

## **The Iberian contribution to cryptic diversity in European bats**

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We investigate the contribution of the Iberian bat fauna to the cryptic diversity in Europe using mitochondrial (*cytb* and *ND1*) and nuclear (*RAG2*) DNA sequences. For each of the 28 bat species known for Iberia, samples covering a wide geographic range within Spain were compared to samples from the rest of Europe. In this general screening, almost 20% of the Iberian species showed important mitochondrial discontinuities (K2P distance values > 5%) either within the Iberian or between Iberian and other European samples. Within *Eptesicus serotinus* and *Myotis nattereri*, levels of genetic divergence between lineages exceeded 16%, indicating that these taxa represent a complex of several biological species. Other well-differentiated lineages (K2P distances between 5–10%) appeared within *Hypsugo savii*, *Pipistrellus kuhlii* and *Plecotus auritus*, suggesting the existence of further cryptic diversity. Most unsuspected lineages seem restricted to Iberia, although two have crossed the Pyrenees to reach, at least, Switzerland.

*Key words:* Chiroptera, cryptic species, refugia, Europe, Iberia, mitochondrial DNA

**A description of a new species of *Pipistrellus* (Chiroptera: Vespertilionidae) from Madagascar with a review of related Vespertilioninae from the island**

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Six species of small vespertilionid bat were recently collected in Madagascar. *Neoromicia matroka* (included by some in *Eptesicus*) and *N. malagasyensis* were already recorded from the island. *Pipistrellus hesperidus* was known but under a different name, *P. kuhlii*. *Neoromicia melckorum* is a new species record for the island. *Hypsugo anchietae* represents a new species and genus record. The last taxon is a previously undescribed species of *Pipistrellus*, which shows affinities to three South-east and East Asian pipistrelle taxa. In this paper, the new species is described and further information on the taxonomy, distribution, ecology, and behaviour of all six taxa are provided.

*Key words:* Vespertilioninae, *Pipistrellus* sp. nov., *Hypsugo anchietae*, *Neoromicia melckorum*, taxonomy, distribution, Madagascar

## **A review of bat research in Thailand with eight new species records for the country**

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A review of the literature relating to the history of bat research in Thailand (1821–2006) is included, together with lists of the 119 bat species currently recorded from the country and the 16 that are omitted for lack of supporting data. The geographical distribution within Thailand of the some of the more significant bat field studies (1896–2004) is mapped and briefly discussed. Based on field work conducted in peninsular Thailand in 1993 and 2003–2004, eight bat species (*Hipposideros ridleyi*, *Myotis hermani*, *Pipistrellus stenopterus*, *Hesperoptenus tomesi*, *Murina suilla*, *Murina aenea*, *Kerivoula pellucida*, and *Mops mops*) are recorded from the country for the first time; information is provided on their taxonomy, distribution, and ecology. Recommendations are made for further bat studies in Thailand, with emphasis placed on selecting less well known species groups, such as forest bats, in under-researched habitats in neglected geographical areas (for example, the deciduous dipterocarp forests of eastern Thailand and the semi-evergreen forests of peninsular Thailand). A need to develop in-country skills in bat acoustics and taxonomy is also highlighted.

*Key words:* Chiroptera, Thailand, systematics, literature review, faunal list, new records

## **The type locality of *Natalus stramineus* (Chiroptera: Natalidae): implications for the taxonomy and biogeography of the genus *Natalus***

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The name *Natalus stramineus* has been historically applied to populations of the genus *Natalus* from virtually the entire Neotropics. The geographic origin of the holotype of *N. stramineus*, however, has never been known with certainty, confounding discussions concerning the species limits, nomenclature, and biogeography of this genus. The type locality of *N. stramineus* was assumed to be Brazil for about 80 years, but was later transferred to the Lesser Antilles. Although the later view has dominated the taxonomy of *Natalus* for the past four decades, there have been recent claims that the type locality might indeed be in Brazil. In this study, I provide morphological evidence that corroborates the Lesser Antillean origin of the holotype of *N. stramineus*. In addition, I argue that *N. stramineus*-like populations do not occur in northern South America implying that the genus *Natalus* is distributed throughout Central and South America as three allopatric taxa. The findings presented here prompt the recognition of two additional species for the continental Neotropics and put an end to lingering confusion about the degree of sympatry, or lack thereof, among these species. Finally, I summarize the available information about the natural history of *N. stramineus*, as herein restricted, and argue that the current distribution of the species is likely the result of ancestral dispersal from northern South America.

