 \pm 0.8$  days) to a nearby site in the current foraging area. The distance between consecutive day roost sites was 792 m on average, with a maximum of 6,000 m. These bats favored forest habitats for roosting sites, whereas they often used residential areas as feeding sites. Our results suggest that they regularly shifted the location of their personal activity range, a small home range with roost switching, probably to track changes in food availability and to avoid local competition for food. The solitary roosting system of this species links to its flexible foraging system, which likely provides an advantage for using limited food resources on a small island, even when food is patchily distributed in urbanized habitats.

*Key words:* home range size, movements, *Pteropus dasymallus inopinatus*, radio-tracking, Ryukyu flying fox, roost switching, social system, urbanization

## **Seasonal variation in bat activity in relation to detector height: a case study**

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The effects of detector height and season on bat activity have not been investigated in the UK and are poorly understood globally, yet are crucial to designing effective acoustic activity surveys. The aim of this study was to test predictions of species foraging preferences for the canopy or understorey and to determine whether this pattern shows seasonal variation. Bat activity was recorded using automated detectors in the canopy and understorey of an ancient broadleaved woodland in south-west England in spring and summer for a total of 40 nights. Activity levels were then compared between each of the two detector heights and two seasons. The canopy detector recorded significantly more bat activity overall and recorded significantly higher activity of *Nyctalus*, *Pipistrellus pipistrellus* and *P. pygmaeus* compared to the understorey detector. *Nyctalus* were more frequent in summer compared to spring. *Pipistrellus pipistrellus* consistently preferred the canopy, whilst *P. pygmaeus* showed this preference in summer only. *Myotis* were more frequent in spring compared to summer, favouring the understorey in spring but displaying a marginal preference for the canopy in summer. This suggests that it is advisable to record at multiple heights at different stages of the active season to assess bat activity in woodland. These effects should be tested in other woodland sites in order to determine the consequences of ground-based recording during a limited survey period.

*Key words:* Anabat, forest, flight height, ultrasound, vertical stratification

## **Vocalizations in the Malagasy cave-dwelling fruit bat, *Eidolon dupreanum*: possible evidence of incipient echolocation?**

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The vocalizations of the Malagasy endemic fruit bat, *Eidolon dupreanum* (family Pteropodidae) were previously not documented. Individuals of this species, which make day roost sites in rock crevices or the dark zones within caves, were recorded while exiting a cave in the Parc National d'Ankarana. Individuals leaving a roost at dusk were recorded 200 m and 35 m inside the cave, as well as two sites outside the cave. Visible light in the cave dropped to 0 lux about 50 m from the entrance. While exiting, individuals flew within 50–100 cm of the ceiling, often settling and perching every 5–10 m along their flight patch and displacing in a leapfrog manner towards the cave entrance. Three distinct call types were identified: social calls 1, social calls 2 and echo clicks. Bats produce the echo clicks while flying towards the entrance, while the other two calls were emitted at roost sites and near the cave entrance. Although the results are preliminary, we suggest that the social calls 1 and 2 were employed for social communication, whilst echo clicks may have been used in a sensory context, potentially as incipient echolocation to navigate in the dark cave.

*Key words:* *Eidolon dupreanum*, cave-roosting, dark zone, vocalization, incipient echolocation, Madagascar

## **Clustering behavior in wintering greater mouse-eared bats *Myotis myotis* — the effect of micro-environmental conditions**

