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Three new species of *Murina* from southern China (Chiroptera: Vespertilionidae)

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The biodiversity of tube-nosed bats (Murininae) from Asia has been underestimated by over 50%. Since 2005, eight taxa have been documented as distinct from the 19 previously known species. We describe three new species of *Murina* collected in southern China between 2004 and 2007. These species differ morphologically, morphometrically, and genetically from previously described species of *Murina*. Morphological differences include pelage color, size, skull shape and tooth morphology. Analysis of mitochondrial DNA barcodes of the cytochrome c oxidase subunit I (COI) gene supports species status based on divergent phylogenetic lineages.

Key words: COI, DNA barcodes, morphometrics, Murininae, Southeast Asia, tube-nosed bats

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Taxonomic revision of the genus *Asellia* (Chiroptera: Hipposideridae) with a description of a new species from southern Arabia

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Two species are currently recognised within the genus *Asellia*, a typical inhabitant of arid areas of northern Africa and south-western Asia. Most of the distribution range of the genus is covered by *Asellia tridens*, while the other species, *A. patrizii*, is restricted to Ethiopia, Eritrea and several Red Sea islands. We analysed the morphological variation in an extensive set of *Asellia* samples covering the range of the genus, including most of the available type material. In a representative subset of samples, we employed molecular genetic analysis to infer the phylogenetic relationships within the broadly distributed *A. tridens*. Morphological comparisons revealed four distinct morphotypes. Except for the endemic *A. patrizii*, almost all African *Asellia* were found to belong to the same morphotype as most of the Middle Eastern specimens. This morphotype was unambiguously identified as *A. tridens*. Two other morphotypes of tentative *A. tridens* were further recognised based on skull shape differences; one in the southern Arabian region of Dhofar, the other in Socotra and Somalia. Phylogenetic analysis of complete sequences of the mitochondrial cytochrome *b* gene yielded three main monophyletic groups, which corresponded to the morphotypes revealed for *A. tridens*. Significant genetic divergences reaching over 5% and 12%, respectively, were discovered between them. Based on the morphological and molecular data obtained, we propose a split of the current *A. tridens* into three separate species: *A. tridens* in northern Africa and most of the Middle East, *A. italosomalica* in Socotra and Somalia, and *Asellia* sp. nov. in southern Arabia. Molecular dating, along with the available paleontological information and geological history of the Arabian Peninsula, supports an Arabian origin of the contemporary *Asellia*. While profound divergence of the Socotran form may be linked to the split of Socotra from the southern Arabian coast in the Middle Miocene, the low sequence variation of *Asellia* in most of Africa and the Middle East suggests a relatively recent colonisation of this vast area during the Pleistocene. The newly described form from southern Arabia most likely represents a relic of aridisation during the Miocene–Pliocene transition.

Key words: *Asellia*, morphology, morphometry, mtDNA, taxonomy, phylogeny

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A new mouse-eared bat (Mammalia: Chiroptera, Vespertilionidae) from South China

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A small *Myotis* species belonging to the *Myotis siligorensis* group was found in four caves in Yunnan province, South China. Twenty specimens of this bat were compared with other East Asian *Myotis* species. Statistical and physical analysis of this sample demonstrates that, despite their similarity to *M. siligorensis*, the Yunnan specimens have characteristics of baculum morphology and cranial proportions suggesting that they represent a distinct species.

Key words: *Myotis* sp. nov., taxonomy, baculum, South China

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Phylogeography and taxonomic status of the greater mouse-tailed bat *Rhinopoma microphyllum* (Chiroptera: Rhinopomatidae) in Iran

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The taxonomic status of the greater mouse-tailed bat (*Rhinopoma microphyllum*) in Iran is not clear and researchers have reported conflicting results. The initial suggestion of the presence of two subspecies *R. m. microphyllum* and *R. m. harrisoni* has been questioned on the basis of small differences between the populations. These differing inferences are based on analysis of morphological characteristics. Here we present a study of the phylogeography of this species using 567 bp of the mitochondrial control region in several localities in Iran and from across its distribution to infer the taxonomic status of this species. Based on the control region sequences, we found high genetic diversity in the Iranian population but variation between populations was not statistically significant. The phylogenetic trees and statistical parsimony network showed all Iranian samples were grouped in the same clade and Levant samples belonged to another clade. These results support the hypothesis that all Iranian specimens belong to one subspecies. We therefore recommend that *R. m. microphyllum* and *R. m. harrisoni* can be synonymized as the same subspecies with the name *R. m. harrisoni*, because molecular results indicate that Iranian samples differ from Levant and Moroccan samples (*R. m. microphyllum*).

