

Cryptic diversity in common mustached bats *Pteronotus cf. parnellii* (Mormoopidae) in French Guiana and Brazilian Amapa

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The common mustached bat (*Pteronotus parnellii*) is a mormoopid bat living in caves in lowland rainforests throughout the north and eastern Neotropics, including several Caribbean islands. Recent studies have shown that this taxon is certainly a composite of several cryptic species, especially in the western part of the Guianan Shield, where molecular reconstructions and bioacoustics point to the presence of at least two cryptic species that may not be related to genuine *P. parnellii*, native to Jamaica. We examined here over 200 bioacoustically identified individuals to show that two phonic types live in sympatry in French Guiana with no overlap in frequencies of echolocation calls. Morphological variation in some skull characters showed consistent and significant differences between the two phonic types, whereas external measurements alone were unable to discriminate between groups. Two mitochondrial markers analyzed in a selection of each of these phonic types were further used to evidence that they represent two genetically discrete groups, and to assign them to the existing molecular clades described elsewhere. Molecular comparisons with reference specimens sampled near the type localities of *P. parnellii* and *P. rubiginosus* further suggest that the 53 kHz phonic type found in French Guiana and Amapa (Brazil) should be assigned to the later species, while the 59 kHz phonic type represents an undescribed species.

Key words: cryptic species, bioacoustics, mitochondrial DNA, Guianan Shield

Genetic structure and cryptic genealogy of the Bonin flying fox *Pteropus pselaphon* revealed by mitochondrial DNA and microsatellite markers

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The Bonin flying fox (*Pteropus pselaphon*) is endemic to the Ogasawara Islands, a collection of small oceanic islands in the Pacific Ocean. It inhabits only five islands: Chichi-jima, Haha-jima, Kita-iwo, Iwo, and Minami-iwo (arranged from north to south). Haha-jima and Kita-iwo, the most widely spaced islands, are separated by a distance of about 160 km. The islands have different histories in the modern era with respect to human activity. At present, *P. pselaphon* population sizes exceed 100 on Chichi-jima and Minami-iwo, but the species is rare on the other three islands. Loss of genetic diversity is of concern because of the small population sizes. We obtained samples from three of the five islands — Chichi-jima, Kita-iwo, and Minami-iwo — and investigated species genetic diversity and genetic structure based on mitochondrial DNA (mtDNA) control region sequences and microsatellite markers. Different mtDNA haplotypes were found in each island population. Based on the mtDNA sequence data, *P. pselaphon* displayed a cryptic genealogy, as haplotypes on each island did not cluster together. The microsatellite marker data, however, revealed a clear genetic structure among the island populations, suggesting the absence of recent inter-island gene flow. Based on these results, we propose that the individual island populations are not evolutionarily significant units, but should be conserved collectively as a single management unit.

Key words: geographical structure, microsatellites, mitochondrial DNA control region, Ogasawara Islands, *Pteropus pselaphon*

Changes of bat activity, species richness, diversity and community composition over an altitudinal gradient in the Soutpansberg range, South Africa

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Bats are important indicator species which can help in identifying areas where conservation efforts should be concentrated and whether these areas are affected by ongoing climate change. To elucidate factors limiting and influencing the elevational distribution of bats in a recognised biodiversity hotspot, the Soutpansberg mountain range (in Vhembe Biosphere Reserve) of northern South Africa, we collected data in and around the Luvhondo Private Nature Reserve, by catching and acoustically monitoring bats over an altitudinal gradient from 900 to 1,748 m. A total of 18 different species could be recorded. Two species, namely *Pipistrellus hesperidus* and *Chaerephon* cf. *ansorgei* appeared to be present and dominant at all altitudes. Activity, species richness and diversity significantly decreased with increasing altitude, whereas community composition was not related to altitude and no endemics to either low or high altitude were detected. It is likely that the change of species richness and diversity over altitude is caused by other factors correlated with altitude such as vegetation type, area size, energy availability and climatic differences. Our research demonstrated that lower altitudes are richer and more diverse in bat species and since no highland endemics have been discovered, conservation efforts in the area, regarding bats, should not ignore these lower altitudes which are most susceptible to human impacts leading to habitat degradation due to over-grazing, bush encroachment, cultivation and denudation of large trees for firewood collection.