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During monthly bat surveys carried out in winters of 2008/2009 and 2009/2010 we studied clustering behavior of greater mouse-eared bats (*Myotis myotis*) hibernating in the Międzyrzecz Fortified Front (MFF) in western Poland. Since the behavior of hibernating bats is usually affected by varying environmental conditions we measured changes in the ambient temperature ( $T_a$ ) and water vapor pressure (WVP) and their variability in the selected areas and analyzed the relationship between clustering behavior of hibernating bats and abiotic conditions. In both winters, the number of solitary roosting individuals of *M. myotis* decreased from autumn to spring while the highest number of bats hibernating in clusters was recorded in the middle of winter. The number of clusters did not change significantly over the winter, but the number of individuals within a particular cluster increased from November (median = 5, inter-quartile range, IQR = 5–8) to March (median = 20, IQR = 14–35.5). The changes of the clusters' size were best explained by a mixed model with WVP and the variability in WVP over the 20 days prior to the bat survey as explanatory variables. As WVP and the variability in WVP decreased, the number of individuals in a cluster increased. Also,  $T_a$  affected the size of clusters. However, neither of the models supported the hypothesis of the effect of variability of  $T_a$  on clustering of *M. myotis*. We propose that huddling enables bats to reduce evaporative water loss during the middle and at the end of the hibernation and reduces costs of spring arousals, perhaps by synchronizing them between clustered individuals and thus allowing the use of passive re-warming.

*Key words:* bats, *Myotis myotis*, hibernation, clustering behavior

## **Distribution patterns of bats in the Eastern Mediterranean Region through a climate change perspective**

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The impact of climate change on different species has been analyzed many times in various geographical areas. However, some areas still have a large knowledge gap while harbouring significant levels of biodiversity. The main aim of this study was to determine how climate change will affect 16 different bat species in the Eastern Mediterranean Region. Using presence only modelling techniques and relevant bioclimatic data forecasts according to two different climate change scenarios (A2A and B2A) of the Intergovernmental Panel on Climate Change (IPCC), the potential geographic distribution of bat species in the eastern Mediterranean region for the current period and the years 2020, 2050 and 2080 were modelled. The results suggest that climate change can affect bats negatively throughout the 21st century in the studied area on two fronts: i) species richness will deteriorate, and ii) the total area occupied by bats will decline. These impacts are likely to be more severely observed in Turkey's coastal areas, northwest Turkey, Red Sea coasts, Israel, and the west of Syria and Jordan. Using only bioclimatic variables as factors, and thus not using any land cover (or habitat) data, was the main limitation of the study. Hence the models and results of the study present 'best case' scenarios.

*Key words:* Chiroptera, Environmental Niche Modelling, climate change, distribution, Eastern Mediterranean

## **Factors influencing bat activity and mortality at a wind farm in the Mediterranean region**

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Our study aims to determine how different climatic variables influence bat activity and mortality at wind farms in Portugal. The study was conducted from March to October 2007 at a wind farm with 20 turbines located in Northern Portugal. Bat activity was determined by ground bounded acoustic sampling, while mortality was assessed through fatality searches around each turbine. Sampling occurred weekly and activity was measured the night before fatality search. The highest activity and mortality rates were from *Nyctalus leisleri* and *Pipistrellus pipistrellus*. The majority of activity and mortality (95% and 94% in that order) occurred from August to October and both were significantly correlated with wind speed, temperature and relative humidity; mortality also appeared to be influenced by wind direction. Our results show that it is possible to establish a relationship between ground bounded activity and mortality. Our results are relevant for the implementation of effective minimization measures and, therefore, for bat conservation in the Mediterranean region. Specifically, our results show that nearly all (94%) of bat mortality at wind farms happens from August to October, at temperatures higher than 13.0°C, and wind speeds lower than 5.0 m.s<sup>-1</sup>.

*Key words:* Chiroptera, activity, mortality, conservation, weather conditions, *P. pipistrellus*, Portugal, *N. leisleri*, wind farms

## **Bat fatalities at wind farms in north-eastern Greece**

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Several recent impact studies reveal that in some localities industrial wind farms are associated with high numbers of bat fatalities. In Europe, most published studies have been conducted in the northwest, while bat diversity generally is much higher in the south of the continent. Here we provide evidence from a post-construction monitoring study conducted in north-eastern Greece between August 2009 and July 2010. Overall, 88 turbines from nine wind farms were intensively searched, and 181 dead and two injured bats were found in their proximity. The most frequently killed species were *Nyctalus leisleri* ( $n = 56$ ), *Pipistrellus pipistrellus*/*P. pygmaeus* (53), *P. nathusii* (35), *Hypsugo savii* (23) and *N. noctula* (10). Fatality rates were high from June to September. Most killed bats were adult males. Observed differences in the temporal pattern of fatalities among species may be associated with differences in their behaviour and distribution. Sex segregation with males at higher elevation, where the wind farms were located, and/or absence of females from such areas during summer may be the reason behind the higher male mortality rates. Bat fatalities were unequally distributed among wind farms and turbines. Four turbines (5%) accounted for 27% and 13 turbines (15%) for 51% of the fatalities. The most frequently killed species exhibited different spatial patterns of fatality, presumably because some turbines were located closer to roosts and/or commuting corridors. Fatalities were positively correlated with tower height but not with rotor size. To reduce bat fatalities, we recommend an increase in the cut-in speed of turbines responsible for fatalities from sunset to sunrise.