Key words: *Rhinopoma microphyllum*, phylogeography, control region, Iran

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Morphometric variation and genetic diversity of the lesser and greater mouse-eared bats (Chiroptera: Vespertilionidae) in Thrace and Anatolia

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We analyzed four morphological characters and a 307 bp fragment of the mitochondrial control region of the greater and lesser mouse-eared bats sampled in four colonies in Turkish Thrace and Anatolia. Bats were identified by reference to their upper tooth-row length and rostral width. Despite a considerable variation in upper jaw measurements, there was not clear pattern relating the observed variability to particular regions. The genetic diversity of the mitochondrial control region was very high in the Thracian and Anatolian colonies (26 unique haplotypes in 82 sampled individuals), suggesting that these regions hosted one or more glacial refugia for *M. myotis*. The lesser and greater mouse-eared bats shared the same, or had very similar haplotypes. All haplotypes of the mitochondrial control region sampled in Thrace and Anatolia belonged to the haplogroup D. Haplotypes from the same group were previously found in the Balkans, Crimea, and Central Europe. The original mitochondrial lineage of *M. blythii*, reported from Kirghizstan, was not present in Anatolia. Apparently, in Europe, Central Anatolia, and Levant the greater and lesser mouse-eared bats have the mitochondrial genome of *M. myotis*.

Key words: *Myotis myotis*, *M. blythii*, *M. oxygnathus*, mtDNA, morphometrics, Anatolia, Thrace

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Status and natural history of *Emballonura semicaudata rotensis* on Aguiguan, Mariana Islands

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Pacific sheath-tailed bats (*Emballonura semicaudata rotensis*) in the Mariana Islands declined greatly in abundance and distribution during the 20th century. The small island of Aguiguan now supports the only persisting population. We studied abundance and natural history of this population from 1995–2008. There was a likely population increase during the study, with 359–466 (minimum and maximum) bats counted at caves in 2008. Bats roosted only in caves, primarily those of relatively larger size. Bats were detected in only seven of 95 caves; three caves were always occupied when surveyed. One cave consistently had the largest colony ($\bar{x} \pm$ SD = 333 ± 33.6 in 2008). Others held 1–64 bats. Cave environments showed no complexities in temperature or humidity. Preliminary observations indicate a litter size of one and the possibility of birthing timed to coincide with the transitional period leading into the rainy season (June–July). We review potential threats to *E. s. rotensis* on Aguiguan and make suggestions for conservation.

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Molossus aztecus and other small *Molossus* (Chiroptera: Molossidae) in Brazil

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We report the first record of *Molossus aztecus* from two localities in southeastern Brazil, Lavras and Viçosa, confirming the presence of this species in South America; both localities are located in the state of Minas Gerais. Samples from Lavras contained both *M. aztecus* and *M. molossus*, permitting direct comparison of the two taxa. At both sites, the original vegetation was Cerrado-Atlantic Forest ecotone and the bats were captured at elevations from 650 to 1,100 m. We compared our specimens of *M. aztecus* from southeastern Brazil with *M. aztecus* from Mexico, *M. molossus* from several parts of Brazil, *M. coibensis* from Panama, *M. barnesi* from French Guiana, and *M. currentium* from Paraguay. Capturing *M. aztecus* and *M. molossus* sympatrically reinforced their distinctiveness; they differ in morphometrical traits and qualitative characters of skull and pelage. We also found that specimens earlier identified as *M. coibensis* from Brazil, are referable to *M. barnesi* from French Guyana.