Key words: Soutpansberg Mountains, bat activity, species richness, species diversity, altitudinal distribution, South Africa, Limpopo Province, Vhembe Biosphere Reserve

Foraging movements of epauletted fruit bats (Pteropodidae) in relation to the distribution of sycamore figs (Moraceae) in Kruger National Park, South Africa

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We examined the distribution of *Ficus sycomorus* in relation to the movements and feeding, behavior of two species of epauletted fruit bats in Kruger National Park in order to learn about the scale and tempo of the seed dispersal of this riparian tree. Radio-tagged *Epomophorus crypturus* and *Epomophorus wahlbergi* restricted > 90% of activity within riparian forests having *F. sycomorus* present; whereas, < 10% of activity occurred in thorn thickets where folivory on *Balanites maughamii* and frugivory on *Sclerocarya birrea* appeared to offer secondary sources of forage. Bats usually carried figs to foliage perches within 200 m of the fruiting tree before feeding. Within a night, maximum one-way movement was 13.9 km as bats visited \leq four foraging patches. No significant difference occurred between foraging ranges of *E. wahlbergi* at Skukuza (16.0 ± 3.0 ha) and *E. crypturus* at Shingwedzi (19.9 ± 5.1 ha). However, *E. crypturus* at Babalala had significantly larger mean foraging range (52.4 ha ± 4.5 ha) than either species elsewhere. Mean foraging range, core use area, and long axis across foraging range of *E. wahlbergi* changed significantly with season, year, and fig abundance. Our study suggests interdependence between *F. sycomorus* and the two species of fruit bats in Kruger National Park with bat movements largely following the distribution of available ripe figs.

Key words: core-use area, *Epomophorus wahlbergi*, *E. crypturus*, *Ficus sycomorus*, figs, foraging range, radio-telemetry, seed dispersal, South Africa

Bat activity across the vertical gradient of an old-growth *Sequoia sempervirens* forest

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We investigated how bats use habitat structure along the vertical gradient of an old-growth *Sequoia sempervirens* (redwood) forest. Ground-based detection methods would underrepresent bats that use the canopy and above-canopy airspace in this forest as they reach far beyond practical netting and acoustic detection range. We equipped two tall trees with full spectrum automated bat detectors at treetop (108 m), lower crown (55 m), and ground level (5 m) from April 2008 to November 2009, excluding December and January. We sampled 1,365 detector nights, recorded 3,769 echolocation sequences (bat passes), and found 12 species, two of which, *Lasiurus blossevillii* and *Tadarida brasiliensis*, that had no prior documented presence in redwood forests. The maximum proportion of bat activity occurred at treetop, although ground level species diversity exceeded that of the lower crown and treetop, and species composition differed among locations. Non-*Myotis* species composed 95% of the calls at the treetop, 88% at lower crown, and 21% at ground level. Calls from *Myotis* species averaged 71% of all calls recorded at ground level compared to less than 4% at both lower crown and treetop. Activity declined markedly, but did continue, during the winter months we sampled. The combination of a temperate climate and observations of larger, migratory species during November, February, and March suggested the potential for resident populations or inland migrants overwintering in this forest. These findings emphasize the importance of sampling throughout the calendar year and including the full reach of the vertical habitat when quantifying bat activity in forests.

Key words: acoustic monitoring, vertical stratification, bat activity, habitat use, old-growth redwood, *Sequoia sempervirens*

Seasonal bat activity in relation to distance to hedgerows in an agricultural landscape in central Europe and implications for wind energy development

