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Surprising genetic diversity in *Rhinolophus luctus* (Chiroptera: Rhinolophidae) from Peninsular Malaysia: description of a new species based on genetic and morphological characters

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In the family Rhinolophidae, the members of the *trifoliatus* clade are easily recognisable by a unique noseleaf structure and a fluffy fur. Within this group, *Rhinolophus luctus* is the largest species with currently six recognized subspecies, distributed from India to Bali. We investigated genetic (karyotype, mitochondrial DNA sequence) and morphological characters from a Peninsular Malaysian sample. Although the diploid number was 2n = 32 in all specimens, karyotype analysis revealed two largely different chromosomal sets, with a Y-autosome translocation present only in one of the taxa. Morphological examination revealed differences concerning size of the baculum and length of the lower toothrow. Based on these results, a new species is described and the former subspecies distributed on the Malayan Peninsula, *Rhinolophus luctus morio*, is elevated to species rank, *Rhinolophus morio*.

Key words: *R. luctoides*, *R. morio*, *R. trifoliatus*, Y-autosome translocation, synaptonemal complex, baculum, echolocation frequency, FISH, mtDNA

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Description of a new species of the *Rhinolophus trifoliatus*-group (Chiroptera: Rhinolophidae) from Southeast Asia

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A new species of woolly horseshoe bat in the *Rhinolophus trifoliatus* species group is described from Sabah in Malaysian Borneo. Two specimens from Central and West Kalimantan, Indonesia are referred to this species. A fourth specimen from western Thailand is referable to this species but on the basis of ~10% genetic divergence at the cytochrome oxidase-I gene is described as a separate subspecies. Morphologically and acoustically the two subspecies are similar. With a forearm length of 52.90–54.70 mm, a skull length of 24.27–26.57 mm and a call frequency of 49.2–50.0 kHz, the new species overlaps in size and call frequency with the sympatric *R. trifoliatus*. However, it differs significantly in having a dark noseleaf and a uniformly dark brown pelage, resembling, but being intermediate in size between *R. sedulus* and *R. luctus*, which have a skull length of 18.99–20.17 and 26.35–32.07 mm, respectively. It also differs from *R. trifoliatus* in the shape and size of the rostral inflation. It can be distinguished from *R. beddomei* (forearm length 55.00–63.44 mm) and *R. formosae* (forearm length 53.85–62.40 mm), which are endemic to the Indian Subcontinent and Taiwan, respectively, by its relatively smaller body size. Acoustic and genetic data are included in the comparison between the species. Both character states support the conclusions based on morphology. Further surveys in intact evergreen forest together with a re-examination of museum specimens may reveal that this species is widespread in Southeast Asia.

Key words: Borneo, evergreen forest, Malaysia, Indonesia, new species, *Rhinolophus*, *trifoliatus*-group, Southeast Asia, Thailand

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An analysis of *Myotis peninsularis* (Vespertilionidae) blending morphometric and genetic datasets

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Myotis peninsularis Miller, 1898 is an endemic bat from the Cape Region in Baja California Sur, México. Its taxonomic status is unclear, either as a valid species or as a subspecies of *M. velifer* (J. A. Allen, 1890). In order to assess its taxonomic status, the objective of this study was to examine phylogenetic relationships of *M. peninsularis*, using molecular and geometric morphometric data. Two mitochondrial genes were analyzed: cytochrome oxidase subunit I (COI) and cytochrome *b* (Cyt*b*). The phylogenetic analysis (maximum likelihood and Bayesian Inference) showed that *M. peninsularis* and *M. velifer* were sister groups, collectively forming a monophyletic assemblage. We observed less than 2% of genetic distance in the Cyt*b*, considered an interval at the subspecies level. The geometric morphometric analysis showed differences in skull shape. We obtained three morphotypes: *M. peninsularis* (Baja California group), *M. velifer incautus* (northern population) and *M. v. velifer* (southern population). The most important differences were located in the braincase (ventral, dorsal and lateral view). The lateral view was the most discriminating. The Cape Region specimens had the sagittal crest more procumbent in the front than the rear of the braincase. The slope line at the rostral lateral view was more abrupt in *M. velifer* populations. Morphologically, the three lineages tended to possess the same normal variation as the entire Mexican population of *M. velifer* but with a specific morphotype associated to its distribution. In a combined molecular and landmark configuration of the phylogenetic analysis, the ancestral shape corresponded to an intermediate shape between *M. peninsularis* and *M. velifer*, presenting a similar variation to the one of intra-specific level in *M. velifer*. We considered *M. peninsularis* a junior-synonym of *M. velifer*.

