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# A moveable face: deconstructing the Microchiroptera and a new classification of extant bats

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Recent comparative-method and molecular studies have called into question both the classic subordinal division of bats into Megachiroptera versus Microchiroptera and the infraordinal separation of microchiropterans as Yinochiroptera and Yangochiroptera: megabats are not necessarily large, nor are microbats uniformly small; some yinochiropterans may be specially related to megachiropterans whilst others are more nearly affiliated with yangochiropterans; and quite apart from the conflict with DNA comparisons, the microbat dichotomy (based on moveable versus fused premaxillae) is neither completely cladistic nor parsimonious. We conclude that current appellations — including the neologism Yinpterochiroptera — no longer embody the authors' intended groups or have been so frequently redefined as to be positively misleading. We therefore adopt the new subordinal names Vespertilioniformes (for the group including Emballonuridae, Nycteridae, and the 'yangochiropterans') and Pteropodiformes (for the taxon comprised of Craseonycteridae, Hipposideridae, Megadermatidae, Rhinolophidae, Rhinopomatidae, and Pteropodidae). These epithets are ultimately based on the oldest valid generic names for included taxa (respectively *Vespertilio* Linnaeus, 1758 and *Pteropus* Brisson, 1762), and are thus impervious to pre-emption or misinterpretation.

*Key words*: Chiroptera, systematics, classification, premaxilla, Megachiroptera, Microchiroptera

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# The definition of *Harpiola* (Vespertilionidae: Murininae) and the description of a new species from Taiwan

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A new species of *Harpiola* from Taiwan is described based on 11 specimens collected between 1998 and 2004. Careful examination of these specimens and those of the genus *Murina*, revealed the valid characters distinguishing *Harpiola* from *Murina*, including the enlarged upper incisors, the well developed first premolars in both toothrows with their bulk subequal to canines and the second premolars in the corresponding toothrow, and the strongly bifid lower canine. The new species from Taiwan can be distinguished from *Harpiola grisea* in India by having different shape of second upper premolar and different structure of first upper molar.

*Key words*: *Harpiola* sp. nov., Taiwan, taxonomy

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# A new species of *Scotophilus* (Chiroptera: Vespertilionidae) from western Madagascar

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We describe a new species of *Scotophilus* (Vespertilionidae) from western Madagascar. This bat differs from the other members of this genus known from the island, Africa, and Asia based on its notably diminutive size, pelage coloration, and tragus shape and length. *Scotophilus* sp. nov. is known from seven different specimens taken at three different sites in the central western portion of the island, in zones with anthropogenic savanna dominated by palms (*Bismarckia nobilis*) and dry deciduous forest. The holotype was collected in the palm leaf roof of a thatched dwelling, which is the first evidence of the synanthropic occurrence of a member of this genus on Madagascar. Four species of *Scotophilus* are now known to occur on Madagascar of which three are endemic.

*Key words*: *Scotophilus*, Vespertilionidae, new species, western Madagascar

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# A new species of bat of the *Hipposideros bicolor* group (Chiroptera: Hipposideridae) from Central Laos, with evidence of convergent evolution with Sundaic taxa

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A new species of bat in the *Hipposideros bicolor* group, found in a very restricted area in Central Laos, is described. The new bat is very similar in general body size and shape to *H. rotalis*, a species whose distribution includes the known range of the new species. However the new species differs noticeably in the size of the noseleaf, rostral chambers, skull structures related to sound emission or reception, frontal skull width, and echolocation frequency. Both species are superficially very similar to *H. orbiculus* and *H. ridleyi*, from the Malayan peninsula, Borneo, and Sumatra, which had been considered sibling species of *H. rotalis*, perhaps implying vicariant speciation involving the Isthmus of Kra. The new species resembles *H. orbiculus* in its smaller internarial septum, and the echolocation frequency is also similar, but skull traits clearly ally *H. orbiculus* with *H. ridleyi*, which is sympatric with it in peninsular Malaysia. Molecular systematic analyses of cytochrome *b* nucleotide sequences of a sample of species in the *H. bicolor* group support the sister status between the new species and *H. rotalis*. However, *H. ridleyi* does not join the latter two in a monophyletic group, apparently having evolved similar morphology and echolocation convergently from a different ancestor.