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Bat activity is often concentrated near linear and edge landscape structures such as hedgerows, but information about seasonal and species-specific bat activity near hedges is scarce despite their abundance in the cultural landscapes of central Europe. Exact knowledge on animals' habitat use, however, is key to effective landscape planning to avoid human-wildlife-conflicts, such as the construction of wind turbines in areas with high bat activity that may result in bat fatalities. We measured bat activity in relation to distance to hedgerows in an agricultural landscape in northeastern Germany. We recorded bat echolocation calls at ground level at 0, 50, 100 and 200 m distances from hedges at five sites during three nights in spring (April to June) and three nights in summer (July to October) at each site. For all bat species we found the overall activity to be similar between seasons, with the highest activity near the hedges, but with considerable variation in species-specific spatial activity patterns between spring and summer. While the genus *Myotis* and *Pipistrellus pipistrellus* were mostly active close to the hedges at a similar intensity over the entire study period (i.e. 84% and 86% of all bat passes, respectively), *Nyctalus noctula* and *Pipistrellus nathusii* showed generally less pronounced concentration of activity near the hedges, and increased activity away from the hedges in summer. Similarly, *Pipistrellus pygmaeus* showed decreased activity away from the hedges during both seasons, but with reduced activity near the hedges in summer. The observed behavioural changes in activity in relation to distance to hedgerows are likely due to migration or the bats foraging for different prey between seasons. Our findings are highly relevant for landscape planning and distance recommendations for the construction of wind turbines linked to their potential threat for bats.

Key words: *Nyctalus noctula*, *Pipistrellus* spp., *Myotis* spp., landscape planning, wind energy, acoustic monitoring, bat conservation, environmental impact assessment, bat fatalities, distance thresholds

Prey selection by *Rhinolophus hipposideros* (Chiroptera, Rhinolophidae) in a modified forest in Southwest Europe

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The knowledge of the diet of endangered species provides information on ecology and behaviour that is essential for the adequate management of their populations. Population decline may be indeed associated with diet specialization and unavailability of feeding resources, especially in modified environments. We studied the diet and prey selection of *Rhinolophus hipposideros* Borkhausen, 1797 in a modified Mediterranean landscape in Portugal, where this species is classified as vulnerable. Diet composition was evaluated by analyzing faecal pellets collected in a breeding colony of *R. hipposideros*, and the available arthropods were sampled using a light trap set outside the roost. The most consumed prey were Lepidoptera, Tipulidae (Diptera), Hymenoptera, Diptera and Neuroptera. Arthropod diversity remained fairly constant in the diet, but not in terms of prey availability. Our results show that *R. hipposideros* is a generalist species that feeds on a great number of prey species. However, our data suggest that, within the broad dietary niche, *R. hipposideros* is not opportunistic, actively selecting Diptera as a preferred food item. Despite the marked differences in foraging habitats, our results are closely match to those of studies done in Western and Central Europe, suggesting that *R. hipposideros* feeds on similar taxa all across Europe. However, as many studies indicate, this species selects broadleaved woodlands and riparian vegetation to forage, so conservation measures should take into account the protection of native forest and the maintenance of forest corridors among them, as *R. hipposideros* seems to avoid crossing open areas.

Key words: *Rhinolophus hipposideros*, diet, prey selection, Mediterranean forest

Roost occupancy, roost site selection and diet of straw-coloured fruit bats (Pteropodidae: *Eidolon helvum*) in western Kenya: the need for continued public education

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Population fluctuations, roost site selection and diet of straw-coloured fruit bats, *Eidolon helvum* (Kerr, 1792) were studied for > one year in western Kenya. Total counts of bats at three identified roosts varied from 7,000 to 48,000 individuals. The bats moved between roosts within the same general area, probably reflecting seasonal variation in the availability of preferred foods and/or harassment and direct persecution at some roost sites by the rural community. Our study suggests that tree density and number of branches on trees were important factors in roost site selection for *E. helvum*, and the removal of roost trees has serious ramifications for their conservation in the region. Germination experiments and observations at roost sites indicated that *E. helvum* consumed fruits from 31 plant species of 16 families, potentially assisting in the dispersal of their seeds. Further monitoring is needed to provide a complete picture of the status and migration patterns of *E. helvum* in Kenya. Additionally, because the bats were viewed negatively and persecuted by roost tree clearance and direct eradication attempts, an education and community outreach programme in local schools and communities is proposed for the long-term conservation of viable populations of *E. helvum* in western Kenya.