*Key words:* *Natalus*, Natalidae, Lesser Antilles, Caribbean biogeography

## **A comparison between emergence and return activity in pipistrelle bats *Pipistrellus pipistrellus* and *P. pygmaeus***

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Bats may be vulnerable to predation during evening emergence and morning return to their roosts. Early emergence increases the risk of exposure to raptorial birds, but emerging late confers a risk of missing the dusk peak of aerial insects. Here, both emergence and return activity was studied in detail at the same roosts for the first time. We investigated six maternity colonies of pipistrelle bats (*Pipistrellus pipistrellus* and *P. pygmaeus*) in NE Scotland and recorded light levels and time of emergence and return of the bats with respect to sunset and sunrise on the same nights. Parameters of return activity generally occurred at lower light intensities than those of emergence. Therefore, the interval between dawn return and sunrise was generally longer than that between sunset and dusk emergence. Emergence and return were equal in duration. Bats clustered more on emergence in comparison with return during pregnancy and lactation, whereas during postlactation this trend was reversed.

*Key words:* *Pipistrellus pipistrellus*, *P. pygmaeus*, emergence, return, predation risk, temperature

## **Songflight behaviour and mating system of the pipistrelle bat (*Pipistrellus pipistrellus*) in an urban habitat**

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The songflight and the territorial behaviour of courting male pipistrelles (*Pipistrellus pipistrellus*) were observed in an urban habitat of this bat species, in the city of Bayreuth in Bavaria. (1) Within the city limits, from the middle of July to the end of October but most intensively in September, the male bats occupied courtship territories averaging about 200 m in diameter. At night they patrolled these territories along regular flight routes emitting characteristic advertisement calls. By day they sheltered in crevices in buildings. (2) The courtship territories were densely distributed in the center of the inner city and rarer at the outskirts. As all known larger winter roosts as well as the ‘invasion centers’ (typical late summer swarming sites of this species) also were in the inner city, territories were situated around winter quarters, but not in the vicinity of the nursery roosts, which were lying at the edge of the city and outside it. (3) The males evidently arrange their courtship territories in such a way that as many females as possible pass through them when they inspect the winter roosts. That is, they are not defending resources important to the females; instead, they position their courtship territories near the resources the females require. As male territories are densely packed, the males offer a possibility for mate choice to the females, so that the mating system also bears some likeness to a lek.

*Key words:* *Pipistrellus pipistrellus*, songflight, mating, courtship territories, urban habitat

## Small scale distribution patterns of female and male Daubenton's bats (*Myotis daubentonii*)

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We analysed the distribution and relative abundance of *Myotis daubentonii* in the lowlands and uplands around the Lahn river near the city of Giessen (Hessen, Central Germany). We assumed a positive correlation between distribution and relative abundance of the trawling *M. daubentonii* with the amount of water surface in our study area. We further expected an unequal distribution of male and female *M. daubentonii* especially during the energy demanding pregnancy and lactation period of females. Daubenton's bats were found at 75% of the 64 ponds and lakes we surveyed by standardized nightly spotlight counts. The number of Daubenton's bats correlated positively with the area of the water surface and negatively with the distance to the nursery colonies. Nursery colonies were located with radio-tracking and existed predominantly in the lowlands close to the Lahn river. Mean flight distance between nursery colonies and foraging areas was 2.3 km (mean  $\pm$  1.4 km, range: 0.6–6.3 km). Sex ratio was determined at three sites studied in detail from 1992–2003 by mist-netting along regular used flight paths ( $n = 1,847$  caught individuals). The number of female per male *M. daubentonii* was unequal and differed significantly between the three sites. In the lowland we found one site clearly dominated by females (median = 4.3 females per male, percentages of females 79.3%,  $n = 169$  individuals) and a second site with an almost balanced sex ratio (median = 1.1 females per male, percentages of females 50.3%,  $n = 939$  individuals). At the third site in the uplands males outnumbered females (median = 0.2 females per male, percentages of females 13.5%,  $n = 739$  individuals). The percentages of females remained largely constant from spring to mid summer and changed at the beginning of September. The study revealed that a detailed knowledge of the spatial distribution of gender specific roost sites and key foraging habitats is necessary for the establishment of meaningful monitoring and conservation measures for bats.