*Key words*: convergence, cytochrome *b*, echolocation, *Hipposideros*, Indo-Malaya, Laos, sibling species, speciation

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# Phylogeographic structure in *Rhinonicteris aurantia* (Chiroptera: Hipposideridae): implications for conservation

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The orange leaf-nosed bat *Rhinonicteris aurantia* (Hipposideridae) is a rare Australian endemic with a fragmented distribution, an uncertain taxonomic status of distributional groups and is subject to human disturbance pressure in several areas. Two mitochondrial DNA markers (ND4 and D-loop) were partially sequenced to investigate the similarity of allopatric isolates and the phylogeographic structure of colonies. A clear phylogeographic pattern based on female philopatry emerged from both markers. Limited movement of females within the Pilbara isolate was also inferred, supported by AMOVA, and in agreement with spatial models generated previously using GIS. The position of the small number of Kimberley haplotypes available fitted with the phylogeographic pattern of both markers, but further sampling is required from this population. Two repeat arrays (with 104 and 6 base pair units) were present in the D-loop, which might be useful as markers in future studies. The phylogeographic pattern also coincided with differences between the Pilbara and the more northern group observed previously in the nasal apparatus involved in echolocation, as well as the frequency of the calls themselves. Formal taxonomic reclassification of isolates was not supported by the ND4 fragment marker, but the combination of patterns from all available datasets suggested that the current recognition of the Pilbara population as a separate form for conservation purposes is justified, according to the concept of 'adaptive evolutionary conservation'. Furthermore, the differences observed in the Pilbara suggested that colonies in the mines of the eastern Pilbara should be managed as a unit distinct from those in the Hamersley Range and Barlee Range according to the precautionary principle until further studies have been conducted.

*Key words*: allopatry, *Rhinonicteris aurantia*, Evolutionary Significant Unit, network, Pilbara, phylogeography

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# New records of Microchiroptera (Rhinolophidae and Kerivoulinae) from Vietnam and Thailand

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The diversity of Rhinolophidae in Thailand and Vietnam is briefly discussed and the taxonomy of Asian Kerivoulinae, with particular reference to the genus *Phoniscus*, is reviewed. Four new country records are included: *Rhinolophus shameli* and *Kerivoula kachinensis* from Vietnam and *Phoniscus jagorii* from Vietnam and Thailand. A second record of *Phoniscus atrox* from Thailand is also discussed.

*Key words*: *Rhinolophus shameli*, *Phoniscus jagorii*, *P. atrox*, *Kerivoula kachinensis*, Thailand, Vietnam, systematics, distribution, ecology

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# Distinguishing between cryptic species *Myotis ikonnikovi* and *M. brandtii gracilis* in Hokkaido, Japan: evaluation of a novel diagnostic morphological feature using molecular methods

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Previously, braincase shape has been the most useful character for species diagnosis of the *Myotis mystacinus* group members in Hokkaido, Japan. However, this character is difficult to apply in live individuals. Recently, the different patterns of venation in the tail membrane were described for species diagnosis of *M. ikonnikovi* and *M. mystacinus* (actually *M. brandtii gracilis* in Japan). We evaluated this new method in these two cryptic species in Hokkaido, Japan, based on molecular analysis. Our results revealed complete congruence between haplotypes of the mtDNA cytochrome *b* gene and the patterns of tail membrane venation in these two species. Thus, tail membrane venation pattern should be regarded as an unambiguous diagnostic character to distinguish *M. ikonnikovi* and *M. b. gracilis* under field conditions in Hokkaido. Further, since our field sampling was extensive, we suggested that only two species in the *M. mystacinus* group, *M. ikonnikovi* and *M. b. gracilis* occur in Hokkaido, and concluded that the occurrence of other cryptic species in the group in Hokkaido is unlikely.