Key words: population status, bat conservation, diet, education

Bat activity over small ponds in dry Mediterranean forests: implications for conservation

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In dry Mediterranean forests, ponds constitute essential water resources for animals, especially during summer months. In south-eastern Spain, land use changes and the human abandonment of mountainous zones have led to the loss of many ponds. These ponds are scarce landscape elements and, despite their usually small size (< 1,000 m²), they support a considerable amount of biodiversity. We studied the patterns of use of these ponds by bats during the activity season in dry forest landscapes of a Mediterranean region using acoustic monitoring. Our hypothesis was that these ponds are valuable landscape elements for bats, and bat activity and richness species will be high over them. Bat activity and species richness were compared between ponds and adjacent sampling points in the forest matrix. We recorded 14 bat species and our results show that both general bat activity (all species grouped together) and species richness were higher in the ponds than in the forest areas. Bat activity was higher in June, however it decreased during drier months (July–August), while activity in the forest increased. The number of species was constant in the areas surrounding the ponds through the study period, but in the forest we observed an increase in July and a gradual decrease in August–September. Similar results were obtained for most individual species, although in some species activity was also influenced by temporal variables. Our study shows that the maintenance of small ponds may have important consequences for bat conservation, as they support high bat diversity, including some species of conservation concern like horseshoe bats (*Rhinolophus* spp.) or *Myotis* spp.

Key words: acoustic monitoring, biodiversity; conservation, Mediterranean region, species richness, water body

Coastal cliffs on islands as foraging habitat for bats

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Small islands usually show simplified ecosystems with limited availability of suitable foraging habitats for bats, thus habitat selection on islands may differ compared to the mainland. Habitats that are marginal on the mainland may be important on islands. The island of Capri consists, to a large extent, of steep limestone cliffs and Mediterranean shrubland, with virtually no forests or other habitats preferred by bats on the mainland. In this study we tested the hypothesis that in resource-limited systems, such as islands, habitats generally deemed of minor value for bat foraging, such as cliffs, may become important. We conducted an acoustic survey of bats in Capri (SW Italy), comparing their use of Mediterranean shrubland and limestone cliffs. We found that cliffs provided the preferred foraging habitat in four of the five species tested. Noticeably, even the barbastelle bat *Barbastella barbastellus*, normally considered a forest specialist, selected coastal cliffs as foraging habitat. Our observations indicate that the paucity of foraging habitats on islands may strongly alter the habitat use by bats. This has important implications for conservation of bats in insular environments.

Key words: *Barbastella barbastellus*, bat conservation, habitat selection, island ecology, Mediterranean

Identification and characterization of swarming sites used by bats in Nova Scotia, Canada

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For bats that are year-round residents of temperate areas, underground openings such as caves and abandoned mines are critical resources in winter as hibernacula, and in autumn for swarming behaviours (mating, socialization, etc.). Like many parts of the world, Nova Scotia, Canada, has many underground openings that have not been surveyed for bats. The feature(s) that affect the suitability of these sites for hibernation or swarming is not known. As such, it is not possible to predict which ones are used by local bats (*Myotis lucifugus*, *Myotis septentrionalis* and *Perimyotis subflavus*). Because it was not safe to enter the sites to conduct hibernation counts, our goal was to relate bat activity at the entrance of underground openings during swarming to quantifiable external metrics and to pre-existing data on internal site characteristics. Specifically, our objectives were to 1) identify abandoned mines and caves that are used by bats for swarming and 2) quantitatively characterize factors which best differentiate between underground openings that are used for swarming, and those that are not. We assumed that sites used by bats for swarming were likely also used for hibernation. Acoustic and/or trapping surveys were conducted at 17 abandoned mines and eight caves in Nova Scotia, five of which were previously known to be hibernacula. Results suggest that at least 12 of the 25 sites were swarming sites (including seven newly identified sites). Logistic regression analysis of nine a priori selected models indicated that internal chamber length was the best predictor of swarming activity. Two external variables, degree of shelter at entrance and total length of rivers in landscape, were also important predictors. These variables have the potential to be used as indicators to identify swarming sites at other sites in eastern North America. The swarming sites identified in Nova Scotia should be targeted for monitoring in light of the devastating impacts that white-nose syndrome is having on North American bats.