Key words: geometric morphometrics, mtDNA, *Myotis peninsularis*, phylogeny, skull

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Dark and pale: taxonomic status of the barbastelle (*Barbastella*: Vespertilionidae, Chiroptera) from Central Asia

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Barbastelles from the Central Asian republics, traditionally included in *Barbastella darjelingensis*, were compared with other *Barbastella* species on the basis of cranial and dental morphometrics, fur coloration and sequences of mtDNA. All these factors indicate that individuals from Central Asia should not be treated as a part of *B. darjelingensis*. They belong to a separate species, closely related to the Egyptian *B. leucomelas*, but morphologically distinct. On the basis of geographical proximity, it seems likely these are representatives of the same taxon as Transcaucasian animals, and therefore the name *B. caspica* Satunin, 1908 appears to be appropriate for this species. Evidence is provided, based on genetic differences, that there may be additional species of *Barbastella* in eastern Asia.

Key words: *Barbastella darjelingensis*, *B. caspica*, Central Asia, taxonomy, nomenclature

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Allometric patterns and evolution in Neotropical nectar-feeding bats (Chiroptera, Phyllostomidae)

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Within the neotropical bat family Phyllostomidae, species of the subfamilies Glossophaginae and Lonchophyllinae have many derived traits adapted to nectarivory, including elongated snouts and jaws and the ability to perform hovering flight. We compared patterns of cranial variation within and between these groups with respect to within-group allometric trajectories, based on 19 linear morphometric variables collected from 221 specimens representing all genera and 62% of the species in the two subfamilies. In a pooled principal component analysis, species belonging to Lonchophyllinae and Glossophaginae occupy similar regions in morphospace, though the latter species have a greater variance. Principal components and common principal components analyses for separate taxonomic lineages (subfamilies, tribes and subtribes) revealed distinct static allometric trajectories among these groups, with variables associated with elongation of the rostrum having distinct allometric coefficients. Our results indicate that distinct cranial morphotypes associated with the degree of elongation of the rostrum in phyllostomid nectarivores are allometrically characteristic of each lineage. The patterns suggest that cranial integration in phyllostomid nectarivores reflects primarily their phylogenetic history rather than adaptive pressures resulting from specialization to particular feeding resources.

Key words: allometry, craniometry, Glossophaginae, Lonchophyllinae, multivariate analysis

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Sexual size dimorphism of a sensory structure in a monomorphic bat

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As a strategy to reserve energy for parental care, females are larger than males in most bat species. Although females are responsible for providing parental care in almost all (if not all) bats, there are some species in which the males are larger than the females, and in other species the sexes are similarly sized. It has been proposed that for non dimorphic bat species, some foraging traits might be responsible for the differences observed between the sexes, though, this hypothesis has not been tested formally. Here, we evaluate the sexual size dimorphism of the phyllostomid insectivorous bat *Gardnerycteris crenulatum* using the morphometric variables of body size and nose-leaf size; the latter is a functional structure that plays an important role in echolocation and determines insectivorous bats' effectiveness in foraging. Our results show that *G. crenulatum* is a sexually monomorphic species in terms of body size, but it is dimorphic in nose-leaf traits. Females exhibit larger nose-leaves than males, which could increase the directionality of their ultrasound emission and hence improve the females' ability to obtain sensory information. We propose that monomorphic bats could be dimorphic for functional structures related to foraging behaviour as a means to increase their energetic effectiveness.