*Key words*: *Myotis ikonnikovi*, *M. brandtii gracilis*, cryptic species, venation pattern, mtDNA cytochrome *b*, non-lethal method

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# Bats of Jaú National Park, central Amazônia, Brazil

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Although recognized as highly diverse, the bat fauna of the Amazon basin has been only patchily sampled. This paper combines data from five short surveys conducted between 1998 and 2001 in Jaú National Park, 220 km east of Manaus, central Amazônia. We used mist-nets, recordings of echolocation calls and roost visits to provide the first bat inventory for this area. A total of 53 bat species in 33 genera and five families were documented, including several species that are regarded as rare, in particular *Saccopteryx gymnura*, *Vampyriscus brocki*, *Molossops neglectus*, and *Promops centralis*. The Chao 1 index indicates that sampling is about 72% complete, suggesting that around 73 bat species might co-exist in Jaú. We compare the composition of Jaú's bat fauna to those of other sites in Amazônia and interpret the resulting patterns of diversity. Data on reproduction are given for 14 species.

*Key words*: Amazônia, inventory, bats, ecology, conservation

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# Habitat use, roost characteristics and diet of the Seychelles sheath-tailed bat *Coleura seychellensis*

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The Seychelles sheath-tailed bat *Coleura seychellensis* is a Critically Endangered species endemic to the Seychelles islands of Mahé and Silhouette, with historical records from Praslin and La Digue islands. Published descriptions exist for only one active roost containing 32 bats. The present study located the species only in coastal boulder field caves with stable cool temperatures and access into palm woodland or marsh habitat. At one roost gaps in the woodland are used for foraging and the natural woodland appears to be important for the conservation of the species primarily as foraging habitat. A second roost on Silhouette island has been located near a large, insect rich marsh habitat. Faecal analysis demonstrated that at this site *C. seychellensis* feeds predominantly on marsh associated Ceratopogonidae (Diptera), in contrast to Curculionidae (Coleoptera) in palm woodland. This dietary plasticity indicates that food is not limiting for this species. The decline in this species may have been caused by habitat alteration caused by invasive plants obstructing roost entrances; conservation of the species requires active habitat management.

*Key words*: Emballonuridae, *Coleura seychellensis*, Silhouette, roost characteristics, conservation, foraging

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# Seasonal foraging by *Rhinolophus euryale* (Rhinolophidae) in an Atlantic rural landscape in northern Iberian Peninsula

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We investigated the foraging behaviour of the Mediterranean horseshoe bat (*Rhinolophus euryale*) in an Atlantic mosaic-like landscape consisting predominantly of meadows and broadleaved tree structures, and containing the largest known breeding colony in northern Iberian Peninsula. We radio-tracked a total of 46 individuals during pre-breeding, lactation and post-lactation periods. Bats were divided into different classes based on season, sex, reproductive condition or age. Significant differences between classes were apparent in the distances travelled to foraging areas. During pre-breeding foraging occurred on average within 1.3 km, and at most 4.2 km from the roost. Contrary to our predictions, lactating females extended mean foraging distances to 4.3 km, and covered the widest range with a maximum individual distance from the roost of 9.2 km. Males in the same period foraged closer (mean 1.9 km), but with lower fidelity to the main roost. The foraging distances of adult bats during post-lactation did not differ from that of lactating females (mean 4.6 km). Newly volant juveniles flew on average 2.6 km, though showed a varied behaviour. No seasonal effect was found on the size of individual foraging home ranges, as great variation was recorded within all groups. We conclude that the increase in foraging distances is the consequence of higher density as colony size increased by 55% from pre-breeding into the lactation period on. Our results show another aspect of the scale of foraging movements of *R. euryale* and highlight the need to take these into account when formulating conservation policy, especially during such crucial periods as lactation and juvenile dispersal.