Key words: *Myotis lucifugus*, *M. septentrionalis*, swarming, hibernation, Nova Scotia

An island-wide monitoring program demonstrates decline in reporting rate for the Christmas Island flying-fox *Pteropus melanotus natalis*

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Flying-foxes (Pteropodidae) show a high rate of island endemism, but island-endemic taxa have shown a high rate of decline and extinction, mostly because their small population sizes are susceptible to hunting pressure and habitat loss. The Christmas Island flying-fox is restricted to the 135 km² Christmas Island (Indian Ocean), as either an endemic species *Pteropus natalis* or a markedly distinct subspecies of *Pteropus melanotus*. Given recent declines and extinctions of other native vertebrate species on this Island, this study sought to monitor population trends for this taxon. Monitoring flying-foxes at roost sites is difficult because they are highly vagile, not all roost sites may be known to observers, and dense vegetation at some sites may make counts inaccurate. These constraints are particularly evident on Christmas Island. In this study, we sought to establish a monitoring program complementary to roost counts, and to assess changes in reporting rate from a baseline sampling of 107 sites spaced across the Island in 2006 to a repeat sampling of those sites in 2012. Every site was visited four times, at night, over a period of 4–6 weeks in June–July of 2006 and of 2012, and observers reported whether or not they heard or saw flying-foxes around the sample site. A reporting incidence measure (varying from 0 to 4) was derived for every site. This measure showed a significant decline (of 39%) between the 2006 and 2012 sampling. The observed rate of decline suggests that this taxon is of considerable conservation concern, and merits further conservation action: indeed in 2014 its Australian conservation status was changed from not listed to Critically Endangered. The cause of the current decline is not yet known, but this study indicates that factors additional to hunting and habitat loss may affect island flying-fox species.

Key words: island, pteropodid, endemic, threatened species, monitoring

Effects of cave gating on population trends at individual hibernacula of the Indiana bat (*Myotis sodalis*)

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Installing gates at cave entrances to protect hibernating bat colonies is a widespread conservation action, particularly for endangered bat species such as the Indiana bat (*Myotis sodalis*). However, there is surprisingly little evidence on the efficacy of gates for improving population growth rates. We used change-point models to determine the effects of gate construction on Indiana bats. We estimated population growth rates at 20 hibernacula pre- and post-gating and quantified the change in population growth rates after gate installation. Hibernacula with increasing growth rates prior to gate placement all experienced decreased growth rates after installation. For hibernacula with declining growth rates prior to construction, growth rates increased moderately after installation. When weighted by population size, average change in growth rates across all 20 hibernacula was negative. Our results suggest that use of gates at hibernacula with growing populations may relate to unintended declines in growth rates but that, at hibernacula with declining populations, installation of gates may lead to moderate increases in local population growth rates.

Key words: cave, change-point, gating, hibernaculum, Indiana bat, *Myotis sodalis*

Phenology of migratory bat activity across the Baltic Sea and the south-eastern North Sea

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We compiled the available information on the occurrence and timing of migratory bat activity across the Baltic Sea and south-eastern North Sea coasts and islands, based on ultrasonic monitoring projects at 19 localities in 2007–2009. The data refer to three species; Nathusius' pipistrelle *Pipistrellus nathusii*, soprano pipistrelle *P. pygmaeus* and common noctule *Nyctalus noctula*. *Pipistrellus nathusii* occurred at all sites (north to 61°N in Finland), while the other species were scarcer, particularly at the northernmost sites. The status of the recorded individuals is unknown. However, the activity most likely was of migrating individuals or individuals on migration stopover, because very few observations were made during the maternity period. Spring activity occurred predominantly in May, with the median observation date of *P. nathusii* 20 days earlier in the south (Germany) than in the north (Finland). Autumn migration was observed throughout August and September and activity that may or may not indicate migration was also observed in October and November. The median date of such activity in autumn usually occurred in September and without any significant difference in timing in relation to latitude. Migratory bats in the Baltic area apparently move on a broad front in most cases. The estimated speed of migration for *P. nathusii* in spring was 55 km/day. The entire coastline and islands around the Baltic Sea are of potential importance for migrating bats in spring (April–May) and autumn (August–September) and should achieve relevant protection according to EU legislation and its implementations.