Key words: *Molossus aztecus, M. barnesi, M. coibensis, M. currentium, M. molossus,* morphology, Brazil

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Environmental components and boundaries of morphological variation in the short-tailed fruit bat (*Carollia* spp.) in Ecuador

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Species in *Carollia*, although loosely recognizable by size and shape, show overlap in most morphological character states as well as in geographic distribution and use of resources. However, there is a lack of understanding regarding where and what this overlap is. Variation in the morphology of *Carollia* should correspond to the environment, yet such patterns remain unknown. Species may coexist as a function of environmental factors and sympatry may not be uniform along the distributional extent of these species. An informed perception of the morphological and ecological variation across their geographic range may clarify not only the limits and extents of their spatial and morphological boundaries, but also may provide insights into the relationships among size, shape and environment. In our quantitative analysis of the variation in morphology and environment we tried to answer what limits species distribution, as well as how morphology changes with the environment within and among species. A combination of multivariate contrasts and partial least square analyses were used to assess the correlations and interactions between size, shape, distribution and environment among *C. castanea* (small), *C. brevicauda* (medium) and *C. perspicillata* (large size) in Ecuador. We show how the three *Carollia* species vary and differentiate along an ecomorphological space of gradients, barriers, size and shape. From a macro-ecological perspective, and contrary to the theory of limiting similarity, the smallest species is the most distinct in its environmental space and also the one that experiences the strongest changes in shape across geographic regions. The other two more similar species, in both size and shape, show a larger overlap in their environmental space. This seems to suggest that size can act as a buffer in extreme or changing environments and that higher gene flow is more probable for larger high-altitude species.

Key words: *Carollia*, distribution, environment, shape, size, Ecuador

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Reproductive phenology of bat assemblages in Vietnamese karst and its conservation implications

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Bats constitute a substantial proportion of mammal diversity within the Asian tropics and subtropics and are particularly susceptible to population losses associated with human activities. This poses a conservation concern in Asian karst areas which support high bat species diversity, yet are experiencing habitat loss and degradation and increasing pressure from tourism and extractive industries. As disturbance during crucial reproductive periods (late pregnancy, lactation and weaning) threatens reproductive success, we investigated the reproductive phenology of a bat assemblage at two karst sites in North Vietnam. Our results indicate that the timing of major reproductive events coincides among two cave-dwelling pteropodids, and among 26 cave and foliage dwelling rhinolophids, hipposiderids and vespertilionids. March–July is the primary reproductive period for all insectivorous species sampled, and protection of maternity roosts during this time is critical. Reproduction in cave-dwelling pteropodids spanned a greater period (March–December), due to two birth periods each year. Lactation in the three insectivorous families studied was positively correlated with rainfall and temperature, with weaning occurring during the peak wet season. The strong congruence in reproductive phenologies in our results and climatic homogeneity of North Vietnam (18–23°N) suggests that our study may have wider applicability within the region. Vietnamese caves support high bat diversity which is likely threatened by harvesting for consumption and tourism development nationwide. Studies to investigate and address these threats should be given high priority.

Key words: bats, reproduction, caves, conservation, Vietnam

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Habitat use in the female Alpine long-eared bat (*Plecotus macrobullaris*): does breeding make the difference?

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Recent discoveries of several new cryptic bat species in Europe, as well as the growing concerns on bat conservation, have resulted in increased efforts to study roost site selection, habitat use and spacing/foraging behaviour. For many of these cryptic species, management is problematic due to the lack of information. We present data on space and habitat use of 14 radio-tagged *Plecotus macrobullaris* females from a nursery in the central part of the species' distribution. They used home ranges larger than 10 km^2, and the behavioural pattern was typically a first foraging bout soon after emergence from the nursery, followed by fast non-foraging flight towards selected habitat types. Habitat selection, as evaluated by K-select analysis, is non-random with preference for ecotones at woodland borders and rural areas, whereas woods are avoided. Body condition differentially affects habitat use for breeding and non-breeding females: breeding females in good condition showed a strong preference for ecotones. Among non-breeding females, the preference for ecotones varied with body condition. Being the sibling species of *P. auritus*, which is considered a woodland bat, the selection pattern observed for *P. macrobullaris* raises some questions about the possible niche partition in cases of sympatry.