*Key words*: *Rhinolophus euryale*, Atlantic rural landscape, seasonality, foraging

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# Habitat selection and spatial use by the trawling bat *Myotis capaccinii* (Bonaparte, 1837)

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Habitat selection and spatial use was studied in a population of *Myotis capaccinii* (Bonaparte, 1837) in the eastern Iberian Peninsula during the spring of 2004. The radio-tracked bats used only aquatic habitats as foraging sites, and most foraging activity concentrated on rivers. Rivers were positively selected and showed the highest preference rank. Pools were also positively selected but only a single pool was used through the tracking period. Foraging was not evenly distributed along rivers. The features of the water surface further determined habitat selection. Open waters with smooth surfaces were selected over cluttered surfaces or waters completely covered by vegetation. This microhabitat preference is thought to be due to a greater efficiency in prey detection and capture over open calm waters. Nonetheless, the extremely high aggregation of foraging individuals observed suggests that the distribution of prey might also affect the location of foraging sites along rivers. Thus, conservation management of *M. capaccinii* should ensure protection of low-flowing or stagnant waters in rivers around the bats' main caves.

*Key words*: *Myotis capaccinii*, trawling bats, radio-telemetry, habitat selection, spatial ecology, Mediterranean

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# The use by bats of habitat features in mixed farmland in Scotland

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Most previous studies of the use bats make of their foraging areas have been concerned with general habitat preferences rather than with microhabitats. The present study focuses on microhabitat preference within three landscape features: linear landscape elements, ponds and rivers. The importance of linear landscape elements to bats was investigated by placing recording stations next to treelines, and others in adjacent open spaces approximately 35 m away. Most pipistrelle (*Pipistrellus pipistrellus* and *P. pygmaeus*) bat activity was recorded next to treelines and very little over open spaces. Bats used treelines for both commuting and foraging, but flew closer to treelines when commuting than when foraging. More insects were caught, and more pipistrelle feeding attempts were recorded close to treelines than further away. The relationship between the number and type of landscape elements leading to and surrounding ponds, and the use pipistrelle and Daubenton's (*Myotis daubentonii*) bats make of such ponds, was similarly investigated. Bats preferred to commute to ponds along woodland edges and streams, and not along hedgerows. More bat activity was recorded over ponds that had little overhanging and surrounding vegetation in comparison to ponds that had more, and over large wide ponds in comparison to small narrow ones. The extent to which pipistrelle and Daubenton's bats' use of river corridors extends beyond the water body was also investigated. Bat activity decreased with increasing distance from rivers, up to a distance of 70 m. River sites which were wooded on both sides attracted more bat activity for a longer duration than sites which had no trees on either side. Pipistrelles made use of the wider river corridor whereas Daubenton's bats restricted their activity almost exclusively to the water body.

*Key words:* echolocation, landscape, microhabitat, pond, river, treeline, *Pipistrellus* spp., *Myotis daubentonii*

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# Flight activity of bats at the entrance of a natural cave

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Activity patterns of bats were investigated at the entrance of a natural karstic cave (Kateřinská cave, Czech Republic). The activity was recorded automatically with a double infrared light barrier allowing discrimination between those bats leaving and those entering the cave. Five periods were defined on the basis of bat flight activity: A) Hibernation period (November–late March), with very low activity; B1) Departure period 1 (late March–mid April), with intensive departure during the first quarter of the night; B2) Departure period 2 (mid April–beginning of June), with emergence activity in the first quarter, and a small number of bats entering the cave in the fourth part of the night. The peak of activity was in the second part of the night. C) Summer period (mid June–mid July), with low activity. D) Autumn period (late July–late October), with very high activity and increasing number of bats entering the cave. The peak of activity was around midnight. All periods showed a non-random temporal distribution and a concentration of flight activity around specific time. There was a positive correlation between the number of bat passes through the entrance and outside ambient temperature and a negative correlation between the number of passes and barometric pressure. Rain had no significant effect on the level of bat activity.