Key words: Europe, life history, migration, wind turbines, *Pipistrellus*, *Nyctalus*

Sex-specific seasonal change in body mass in two species of vespertilionid bats

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In most mammals, reproductive cost differs between males and females in timing and duration because of the different sex-specific energy allocation strategies to maximize fitness. The differences in reproductive strategy adopted by sexes may result in differences in seasonal variation of body mass. Here seasonal variations in body mass are discussed for two species of vespertilionid bats: Daubenton's bat (*Myotis daubentonii*) and Savi's pipistrelle (*Hypsugo savii*). Both species were observed to have a seasonal variability in body conditions, which was sex dependent. In late spring and for a given forearm length, females were heavier than males, but differences were small in late summer. Furthermore, female's body mass decreased during late spring and summer likely to support the energy requirement for lactation, while male's mass did not change (*H. savii*) or slightly increase (*M. daubentonii*) over the same period. On the contrary male *M. daubentonii* depleted body fat reserves during early autumn, likely because of the energy expenditure to increase mating opportunities. Our results suggest that seasonal changes in body condition in hibernating bats may reflect the differences in reproductive strategies between sexes.

Key words: reproductive cost, body condition, *Hypsugo savii*, *Myotis daubentonii*, reproductive strategies

MicroCT imaging reveals morphometric baculum differences for discriminating the cryptic species *Pipistrellus pipistrellus* and *P. pygmaeus*

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With the recent and continuing discovery of further cryptic bat species, it is essential to find morphological species discriminating characters. *Pipistrellus pipistrellus* (common pipistrelle) and *Pipistrellus pygmaeus* (soprano pipistrelle) have been recognized as separate species since 1997, but no reliable morphological species discriminating trait has yet been found. The most commonly used morphological species discrimination traits are ‘wing vein’ pattern and shape and color of the penis, but these have not been validated on sets of genetically identified specimens. The baculum (os penis) has long been used successfully in species discrimination in bats and other mammals. In this study, we tested the reliability of the established traits and demonstrated how to reliably separate the common pipistrelle and the soprano pipistrelle by simple baculum measurements. The bacula of museum specimens of these two species and of *Pipistrellus hanaki* were imaged with high-resolution microCT. 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. We showed that *P. pipistrellus* and *P. pygmaeus* specimens can be discriminated by measuring the projected length, height, and width of the baculum ($n = 48$; all but one classified correctly). Geometric morphometrics was used to analyze and locate variations in baculum shape. Principal component analysis of baculum variation was not sufficient to separate these species. Most of the interspecific variation in baculum shape can be found in the proximal third (the base) of the baculum, and most individual variation can be observed in lateral view, especially in the dorsoventral curve. Quantitative details of morphology are becoming more important to distinguish cryptic species and understand their phylogeographic distributions. The simple baculum measurements can be used to classify single specimens and could be taken without microCT, on a resected baculum.

Key words: os penis, morphometrics, micro-CT, x-ray microtomography, Vespertilionidae

A review of the occurrence of bats (Chiroptera) on islands in the North East Atlantic and on North Sea installations

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The bats recorded from Iceland, the Faroe Islands, the Shetland Islands, the Orkney Islands, and North Sea installations are reviewed to the end of 2012. In total 12 species have been positively identified, while a considerable proportion of all records are sightings of unidentified bats. Eight of the species are European in origin and four originate from the New World. The largest number of species (8) has been recorded in Iceland, but the greatest number of individuals (180) has been found in Orkney. The bat invasion on the Faroe Islands in 2010 is without precedence, when 70 observations of a minimum of 45 individuals were noted. Most observations in the study area occurred in the autumn, with fewer in the spring. Most observations were of single animals, but there were also sightings of up to 12 individuals. There has been a marked increase in bat records in the past three decades. We discuss whether this is a real increase, or due to improved communications, increased public awareness, increased shipping, changes in weather patterns and/or the effects of climate change. All factors appear to be involved.

Key words: Iceland, Faroes, Shetlands, Orkneys, North Sea, vagrancy, ship-assistance, climate change, invasion, identification problems

A survey of bats in a karst landscape in the central Philippines

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Karst landscapes are biologically diverse and unique ecosystems that are especially important to bats. As in other parts of Southeast Asia, cave roosting bats in the Philippines have suffered extensive human disturbance, and as a result, may be declining. Here we contributed to a region-wide effort to assess the status of cave bats by surveying bats in well-known caves and forest on limestone on Bohol Island in the central Philippines. We also assessed cave disturbance through physical signs and interviews. We observed and acoustically detected bats representing a total of 14 taxa in 23 of the 25 caves surveyed. Few species were present in most caves (median = 2 spp.) and only three caves had large numbers of bats (> 1,000). However, of the 29 bat species captured in forest, 19 are known to roost in caves, including the poorly known Philippine endemic, *Hipposideros coronatus*. Most surveyed caves experienced either current or historical human disturbance (88%), primarily by collectors of edible bird's nests, bats for food, and guano for use as fertilizer in rice fields. High species richness, signs of population decline, and high human disturbance all point to Bohol Island as an important conservation area for cave-roosting bats in the Philippines.