*Key words:* *Myotis daubentonii*, sex ratio, abundance, distribution, conservation

## **Occurrence and morphometric variability in the frugivorous bat species, *Cynopterus sphinx* and *Rousettus leschenaulti*, from a tropical rainforest, Xishuangbanna, SW-China**

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Occurrence and morphometric variation were recorded over one and a half years for two species of frugivorous bats, *Cynopterus sphinx* and *Rousettus leschenaulti*, from six localities in and around a tropical rainforest in Xishuangbanna, SW-China. Occurrence of both species was simultaneous. The two species breed all throughout the year, but we found one distinct peak in breeding season for each species. Although the overall morphology between the two species did not differ significantly, statistical analysis of morphological characters revealed consistent spatial correlations for both taxa. Body size and forearm length for both univariate and multivariate analyses (as derived from principal component analysis) was strongly and positively correlated with morphometric variations across the locations for *C. sphinx* and *R. leschenaulti*. Both, the different peaks in breeding season and the consistent spatial correlations suggest mechanisms to help resource partitioning. The study represents the first species documentation from this area.

*Key words:* frugivorous bats, tropical rainforest, morphometric variation, SW-China

## Habitat use and conservation of bats in rainforest and adjacent human-modified habitats in eastern Madagascar

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We used roost searches, mist netting and acoustic sampling to investigate the habitats used by bats in Parc National de Mantadia and the Réserve Spéciale d'Analamazaotra, eastern Madagascar. Four species were caught in relatively intact humid forest (*Myotis goudoti*, *Miniopterus manavi*, *Miniopterus majori* and *Emballonura atrata*) two in agricultural land, *Neoromicia matroka* and *Neoromicia melckorum*, and one, *Rousettus madagascariensis*, in *Eucalyptus* plantations. *Mormopterus jugularis*, *Chaerephon pumilus* and *Mops leucostigma* were found roosting in buildings ca. three km from the humid forest. Acoustic sampling revealed that *Neoromicia* spp. and molossids were ubiquitous and were recorded from intact and degraded humid forest, *Eucalyptus* plantations and agricultural land. *Myotis goudoti* showed the strongest association with intact humid forest. Taxon richness, determined by acoustic sampling, was highest in humid forest but activity was highest in plantations and agricultural land. Mixed-habitat landscapes that surround protected forests and consist of a mosaic of regenerating forest, agriculture, wetlands, villages and plantations are important for bats and promote chiropteran diversity because they provide roosting and foraging sites for species that rarely use intact forest. The humid forests of eastern Madagascar have lower bat diversity than the island's western deciduous karst forests.

**Key words:** acoustic, roosts, habitat, landscape, conservation, Madagascar

## The diet of three synanthropic bats (Chiroptera: Molossidae) from eastern Madagascar

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We analysed 890 faecal samples from 145 molossid bats in eastern Madagascar during the austral summer and winter. Coleoptera, Hemiptera, Lepidoptera and Diptera were the most important sources of food for *Mops leucostigma*, *Mormopterus jugularis* and *Chaerephon pumilus*. The percentage volume of Hemiptera and Lepidoptera were similar in the diet, pooled across season, for all species but significant differences were found for Diptera and Coleoptera. *Mops leucostigma*, however, had the highest volume of Diptera and *M. jugularis* of Coleoptera. Hemiptera were an important food source for all species during both seasons, whereas Coleoptera were prevalent in the diet only during the summer. Diptera were rarely eaten by *M. jugularis* but constituted a major source of food for the other two species during the winter. Although there was little evidence of strong interspecific dietary partitioning, *M. jugularis* appeared to have a more limited dietary composition at the ordinal level. Major differences in dietary composition were between season rather than species at the ordinal level. Further investigations are recommended to assess the potential role of molossids in consuming economic pests of cotton in Madagascar.