Key words: *Plecotus macrobullaris*, habitat selection, home range size, radio-tracking, Italy

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Ecological aspects of the tent building process by *Ectophylla alba* (Chiroptera: Phyllostomidae)

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Twenty-two species of bats worldwide are known to use modified leaves as their roost, known as 'tents'. It has been suggested that the mating system of these species is resource-defense polygyny, with the presumably male-constructed tent serving as an attractant of females, but in *Ectophylla alba* a female was observed building a tent. The objectives of this work were to determine: 1) if both sexes build the tent; 2) if there is a relationship between number of tents and mating seasons and 3) the time availability of the *Heliconia* leaves that this species uses to makes its roost as well as the effect of the bats on the plant. The study site was the Tirimbina Biological Reserve, Sarapiqui, Costa Rica. During 53 weeks, we censused the tents of *E. alba* in nine hectares. Construction of tents was filmed with a video camera and infrared lights. To measure the average life of the tents and the leaves that had not been modified, we marked leaves that were visited weekly to monitor for deterioration. Our results show that both females and males construct tents. Roost construction is costly in terms of time and effort, so the bats maximize the time spent occupying the tent. The modifications that the bats make to the leaves considerably reduce the lifetime of the leaves. This has implications for both the plant used and for the bats that build the tents.

Key words: tent-roosting bats, *Ectophylla alba*, tents, *Heliconia*

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Sex-specific roost selection by bats in clearfell harvested plantation forest: improved knowledge advises management

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To maximize energetic savings, female bats often roost communally whilst pregnant or with non-volant dependents, whereas male bats more often roost alone; however, differences in selection of roosts by sex have not often been investigated. Better understanding of female colony locations could focus management to protect the majority of bats. New Zealand's long-tailed bat (*Chalinolobus tuberculatus*) roost in exotic plantation forest, where sex-specific roost selection has not been investigated, and therefore such management is not possible. We investigated sex-specific roost selection by long-tailed bats for the first time. Roosts and paired non-roosts were characterized testing predictions that males and females select roosts that differ from non-roosts, and males and females select different roosts. Females and males chose *Pinus radiata* roosts that differed from non-roost trees. Results suggest each sex chose roosts that maximized energetic savings. Female bats used roosts closer to water sources, that warmed earlier in the day, which allowed maintenance of high temperatures. Males appeared to choose roosts that allowed torpor use for long periods of the day. Males may be less selective with their roost locations than females, as they roosted further from water sources. This could allow persistence of male bats in marginal habitat. As all female long-tailed bats chose roosts within 150 m of waterways, management to protect bats could be focused here. To protect bats least able to escape when roosts are harvested, harvest of forest stands selected by female bats as roost sites should be planned when bats are not heavily pregnant nor have non-volant dependents.

Key words: *Chalinolobus tuberculatus*, energetic savings, plantation forest, roost selection, threatened species, waterways

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Conspicuous visual cues can help bats to find tree cavities

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In bats, vision plays a role in various contexts, particularly for long distance orientation and the detection of food. However, the extent to which vision is used is still poorly known. Here we test whether conspicuous visual cues increase the performance of the brown long-eared bat *Plecotus auritus* in an experimental paradigm based on tree hole discovery by bats. We used experimental logs with bark 'stripped off' (conspicuous bright area around entrance) and with bark 'not stripped off' to investigate whether there were differences in effectiveness of finding the entrances with or without light. Results indicate that the bats' effectiveness in finding the stripped entrances increased when light was provided. We suggest that the entrance was more visible due to high contrast between bark and wood. Our results indicate that visual cues could play a role in preselection of roost sites for this species.