Key words: Bohol, cave bats, disturbance, echolocation, karst, Philippines

Acoustic identification of bats in the southern Western Ghats, India

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Bats play crucial roles in ecosystems, are increasingly used as bio-indicators and are an important component of tropical diversity. Ecological studies and conservation-oriented monitoring of bats in the tropics benefit from published libraries of echolocation calls, which are not readily available for many tropical ecosystems. Here, we present the echolocation calls of 15 species from the Valparai plateau in the Anamalai Hills, southern Western Ghats of India: three rhinolophids (*Rhinolophus beddomei*, *R. rouxii* (*indorouxii*), *R. lepidus*), one hipposiderid (*Hipposideros pomona*), nine vespertilionids (*Barbastella leucomelas darjelingensis*, *Hesperoptenus tickelli*, *Miniopterus fuliginosus*, *M. pusillus*, *Myotis horsfieldii*, *M. montivagus*, *Pipistrellus ceylonicus*, *Scotophilus heathii*, *S. kuhlii*), one pteropodid (*Rousettus leschenaultii*) and one megadermatid (*Megaderma spasma*). Discriminant function analyses using leave-one-out cross validation classified bats producing calls with a strong constant frequency (CF) component with 100% success and bats producing frequency modulated (FM) calls with 90% success. For five species, we report their echolocation calls for the first time, and we present call frequencies for some species that differ from those published from other parts of the species' ranges. This exemplifies the need for more local call libraries from tropical regions to be collected and published in order to record endemic species and accurately identify species whose calls vary biogeographically.

Key words: acoustic identification, call library, bats, frequency modulated, constant frequency, multiharmonic, Western Ghats, India, South Asia

Evaluation of mobile acoustic techniques for bat population monitoring

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Understanding population trends of any species is essential for conservation and management. However, due to difficulty in sampling some species, population status of many bat species is poorly understood. In an effort to resolve this issue, especially in light of emerging threats (e.g., white-nose syndrome and wind energy), a national mobile acoustic monitoring protocol, modeled after European programs, was developed to survey summer bat populations in the United States. While the program calls for conducting transects along roadways, some have suggested that waterways may allow for the gathering of more information. Therefore, we quantified species richness and abundance along car and boat transects to identify the most efficient mobile method. Furthermore, to compare the capabilities of mobile acoustic transects to a more traditional and better understood survey method, we compared species density along transects to stationary acoustic detectors. Using sample-based rarefaction, there was no difference at the 95% confidence level in species density (species/sample) between methods, however stationary points accumulated species more quickly than mobile methods. Of the mobile transect methods, car transects had higher diversity indices than boat transects and tended to show slightly higher species density. While over 1.5 times as many calls were recorded and identified along boat transects, there were no clear advantages of boat transects for monitoring bats except for *Myotis grisescens*. Additionally, car transects were least time consuming, leading us to conclude that car transects are the most efficient mobile acoustic method to monitor species. Mobile acoustic transects can likely monitor 2–4 species in the Eastern United States, including species with no current population monitoring methodology.

Key words: active sampling, Anabat, bats, mobile acoustic monitoring, passive sampling, population monitoring, sampling methods

Estimating sample size for landscape-scale mark-recapture studies of North American migratory tree bats