*Key words:* wind turbine, bat fatalities, migration, elevational distribution, *Nyctalus*, *Pipistrellus*

## **Do green roofs provide habitat for bats in urban areas?**

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Green roofs, (roofs that are deliberately vegetated), are a technology that seeks to lessen the impacts of urbanisation on people and wildlife. This study investigates their value for UK bat species within the context of the built environment. Green roofs were categorised as 'sedum' or 'biodiverse' according to their dominant vegetation type. Bat activity was monitored over 13 biodiverse, nine sedum and 17 conventional un-vegetated roofs located within the Greater London area for seven nights using Anabat SD1 detectors. Influence of roof type and environmental variables on bat activity were evaluated using generalised linear models. *Pipistrellus pipistrellus* were most frequently recorded followed by *Pipistrellus pygmaeus*, *Nyctalus/Eptesicus* and *Pipistrellus nathusii*. The mean number of call sequences per night was 5.2. Feeding events accounted for 16% (217) of call sequences. Bat activity was significantly higher over biodiverse roofs compared to conventional roofs. A greater extent of suitable habitat within the surrounding area had a positive influence on bat activity but numbers of call sequences and feeding events were significantly higher over biodiverse roofs compared to conventional roofs when suitable habitat within a 100 metre radius of the roof was below 33% cover. Other factors affecting bat activity included roof height (negative influence with increased height) and the month of survey. No significant differences were found between sedum and conventional roofs. The findings suggest that biodiverse roofs offer enhanced habitat for bats within the context of urbanised environments. Further studies are needed to predict more accurately their value as a bat conservation measure.

*Key words:* green roofs, bat activity, Anabat, generalised linear modelling, urban environments

## **The effect of tourist visits on the behavior of *Rousettus madagascariensis* (Chiroptera: Pteropodidae) in the caves of Ankarana, northern Madagascar**

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Disturbance by tourists of bats in their day roosts represents a potential threat to the conservation of these mammals. We assessed the effect of experimental tourist visits on behavior of the Malagasy endemic *Rousettus madagascariensis* (Chiroptera: Pteropodidae) in the Ankarana National Park, northern Madagascar. We measured bat behavior, including time activity budgets, under two levels of experimental human visit proximity (far and near) and illumination (low and high). These visits caused an increase in bat flights and an increase in alertness in a frequently-visited colony with faint ambient daylight. The greatest response occurred for human approaches to 5–6 m that directly illuminated the bats and the least response occurred for approaches to 12–14 m that did not directly illuminate the bats. In an infrequently-visited colony with no ambient daylight, visits that remained 12–14 m away and did not illuminate the bats directly caused an increase in alert behavior and a decrease in bat grooming behavior. The difference in response between the colonies suggests that *R. madagascariensis* may demonstrate an attenuated response to some frequent human visits. Alternatively, colonies roosting with some ambient light may be less sensitive to disturbance from visits, and colonies with previous experience primarily with hunting visits may be more responsive to disturbance. Maintaining a minimum visit distance of 12 m and not illuminating the bats directly, as well as not opening other roost sites to tourism, is likely to help to limit disturbance of *R. madagascariensis* by tourists at Ankarana.