Key words: roost, sensory ecology, vision, *Plecotus auritus*, Vespertilionidae

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Nocturnal activity patterns of northern myotis (*Myotis septentrionalis*) during the maternity season in West Virginia (USA)

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Nocturnal activity patterns of northern myotis (*Myotis septentrionalis*) at diurnal roost trees remain largely uninvestigated. For example, the influence of reproductive status, weather, and roost tree and surrounding habitat characteristics on timing of emergence, intra-night activity, and entrance at their roost trees is poorly known. We examined nocturnal activity patterns of northern myotis maternity colonies during pregnancy and lactation at diurnal roost trees situated in areas that were and were not subjected to recent prescribed fires at the Fernow Experimental Forest, West Virginia from 2007 to 2009. According to exit counts and acoustic data, northern myotis colony sizes were similar between reproductive periods and roost tree settings. However, intra-night activity patterns differed slightly between reproductive periods and roost trees in burned and non-burned areas. Weather variables poorly explained variation in activity patterns during pregnancy, but precipitation and temperature were negatively associated with activity patterns during lactation.

Key words: Anabat, bats, *Myotis septentrionalis*, night-roosting, northern myotis, West Virginia

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Emergence time and foraging activity in Pallas' mastiff bat, *Molossus molossus* (Chiroptera: Molossidae) in relation to sunset/sunrise and phase of the moon

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The decision on when to emerge from the safety of a roost and forage for prey is thought to be a result of the trade off between peak insect abundance and predation pressure for bats. In this study we show that the velvety free-tailed bat *Molossus molossus* emerges just after sunset and just before sunrise for very short foraging bouts (average 82.2 min foraging per night). Contrary to previous studies, bats remain inactive in their roost between activity patterns. Activity was measured over two complete lunar cycles and there was no indication that phase of the moon had an influence on emergence time or the numbers of bats that emerged from the roost. This data suggests that *M. molossus* represents an example of an aerial hawking bat whose foraging behaviour is in fact adapted to the compromise between the need to exploit highest prey availability and the need to avoid predation.

Key words: *Molossus molossus*, emergence, foraging, nocturnal, predator pressure, activity

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Activity of two species of free-tailed bats over a stream in southeastern Brazil

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The objective of the present study was to investigate activity time of the molossid bats *Nyctinomops laticaudatus* and *Molossus molossus* at the same locality, and to test whether activity of one species affects activity of the other. During January 2007–May 2009, we sampled for 15 nights over a stream in southeastern Brazil. Total sampling effort was 166 h and 693 m of nets. Time of capture was transformed into minutes in relation to sunset. First captures of *M. molossus* occurred just after sunset except for one individual that was captured before sunset. Total activity time of *M. molossus* ranged from 27 min before sunset to 743 min after sunset. Total activity time of *N. laticaudatus* ranged from 42 to 675 min after sunset and activity differed significantly between species. Activity of *M. molossus* was related to time of sunset, as expected based on behavior of other insectivorous species, whereas activity of *N. laticaudatus* seemed independent of sunset.

Key words: capture time, sunset, activity, *Molossus molossus*, *Nyctinomops laticaudatus*, insectivorous bats, Brazil

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Finding your friends at densely populated roosting places: male Egyptian fruit bats (*Rousettus aegyptiacus*) distinguish between familiar and unfamiliar conspecifics

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Individual recognition via olfactory, auditory, or visual cues is crucial for animals to form and maintain stable social groups, particularly in large colonies such as those of Egyptian fruit bats (*Rousettus aegyptiacus*). We tested whether Egyptian fruit bats are able to distinguish between familiar and unfamiliar conspecifics, using two captive groups of male bats. We recorded the behavioural and auditory responses of focal animals in a binary choice experiment in which they could approach either members of their own social group or unfamiliar individuals. In general, bats preferred to stay close to other bats, familiar or unfamiliar, over resting alone and spent more time in close proximity to members of their own group than to unfamiliar conspecifics. The majority of bats interacted more with the unfamiliar individuals, although this result did not reach significance. We conclude that Egyptian fruit bats are able to distinguish between familiar and unfamiliar conspecifics. Since only one individual emitted social calls and bats never produced echolocation calls during the experiment, we infer that individual recognition was most likely mediated via olfactory and/or visual cues. The ability to identify familiar individuals may indicate that males of Egyptian fruit bats form stable groups within their large colonies.