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Concern for migratory tree-roosting bats in North America has grown because of possible population declines from wind energy development. This concern has driven interest in estimating population-level changes. Mark-recapture methodology is one possible analytical framework for assessing bat population changes, but sample size requirements to produce reliable estimates have not been estimated. To illustrate the sample sizes necessary for a mark-recapture-based monitoring program we conducted power analyses using a statistical model that allows reencounters of live and dead marked individuals. We ran 1,000 simulations for each of five broad sample size categories in a Burnham joint model, and then compared the proportion of simulations in which 95% confidence intervals overlapped between and among years for a 4-year study. Additionally, we conducted sensitivity analyses of sample size to various capture probabilities and recovery probabilities. More than 50,000 individuals per year would need to be captured and released to accurately determine 10% and 15% declines in annual survival. To detect more dramatic declines of 33% or 50% survival over four years, then sample sizes of 25,000 or 10,000 per year, respectively, would be sufficient. Sensitivity analyses reveal that increasing recovery of dead marked individuals may be more valuable than increasing capture probability of marked individuals. Because of the extraordinary effort that would be required, we advise caution should such a mark-recapture effort be initiated because of the difficulty in attaining reliable estimates. We make recommendations for what techniques show the most promise for mark-recapture studies of bats because some techniques violate the assumptions of mark-recapture methodology when used to mark bats.

Key words: capture probability, Burnham joint model, lasiurines, mark-recapture, migration, recovery probability, survival

The impact of sampling method on maximum entropy species distribution modeling for bats

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As species distribution modeling (SDM) becomes more commonly incorporated into ecological studies, there is a need to address how the use of different sampling techniques for assessing the presence of a species can impact the final models produced. Over a four-year period, we sampled for the presence of bats throughout North Dakota via mist netting (physical capture) and ultrasonic acoustic monitoring. We used maximum-entropy modeling to develop habitat suitability maps for each study species using physical capture data, acoustic data and both detection techniques combined. We evaluated the amount of niche overlap between maps to determine how sampling technique impacted the final SDMs and which technique was best for modeling SDMs for each species. We found variation among species in the amount of overlap between SDMs, ranging from pronounced differences (33.9% overlap; *Myotis septentrionalis*) to highly similar models (80.4% overlap; *Myotis lucifugus*). Our findings show that acoustic detection results in better SDMs for *Myotis* spp. while physical capture was best for modeling *Eptesicus fuscus* and *Lasionycteris noctivagans*. Although both methods produce highly reliable SDMs, care must be taken when using maximum-entropy modeling for species in which presence data can be gathered in multiple ways. We emphasize that researchers should consider the ecology and behavioral characteristics of their focal species to address any biases associated with sampling technique.

Key words: acoustic sampling, distribution, MaxEnt, mist nets, physical sampling, sampling bias, SDM, species

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The misuse of relative humidity in ecological studies of hibernating bats

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Field biologists almost invariably report relative humidity as a measure of moisture in the air and assume that relative humidity somehow predicts evaporative water loss from an animal. In this paper, I use the vapor pressure gradient to show that, under conditions of constant relative humidity, evaporative water loss from the body surface of a hibernating bat can vary by more than 100%, depending on ambient temperature. Potential evaporative water loss at constant relative humidity is an increasing curvilinear function of ambient temperature for a torpid bat that has a surface temperature equal to surrounding air temperature, but a decreasing curvilinear function of air temperature for an aroused bat in the hibernaculum. Under some circumstances, evaporative loss actually can be greater in a hibernaculum with higher relative humidity than in one with lower relative humidity. When examining potential differences in evaporative water loss between sites, habitats, or treatments, biologists should consider the absolute (not relative) level of ambient moisture, as well as the surface temperature of the animal, which greatly affects the tendency of water molecules to evaporate.

Key words: evaporation, evaporative water loss, hibernation, humidity, relative humidity, vapor pressure

A device for restraining bats

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Herein we describe a safe, practical, and inexpensive device for restraining bats (Order Chiroptera). With advances in molecular techniques, biopsies from the flight membranes of bats have become routine; however, tissue sampling requires that the bat be restrained and often this work is performed by two people: one to hold the animal and another to conduct the procedure. The McMaster bat restrainer permits a single user to safely, effectively, and comfortably restrain a bat — both in the field and in the laboratory — while still having full access to its forearms, flight membranes, and/or dorsum/ventrum. The restrainer is light weight, portable, simple to use, easy to modify, and minimizes handling stress on bats. Investigators should take precautions to appropriately decontaminate the restrainer when working in areas where bats could be infected with the psychrophilic fungus that causes white nose syndrome (WNS), *Pseudogymnoascus destructans*.

Key words: animal handling, Chiroptera, marking, measurement, photography, PIT-tagging, restraint, tissue biopsy, wing membrane