*Key words*: flight activity, caves, seasonal changes, IR light barrier

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# Ultrasound social calls of greater horseshoe bats (*Rhinolophus ferrumequinum*) in a hibernaculum

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Ultrasound calls made by adult *Rhinolophus ferrumequinu*m in a hibernaculum in early October were recorded using a time expansion detector during two 24 hrs periods. In addition to echolocation calls (83–84 kHz), ultrasound social calls were recorded, similar to those recorded previously in a nursery roost. The recordings also included social calls not found in the repertoire of the nursery roost colony from late April until early October. These were multiple component ultrasound social calls with six or seven components and prolonged trill calls. The trill call frequency varied periodically over a range of 2.9 ± 1.7 kHz about the mean with a period of 8.0 ± 3.1 ms. The trill calls and very long ultrasound social calls have not been reported previously. The possibility that the trill calls may be used by male bats as advertisement calls in the cave is discussed.

*Key words*: *Rhinolophus ferrumequinum* male bats, trill ultrasound social calls, hibernaculum

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# The sessile serotine: the influence of roost temperature on philopatry and reproductive phenology of *Eptesicus serotinus* (Schreber, 1774) (Mammalia: Chiroptera)

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Maternity colonies of serotine bats inhabiting large roof spaces were studied at three localities in southwestern Germany and Luxembourg. Bats of all three colonies returned to the maternity roosts during the second or third week of April, and were strongly philopatric to their main roost. Roost switching occurred only rarely and for short periods. Measurements of temperature inside two roosts showed gradients according to height and aspect of the roof space with a mean roost temperature of 22°C during gestation and lactation. The availability of adequate microclimates within the roost during gestation and lactation was thought to favour roost philopatry. Females of all ages and reproductive classes inhabit the roosts throughout summer. Mean (± SD) inferred gestation length was 52 ± 6 days, and variations were not related to roost temperatures during gestation. The mean date of birth was 16th June with most births occurring within a period of 14 ± 6 days and of young first emerged from the roost 36 ± 7 days after birth. Prolonged adverse weather conditions, leading to low roost temperatures, resulted in mortality of 11–27% of preweaning young in four of the five years studied. Since immigration occurs, the number of young emerging from the roost cannot be deduced from the number of females present during gestation or lactation. Adult females and young start to disperse after the first young are weaned at the beginning of August and are last observed in October. The implications of these results for the epidemiology of European bat lyssavirus 1 are discussed.

*Key words*: *Eptesicus serotinus*, roost microclimate, reproductive phenology, philopatry, juvenile mortality, European Bat Lyssavirus

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# Ethogram and diurnal activities of a colony of *Artibeus lituratus* (Phyllostomidae: Stenodermatinae)

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The diurnal behavior of members of a harem group of the big fruit-eating bat, *Artibeus lituratus*, in Mérida, Venezuela was investigated while they roosted beneath palm leaves. Behaviors were recorded applying a digital video camera to characterize diurnal activities, and from these an ethogram was constructed. Scan sampling and focal sampling were used to analyze the recorded behaviors. Four long behavioral states and seven short behavioral events were distinguished. During the diurnal period, most bats were inactive and were presumed to be sleeping, although at least one individual always remained active and alert. The fact that at least one bat was always alert during the day-roosting period suggests that some level of vigilance may be needed for bats to successfully occupy exposed roosts. Although the bats were inactive more than 80% of the day-roosting period, this was an interrupted phenomenon since individuals did not sleep continuously for more than 20 min (on average) when they were observed sleeping. Differences between the single harem male and an associated female were significant in terms of the frequency of states and events, and duration of some behavioral states. The harem male was active (i.e. alert) 13% of time of the diurnal period, whereas the female was active 1% of the time during this same period. Differences may be related to predation risks or actual and potential incursions of other males into the roost. The male allocated 4% of his time to grooming, whereas the female allocated 9% of her time to grooming, which may be related to the female's reproductive condition.