Key words: Pteropodidae, recognition, choice test, social system, male stable groups, cues

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Life expectancy, causes of death and movements of the grey-headed flying-fox (*Pteropus poliocephalus*) inferred from banding

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This study was designed to generate information on demography and movements in large flying-foxes, information that is critical to management planning. Between 1989 and 2002, 2,244 wild grey-headed flying-foxes, *Pteropus poliocephalus*, were harp-trapped, banded and released at sites across south-eastern Australia; 918 hand-reared orphans were also banded and released at four sites. Retraps of wild animals were few ($n = 10$) and are not discussed here. Recoveries ($n = 86$) from the public reporting dead wild flying-foxes (total 4.27%) and 38 hand-reared orphans (4.13%) are discussed. Recovery data were analysed via standard multiple regression; there was no difference between the sexes of wild *P. poliocephalus* in age at death or distance travelled, but hand-reared animals, on average, lived less than half as long as their wild counterparts ($P < 0.001$) and did not travel as far ($P < 0.01$). The average age of wild *P. poliocephalus* at death was 7.1 ± 3.9 years ($\bar{x}$ ± SD, $n = 86$); the oldest flying-fox was 18 years of age. Generation length is estimated at 7.4 ± 3.76 years. Major causes of death of 86 wild *P. poliocephalus* were: hyperthermia (33.7%); electrocution (18.6%); entanglement in fruit-tree netting (5.8%); entanglement in barbed wire (4.7%); unknown (32.6%). 77% of recoveries of wild-banded *P. poliocephalus* were within 20 km of where they were banded; the longest movement recorded was 978 km. 1,632 wild black flying-foxes, *P. alecto* were trapped and banded; 27 were retrapped; seven were recovered dead (0.42%); from another 136 banded as hand-reared orphans, three were recovered (2.2%). Of 583 wild little red flying-foxes, *P. scapulatus*, trapped and banded, none were retrapped; one was recovered (0.2%). Data from *P. alecto* and *P. scapulatus* were too few for statistical analysis.

Key words: *Pteropus*, harp-trapping, hand-rearing, banding, life expectancy, causes of death, movements

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Potential and limits in detecting altitudinal movements of bats using stable hydrogen isotope ratios of fur keratin

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Despite their small size, bats are exceptionally mobile. But where and when bats move seasonally often remains enigmatic, particularly for altitudinal movements. Recently, stable hydrogen isotope ratios (δD) of metabolically inert material like hair keratin have been utilized to track altitudinal movements of animals. Here, we measured δD in hair keratin of seven bat species captured in the Merendon Mountain Range in Honduras: three species were captured only at the low elevation site (≈ 1,100 m above sea level), one species only at the high elevation site (≈ 1,500 m a.s.l.) and three species at both sites. Based on information from the literature, we categorized two out of the seven species as sedentary (obligate fruit-eating *Artibeus toltecus* and insect-feeding *Micronycteris microtis*). All others were categorized as potentially migratory species (obligate fruit-eating *Artibeus jamaicensis*, *Sturnira ludovici* and *Sturnira lilium* and insect-feeding *Myotis keaysi* and *Molossus ater*). Hair keratin of insectivorous species was enriched in deuterium by about 40‰ relative to that of co-existing fruit-eating species, irrespective of whether they were sedentary or potentially migratory, suggesting that δD of consumer tissue increases markedly with increasing trophic level. Hair keratin of sedentary *A. toltecus* and potentially migratory *S. ludovici* did not differ between populations of the two elevations indicating that the altitudinal gradient in δD may be too small and/or that variation in hair keratin δD too large to unravel altitudinal movements of less than 400 m in bats based on keratin δD alone.