Key words: nose-leaf, *Gardnerycteris* (*Mimon*) *crenulatum*, insectivore, foraging strategy, functional structure

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Evidence of echolocation call divergence in *Hipposideros commersoni* sensu stricto (E. Geoffroy, 1803) from Madagascar and correlation with body size

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Previous studies conducted on morphological variation of the endemic Malagasy bat *Hipposideros commersoni* sensu stricto (Hipposideridae) revealed a north-south morphological cline, with larger individuals present in the north. Little is known about potential sexual differences in the echolocation calls of this species. We captured 59 adult individuals (24 males and 35 females) at different sites spanning the western half of Madagascar, measured their forearm length and recorded echolocation calls. These data were used to examine possible variation in echolocation calls and body size, which showed statistically significant differences. Male *H. commersoni* have an average forearm length of 93.1 mm and emit calls at 68.6 kHz, while the average measurements for females are 83.9 mm and about 72.9 kHz, respectively. Principal component analysis revealed variation in morphological and bioacoustic parameters, suggesting a high intraspecific variation. Regression analysis of intersexual data showed that females from the far north (Ankarana) significantly deviate from the allometric relationship by emitting echolocation calls lower than predicted by their size. These divergences may be associated with phenotypic variation, migratory movements or presence of a possible cryptic species. Detailed phylogenetic and phylogeographical analyses of the *H. commersoni* complex are needed to address these questions.

Key words: acoustic divergence, allometry, ecology, *Hipposideros commersoni*, Madagascar, morphology, polymorphism

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The relationship between male sucker-footed bats *Myzopoda aurita* and the traveller's tree *Ravenala madagascariensis* in south-eastern Madagascar

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Here we expand our previous study to provide more detailed information on the relationship between the male eastern sucker-footed bat *Myzopoda aurita* and the traveler's tree *Ravenala madagascariensis* in south-eastern Madagascar, during six month-long field work sessions carried out over two years. We caught 593 bats, 229 newly caught and 364 recaptures, exclusively males, roosting in 37 day roosts in the partially unfurled central leaves of *R. madagascariensis*. No bats were found in any other roosting situation. To analyse potential roost availability, we monitored partially unfurled central leaves on *R. madagascarienis* on four transects and 12% appeared suitable as *M. aurita* roosts. These leaves took three to 25 days to unfurl, and roosts became available between one and 19 days after unfurling commenced. Day roosts were occupied for one to 12 days. Bats were more likely to occupy roosts in taller trees. The size of roosting groups varied between one and 36 individuals. Movements of bats between roosts were recorded on 35 occasions and between two and nine individuals of *M. aurita* found in one roost were subsequently found together in a different roost. *Myzopoda aurita* occurs in degraded forests and anthropogenic habitats of eastern Madagascar where it may be affected by loss of roosts since *R. madagascariensis* is used extensively for building and thatching houses.

Key words: *Myzopoda aurita*, *Ravenala madagascariensis*, roost availability, roosting ecology, sexual segregation, Kianjavato, Madagascar

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Dietary plasticity in the Ryukyu flying fox on a subtropical island at the northern range limit of *Pteropus*

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Fruit bats are divided into two types of foragers: specialists that use limited core plant taxa, and generalists that use a variety of plants. We examined the food habits of *Pteropus dasymallus* at two sites with different flora, a forested and an urbanized area in a subtropical island. The plant species used differed between the two sites, and the degree of use of three food types (fruits, flowers, and leaves) also changed. These results suggest that *P. dasymallus* shows dietary plasticity according to food conditions of living locations. The plant diversity was higher in the urbanized area than in the forested area, however, actual diet breadth (Levins' index) was lower in the urbanized area, due to the intensive use of specific plant species in the urbanized area. The bats used *Ficus microcarpa*, as a core plant, which long fruiting periods and high abundance in the urbanized area. In addition, we compared these findings on the diet breadths to those reported in other *Pteropus* species, and suggested that diet breadths of flying foxes might be generalized in subtropics in which food shortages occur irregularly and be specialized in tropics with a high abundance of specific plants with long fruiting periods.

Key words: diet breadth, dietary generalist, dietary specialist, food habits, *Pteropus dasymallus*, subtropics, urbanization

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Activity of insectivorous bats associated with cattle ponds at La Michilía Biosphere Reserve, Durango, Mexico: implications for conservation

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Most bats depend strongly on surface water to survive and reproduce, and thus it is a limiting resource in markedly seasonal environments, such as semiarid and temperate Mexico. Cattle ranching, an important activity in these areas has resulted in construction of rainwater reservoirs that may represent the only available surface water during the dry season. Using acoustic detectors we measured activity in cattle ponds at La Michilía Biosphere Reserve, Durango, Mexico to assess patterns of use by insectivorous bats. We tested for differences in activity between ponds and seasons, and for relationships between bat activity and a set of environmental and pond variables. Bat activity was significantly higher at ponds in the dry season; ponds were used by aerial, trawling, and gleaning insectivores. In the rainy season gleaners did not use ponds, and the other guilds used them less frequently. Larger, older ponds with aquatic vegetation were used more frequently in the dry season, whereas maximum temperature and moon phase affected use in the rainy season. Cattle ponds are common in rangelands and forests of northern Mexico; they constitute important foraging and drinking resources in an area that harbors the largest populations of insectivorous bats in the world.