*Key words*: *Artibeus lituratus*, ethogram, behavior, diurnal activity, Venezuela

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# *Muntingia calabura* — an attractive food plant of *Cynopterus sphinx* — deserves planting to lessen orchard damage

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Of the 14 species of pteropodid bats that are found in India, *Cynopterus sphinx* receives most of the blame for causing damage to commercial fruit crops. We observed the number of visits made by *C. sphinx* to four species of commercial fruits in orchards (*Mangifera indica*, *Achras sapota*, *Psidium guajava* and *Vitis vinifera*), and four species of wild/non-commercial fruits (*Muntingia calabura*, *Ficus bengalensis*, *F. religiosa* and *Bassia latifolia*) in suburban areas. The total number of bat visits to *M. calabura* was significantly greater than to all other fruit species. The range of percentages of total nightly bat visits was from as low as 5% (*V. vinifera*) to 47% (*F. religiosa*), in comparison to the total nightly visits made to *M. calabura*. In addition, the number of mist-netted individuals of *C. sphinx* per hour near *M. calabura* was also significantly higher than near other fruit species. We suggest that if *M. calabura* is grown in and around orchards, damage caused by *C. sphinx* to commercial fruit crops may be decreased and therefore would serve as a non-destructive method for managing removal of commercial fruits by bats.

*Key words*: *Cynopterus sphinx*, orchards, bat damage, non-destructive control, *Muntingia calabura*

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# Olfactory discrimination ability of the short-nosed fruit bat *Cynopterus sphinx*

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We carried out a set of experiments on a megachiropteran bat *Cynopterus sphinx* to examine its olfactory discrimination ability to a variety of food odor substances. We used seven undiluted odorants such as isoamyl acetate, ethyl acetate, hexanol, benzaldehyde, limonene, pinene, and dimethyl disulfide for odor discrimination experiments. These volatile substances are present at various quantities in the natural food (fruits and nectar) of *C. sphinx*. Equal amount (200 µl) of seven odor substances kept individually but simultaneously in seven of eight specimen tubes which were equipped in a radially and horizontally arranged experimental set-up. In addition to the odorants, about 5 mm pieces of any one of the fruits such as guava, papaya and sapota were offered in cups as reward to the bats. The behavior of bats was observed visually and number of bat-visits to the odorants, and to the scentless control was continuously recorded in an event recorder. The mean number of approaches made by the bats differed across the odorants and scentless control ($\chi^2 = 34.94$, $d.f. = 7$, $P < 0.001$). Bats made relatively more number of visits to the odorants compared to the control, except hexanol and dimethyl disulfide. Among the odor substances, bat-visits and preference factor showed a gradational pattern with relatively maximum to ethyl acetate and minimum to dimethyl disulfide. The pattern of bat-visits was bimodal to benzaldehyde and dimethyl disulfide, whereas it was unimodal to all the remaining five odorants. Our study suggests that *C. sphinx* is able to discriminate different odor substances in a complex olfactory environment.

*Key words*: *Cynopterus sphinx*, food odor, odor discrimination, olfactory sense, temporal pattern

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## Short Notes

# Avian host DNA isolated from the feces of white-winged vampire bats (*Diaemus youngi*)

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*Key words*: *Diaemus youngi*, fecal DNA, molecular scatology, noninvasive

# Timing of migration by eastern red bats (*Lasiurus borealis*) through Central Indiana

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*Key words*: *Lasiurus borealis*, migration, Indiana

# Hiding low in the thicket: roost use by Ussurian tube-nosed bats (*Murina ussuriensis*)

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*Key words*: *Murina ussuriensis*, day roost, foliage roost, dead leaves, bamboo grass thicket

# Depositing masticated plant materials inside tent roosts in *Cynopterus sphinx* (Chiroptera: Pteropodidae) in Southern India

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*Key words*: *Cynopterus sphinx*, tent-making, roost-protection hypothesis, ectoparasites, microorganisms