Key words: altitudinal migration, Honduras, Neotropical bats, stable hydrogen isotopes, trophic level, tropical mountain ecosystems

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Species richness and diversity of a West Indian bat assemblage in a fragmented ecosystem

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We examined the assemblage of bats in a fragmented landscape along the northern coast of the island of Puerto Rico, West Indies, by mist netting and acoustic monitoring over a period of 25 months. Twelve of the 13 species present in the region were detected. It took nine nights of net and acoustic monitoring to detect 69% of the species, and 44 nights to reach 92%. Diversity was high, considering the insular nature of the assemblage and the fragmented nature of the ecosystem. We did not detect any important seasonal pattern in bat activity. The fruit eating bats at this study site are important importers of various seeds. *Artibeus jamaicensis* was most frequently captured and it appears to breed throughout the year at this location. Our results have important implications for management and conservation of biological diversity on tropical islands, and set a baseline against which the effect of further urban encroachment can be compared.

Key words: Caribbean bats, phyllostomids, fragmentation, West Indies

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Using echolocation calls to identify Thai bat species: Vespertilionidae, Emballonuridae, Nycteridae and Megadermatidae

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Variation in the acoustic structure of bat echolocation calls can often provide sufficient information for reliable and efficient species identification. The aim of this study was to investigate the use of echolocation call structure to identify a number of bats in the families Vespertilionidae, Emballonuridae, Nycteridae and Megadermatidae from Thailand. These species typically emit echolocation calls with a frequency-modulated (FM) sweep dominating part or all of their calls. A total of 510 echolocation calls from free-flying individuals were recorded throughout Thailand. According to the frequency-time spectra, these calls were categorized into four types: broadband FM (eight species), narrowband FM (seven species), long multiharmonic (four species) and short multiharmonic (three species). Discriminant function analysis was used to classify calls from individual bats to species. Correct classification levels were 85.9% for individuals emitting broadband FM calls (six species with adequate sample sizes), 70.4% for narrowband FM bats (seven species), 84.4% for species emitting long multiharmonic calls (four species) and 96.7% for species emitting short multiharmonic calls (two species with adequate sample sizes). However, classification rates were often low at the species level. Acoustic identification of bats emitting FM calls should be approached with caution in species-rich communities, in contrast with the identification of rhinolophoid bats where many species use distinctive constant frequencies that can facilitate identification. and provides a basis for rapid acoustic surveys of large areas in Thailand, and potentially other parts of Southeast Asia.

Key words: echolocation, bat families, frequency modulated (FM), broadband, narrowband, multiharmonic

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Short CF-FM and FM-short CF calls in the echolocation behavior of *Pteronotus macleayii* (Chiroptera: Mormoopidae)

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Echolocation signals were recorded from the Macleay's bat (*Pteronotus macleayii*) while hunting for insects in the field. Search, approach and terminal phases were identified in the foraging activity of the species. During search phase, *P. macleayii* emitted calls consisting of a short CF component followed by a downward FM sweep (sCF-FM), typical of the small *Pteronotus* species. In addition, FM-sCF calls were recorded. In search flight some sequences consisted only of sCF-FM calls while others consisted only of FM-sCF calls. Most sequences, however, combined both call designs. Based on this and previous studies we suggest that sCF-FM and FM-sCF calls will characterize the vocal repertoire of each of the small *Pteronotus* species. We discuss the relevance of our results for acoustic identification of *P. macleayii* and the other small *Pteronotus* in the field.

Key words: echolocation, evolution, FM-sCF, mormoopid bat, *Pteronotus macleayii*, sCF-FM

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Timing and pattern of molt in Kuhl's bat, *Pipistrellus kuhlii*, in Saudi Arabia

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Kuhl's bat (*Pipistrellus kuhlii*) from Unizah Province, near the center of Saudi Arabia, was studied monthly from May 2005 to August 2006 to investigate the timing and patterns of molt. Adults and juveniles undergo a single molt extending annually over a five month period in summer from late April until September and following the breeding season. Few males of Kuhl's bat initiate molt before females but the majority of both sexes molt in July and terminated the molt almost simultaneously. Molting begins on the dorsum and then spreads to the ventrum once the dorsal molt is completed. Our findings provide comparable observations to previous studies on molt in bats suggesting that bats appear to exhibit a species-specific timing and sequence of molt.

Key words: molt, pattern, timing, *Pipistrellus kuhlii*, Unizah, Saudi Arabia