**Key words:** *Chaerephon*, *Mops*, *Mormopterus*, dietary overlap, Madagascar, molossid, prey selection, roost

## **The trophic niche of the Geoffroy's bat (*Myotis emarginatus*) in south-western Germany**

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In Germany, the Geoffroy's bat (*Myotis emarginatus*) is one of the rarest bat species. In south-western Germany (federal state of Baden-Württemberg), only four nursery roosts of *M. emarginatus* are known. Referring to the trophic niche of this species and to own observations, we hypothesized that cowsheds are important foraging areas for *M. emarginatus* in Central Europe. This would have important implications for the conservation of this species. To test this hypothesis we conducted a diet analysis aiming at three major aspects: the trophic niche, indications for foraging habitats used, and the importance of these foraging habitats throughout the nursery season. Flies (Brachycera) made up the largest volume in the diet of *M. emarginatus* throughout the season, followed by spiders (Araneida) and butterflies (Lepidoptera). Among the flies, the genus *Musca* and the species *Stomoxys calcitrans* were found in more than half of the investigated faecal pellets. Both of these fly-taxa are strongly related to cattle farming. Therefore we conclude that the individuals of the investigated colony of *M. emarginatus* were mainly hunting in the vicinity of cattle farms during the whole nursery season. Consequently, the preservation of traditional cattle farming is likely to play a key role for the conservation of *M. emarginatus* in Central Europe.

*Key words:* *Myotis emarginatus*, faecal analysis, Brachycera, foraging habitats, cowsheds

## Echolocation calls, wing shape, diet and phylogenetic diagnosis of the endemic Chinese bat *Myotis pequinius*

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We describe the echolocation calls, flight morphology and diet of the endemic Chinese bat *Myotis pequinius* Thomas, 1908. Orientation calls are broadband, and reach low terminal frequencies. Diet comprised 80% beetles by volume. Wing shape and call design suggest that the bats fly in cluttered habitats, and the possession of moderately long ears and the dietary composition imply they forage at least sometimes by gleaning. *Myotis pequinius* resembles a larger Oriental version of the western Palaearctic species *M. nattereri*. Phylogenetic analysis based on sequences of the cytochrome *b* gene of mitochondrial DNA (1,140 base pairs) from a range of Palaearctic *Myotis* species confirmed that *M. pequinius* is close to the *nattereri* group, and is a sister-species to the eastern Palaearctic *M. bombinus*. One bat sequenced from China could not be identified from available species descriptions. It was smaller than *M. pequinius*, and also differed from it in sequence divergence by 6.7%, suggesting the existence of additional, cryptic taxonomic diversity in this group. Our phylogenetic analysis also supports the recognition of *M. schaubi* as a species distinct from *M. nattereri* in Transcaucasia and south-western Asia. *Myotis nattereri tschuliensis* is more closely related to *M. schaubi* than to *M. nattereri*, and is best considered either as a subspecies of *M. schaubi*, or possibly as a distinct species.

*Key words:* cytochrome *b*, echolocation calls, diet, wing shape, *Myotis*

## **Echolocation signals of the plecotine bat, *Plecotus macrobullaris* Kuzyakin, 1965**

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*Plecotus macrobullaris* was recorded in an alpine region in Switzerland. Like other species of the genus *Plecotus*, *P. macrobullaris* emitted multiharmonic, downward frequency-modulated signals consisting mostly of the 1st and the lower part of the 2nd harmonic. Signal structure depended on the distance to the background. The shortest signals (0.8 ms) were recorded close to the background. The first harmonic began at about 46 kHz and ended around 23 kHz. Signals were emitted in groups. The longest signals (up to 7.3 ms) were recorded above a meadow, far from background targets. These signals, which were more shallowly modulated, started at about 42 kHz and ended around 15 kHz. They occasionally lacked the 2nd harmonic and were often emitted only every 2nd or 3rd wing beat cycle. In short signals of up to 4 ms, the 1st and 2nd harmonic did not overlap, whereas overlap was prominent in longer signals. Although *P. macrobullaris* is genetically more closely related to *P. auritus*, its signal structure is closer to that of *P. austriacus*. Taking further evidence from morphological data, signal structure, and flight behaviour into account, we conclude that *P. macrobullaris* occupies a similar niche in mountainous areas as *P. austriacus* does in the lowland.