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## **Development of the over-water mist net support system: a novel ecological research tool**

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The habitats in areas like the Northern Great Plains of North America present challenges to bat researchers in the field. Due to limited vegetative cover, mist-netting efforts often must be concentrated over ponds, streams or rivers. This can present problems to researchers, such as deep water, soft mud bottoms or uneven terrain, all of which can make traditional mist netting difficult and unproductive. While boats can be useful under these circumstances, this leads to additional safety and logistical challenges. The purpose of this study was to address these problems by developing a novel tool that permits sampling with mist nets over water without the need to directly enter the water. We developed a basic conceptual design for a mechanical gate-like support system that: 1) supports a traditional mist net system, and 2) swings out over a body of water. Initial results indicate that the over-water mist net support system is an effective, versatile research tool that allows researchers to sample for bats under challenging field conditions in which placement of traditional mist net systems would be dangerous or not feasible.

*Key words:* bats, mist nets, survey design, water

## Dextrocardia in short-nosed fruit bats (*Cynopterus sphinx*) and their relative heart masses

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Autopsies carried out on 26 short-nosed fruit bats (*Cynopterus sphinx*, Pteropodidae, Chiroptera) from Guangdong Province, South China, revealed that the hearts of three individuals were found lying in the right hemithoracic cavity with their base-to-apex axes directed to the right. This is the reverse of what is normally seen in mammals and is similar to the rare congenital heart defect known as dextrocardia which has been described in humans. A comparison of the two orientated hearts found that there was no significant difference in heart mass (MH) or relative heart mass (RHM). We observed that the short-nosed fruit bat has higher RHM compared to non-flying mammals but lower RHM when compared to insectivorous bats, and similar RHM when compared to those of other fruit bats.

*Key words:* *Cynopterus sphinx*, dextrocardia, short-nosed fruit bat, heart mass, relative heart mass

### INTRODUCTION

The mammalian heart is an asymmetric structure, which receives its polarity from the three body axes; the anterior-posterior axis (A-P), the dorsal-ventral axis (D-V), and the left-right axis (L-R) (Brand, 2003). The vast majority of mammalian hearts, including those of bats, are located in the left hemithorax along the A-P axis (Rowlatt, 1967; Tagoe *et al.*, 1995; Pauziene *et al.*, 2000; Mauricio *et al.*, 2005). However, in rare cases, the position of the human heart has been found lying in the right hemithorax with its base-to-apex axis directed to the right. This cardiac positional anomaly is known as dextrocardia (Mahendrakar and Seth, 2004) which is a congenital heart disease with a low incidence rate of around one in 12,000 pregnant women (Bohun *et al.*, 2007). To the best of our knowledge, although dextrocardia has been described in domestic animals such as dog (Carrig *et al.*, 1974) and cat (Abduch *et al.*, 2003), it has not been found in any wild mammal population. In this paper, we report the first case of dextrocardia in bats (order Chiroptera).

### MATERIALS AND METHODS

Twenty-six adult female short-nosed fruit bats (*Cynopterus sphinx*) were captured from the same colony in Guangdong Province, South China (113.14°E, 23.10°N) as part of the investigation into the SARS outbreak in China. *Cynopterus sphinx* is not a protected species in China and is widely distributed in Guangdong Province. The handling of all bats conformed to guidelines for animal care and approved by the Ethical Committee, State Key Laboratory of Reproductive Biology, Institute of Zoology, Chinese Academy of Sciences. Before any bats were euthanized their body mass ( $M_b$ ) was measured. The hearts were extracted through a standard thoracotomy procedure after which the venous and connective tissues were removed. Each heart was squeezed empty of blood, weighed on electronic scales (SB-S702, Shanghai; accurate to 0.01 g) and then measured immediately. The transverse and vertical diameters of the hearts ( $D_T$ ,  $D_V$ ) were measured using vernier calipers. Comparisons between right and left orientated bat hearts were carried out using Mann-Whitney (M-W) *U*-tests. A comparison of heart mass ( $M_H$ ) and relative heart mass (RHM,  $M_H/M_b$ , in %) was also carried out between the two different types of heart (Mann-Whitney *U*-test).

### RESULTS

Out of the 26 short-nosed fruit bats studied, three individuals were found to have their hearts situated in the right hemithoracic cavity when their