*Key words:* *Plecotus macrobullaris*, echolocation, signal structure, foraging behaviour

## **Vocalizations emitted during mother-young interactions by captive eastern red bats *Lasiurus borealis* (Chiroptera: Vespertilionidae)**

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We recorded acoustic signals during interactions between mother eastern red bats and their nursing young. Mothers and young produced tonal (structured change in frequency over time) frequency-modulated (FM) signals with varying harmonic components in situations ranging from reunion to just before nursing. Pups left by their mothers were usually silent, only occasionally producing tonal isolation calls. Adult females used FM signals in stressful situations, times when young usually produced clicks. Vibrational signals ('hums') composed of clicks (broadband, no structured change in frequency over time) characterized pup-pup and mother-pup interactions but pups also used other clicks that differed in frequency components from clicks comprising the hums. In stressful situations, adults produced FM signals, the pups, clicks. FM signals of pups decreased in frequencies with increasing age (size). Echolocation calls of adults and subadults hunting flying prey differed in frequency components. Differences in duration of echolocation calls coincided with setting (short calls in flight cages, open calls in the open). FM signals produced by pups searching for their mothers' nipples showed little potential for individual signatures. Calls and calling behaviour of eastern red bats that are solitary and foliage-roosting, differed from those of more gregarious species roosting in more sheltered situations.

*Key words:* clicks, frequency modulated signals, echolocation, harmonics, signatures, *Lasiurus*

## **Female interactions in harem groups of the Jamaican fruit-eating bat, *Artibeus jamaicensis* (Chiroptera: Phyllostomidae)**

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Harem groups of the Jamaican fruit-eating bat (*Artibeus jamaicensis*) are well-defined units that occupy different crevices in caves. For two consecutive years, we analyzed the non-random associations among female bats and their interactions with other members of the harem. Female members occupying the edges of the harems came from different parts of the cave and were more frequently expelled from the roosting site. Females from the central core of the harem were attacked less often and received more affiliative interactions. Females occupying areas between the central core and the edges were the most active in repelling arriving females and were responsible for grooming the central core females. During the breeding season, aggressive activities decreased and females became more tolerant, which suggests that a potential benefit of roosting together is that it provides for a more suitable place to nurse newborns, because all females produce a better environment, in thermoregulatory ways.

*Key words:* aggressive interactions, affiliative interactions, *Artibeus jamaicensis*, harem groups

## **Reproductive anatomy and cyclicity of the male bat *Brachyphylla cavernarum* (Chiroptera: Phyllostomidae)**

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Our data show that the Lesser Antillean fruit-eating bat (*Brachyphylla cavernarum*), which is endemic to the West Indies, is a monestrous, seasonal-breeding species. The microscopic and gross anatomical structure, function, and seasonal cyclicity of the testes and accessory sex glands are described and illustrated. Accessory sex glands undergo an annual cycle in synchrony with the testicular cycle. The accessory sex gland complex (prostate-seminal vesicle) and Cowper's glands secrete fructose, the concentration of which varies seasonally in direct proportion to glandular hypertrophy in apparent response to the level of circulating plasma testosterone. The penis lacks a bony ossicle (os penis or baculum), which is characteristic for other phyllostomids studied. Of interest is the observation that not all males are reproductively active at the same time, which may have implications for the behavioural ecology of this species.

*Key words:* testes, seminal vesicle, prostate, Cowper's glands, fructose, testosterone, *Brachyphylla*

## **Age related variation in the energy costs of torpor in Daubenton's bat: effects on fat accumulation prior to hibernation**

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Insectivorous bats in their first year of life generally deposit less fat prior to hibernation than older bats of the same species. In the present study we explored the energy expenditures of first-year (sub-adult) and older than one year (adult) Daubenton's bats (*Myotis daubentonii*) during torpor and their patterns of roost site selection and fat accumulation in an artificial roost site, removing from the equation the effects of differences in aerial foraging behaviour by feeding them on non-aerial prey (mealworms). Sub-adult bats had oxygen consumption during torpor that averaged  $2.75 \times$  greater than adult individuals. In an artificial enclosure in which bats could fly freely and choose whether to roost inside or outside of a hollow brick, sub-adults gained body mass at a significantly lower rate ( $67.8 \text{ mg} \times \text{day}^{-1}$ ) than adults ( $100.3 \text{ mg} \times \text{day}^{-1}$ ), despite being fed non-aerial prey (mealworms). The difference in rates of mass accumulation ( $32.5 \text{ mg per day}$ ) far exceeded the theoretical influence of different metabolic rates ( $7 \text{ mg} \times \text{day}^{-1}$ ) in torpor. Despite lower rates of mass gain in this artificial situation, sub-adults ultimately achieved the same mass accumulation as adults because they continued to accumulate fat for a longer period, an option that might be unavailable to them in the wild as feeding conditions deteriorate. The rate of body mass accumulation was positively correlated with the time spent utilising the brick roost site, but utilisation of this site did not differ significantly between age classes. These data support the hypothesis that differences in the accumulation of fat between age classes may reflect in part differences in expenditure as well as differences in food intake, but the contribution of differences in metabolism during torpor are relatively small.

*Key words:* *Myotis daubentonii*, oxygen consumption, hibernation torpor, fat accumulation

## Effects of forearm bands on horseshoe bats (Chiroptera: Rhinolophidae)

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We assessed effects of forearm bands on three species of horseshoe bats (*Rhinolophus ferrumequinum*, *R. euryale* and *R. mehelyi*) marked for studies on regional movements and colony structure in Northern Bulgaria. Overall, more than 85% of the 580 recaptured individuals showed no negative impact of the banding. We had to note, however, slight or severe injuries in 7.6 and 6.4% of the bats, respectively. Injury rates varied greatly according to species and ring sizes. The use of the smaller of two tested ring sizes caused major injury rates of more than 60% of the recaptured *R. mehelyi*. But even in *R. ferrumequinum*, for which we obtained the largest sample size, and for which the recommended ring size is well-established, carefully fitted forearm bands caused injuries in 9.3% of the recaptures, an injury rate that is much higher than in most vespertilionid bat species. The main reason for the sensitivity of the horseshoe bats to ringing was that the ring rubbed raw the bats' propatagium; the resulting injuries led to growing scars and infections. We compare published and unpublished injury rates of 28 bat species with our results and discuss the use of alternative marking methods. We suggest that banding of horseshoe bats should be limited to well defined projects and only used if the study populations are in a good preservation condition and long term effects of the marking method can be monitored.

*Key words:* ringing, marking methods, *Rhinolophus*, Vespertilionidae

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## SHORT NOTES

### **Cryptic sympatric diversity in *Emballonura alecto*: further bat species?**

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*Key words: Emballonura alecto, cryptic species, sympatric speciation, tropics*

**Further range extension of *Pipistrellus kuhlii* (Kuhl, 1817) in central and eastern Europe**

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*Key words: Pipistrellus kuhlii, distribution, expansion, Europe*

**Deliberate insectivory by the fruit bat *Rousettus aegyptiacus***

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*Key words:* Chiroptera, feeding, fruit bats, insects, Pteropodidae, Scarabidae

**A case of exceptionally high predation levels of *Rousettus madagascariensis*  
by *Tyto alba* (Aves: Tytonidae) in western Madagascar**

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*Key words: Tyto alba, predation, Rousettus madagascariensis, western Madagascar*

**Tent building by female *Ectophylla alba* (Chiroptera: Phyllostomidae) in Costa Rica**

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*Key words:* Costa Rica, *Ectophylla alba*, leaf modification, roost site selection, Phyllostomidae, tent-roosting, tent-building

**Notably range extension of *Sturnira aratathomasi* Peterson and Tamsitt 1969 in Perú**

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*Key words:* *Sturnira aratathomasi*, distribution, Perú, Apurímac, the Andes, dry forests

**Aggressive behaviour of greater mouse-eared bat (*Myotis myotis*) towards lesser horseshoe bats (*Rhinolophus hipposideros*) in a hibernaculum**

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*Key words: Myotis myotis, Rhinolophus hipposideros, aggressive behaviour, hibernation*