Key words: acoustic monitoring, Chiroptera, echolocation, environmental variables, northern Mexico, ponds, protected areas

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Roost selection by Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) in a pristine habitat at three spatial scales

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Although several studies have described roost use by Rafinesque's big-eared bats (*Corynorhinus rafinesquii*), few studies have examined roost selection. We examined roost use and selection by Rafinesque's big-eared bat at the tree, stand, and landscape scales during the maternity season in pristine old-growth habitat in the Coastal Plain of South Carolina. We located 43 roosts (14 maternity, 29 solitary) through cavity searches and radio-telemetry. Maternity colonies and solitary individuals selected roosts based on similar characteristics. The best model explaining roost selection by all bats included tree and stand characteristics; landscape factors had little influence on roost use. Bats selected large diameter trees in areas with a high density of trees with cavities in the surrounding area. Most roosts (67.4%) were in water tupelo (*Nyssa aquatica*) in semi-permanently flooded and saturated areas. Half of maternity roost cavities had upper bole openings whereas only 25.8% of solitary roosts had upper bole openings. Bats that roosted with maternity groups stayed in roosts for significantly shorter periods of time (1.3 ± 0.1 days) and used significantly more roost trees (5.0 ± 0.6 roosts) than adult males (3.8 ± 1.10 days, 2.3 ± 0.4 roosts, respectively). Maternity colony use of cavities with upper bole openings and shorter residency times suggest that predator avoidance may have been an important factor governing roosting behavior of maternity colonies in this area. Our results suggest that retention of large diameter, hollow trees in wetland areas will benefit Rafinesque's big-eared bat individuals and maternity colonies in this area.

Key words: bottomland hardwoods, predator avoidance, Rafinesque's big-eared bat, roost selection, roost fidelity

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Geographic and potential distribution of a poorly known South American bat, *Histiotus macrotus* (Chiroptera: Vespertilionidae)

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The vespertilionid bat *Histiotus macrotus* occurs in western Argentina, central regions of Chile and south of Argentina and Chile, and it may be also present in Bolivia and southern Peru. In this work, we analyzed the geographic and potential distribution of a poorly known species of South American bat. As a tool, environmental niche modeling has been used to study the distributional patterns of species and more recently, taxonomic boundaries of cryptic species. We used MaxEnt v 3.3.e, Worldclim database and a vegetation map, covering the entire area of species' occurrence. We registered 64 localities from Argentina (43), Chile (10), Peru (8) and Bolivia (5). We divided recording localities in different datasets according to several taxonomic schemes, and analyzed potential distribution models separately (i.e., all known records; Argentina-Chile; Peru) in five different models. Models including all known localities showed a disjoint distribution, with two basic core areas of high predictive values, one in NW Argentina and another in southern Chile and SW Argentina separated by the South American Arid Diagonal. A third area appeared in Atacama and Sechura deserts in the models that included Peruvian and Bolivian localities. Model including only Peruvian localities showed the opposite pattern, with high predictive values only in arid environments from southern Peru. We interpreted that localities correctly assigned to *H. macrotus* belong to a taxonomic complex distributed in two contrasting areas, each one inhabited by a different taxon: 1) Bolivia and NW Argentina and 2) S and central Chile and SW Argentina. Given the systematic uncertainty of *Histiotus*, these two forms might be sister species or may not share an immediate common ancestor within the genus. Further, we consider that the specimens from localities referred to *H. macrotus* from southern Peru should be revised. These alternatives await a comprehensive molecular phylogenetic analysis of *Histiotus*.

Key words: *Histiotus macrotus*, environmental niche modeling, MaxEnt, South American Arid Diagonal

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Not to put too fine a point on it — does increasing precision of geographic referencing improve species distribution models for a wide-ranging migratory bat?

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Bat specimens held in natural history museum collections can provide insights into the distribution of species. However, there are several important sources of spatial error associated with natural history specimens that may influence the analysis and mapping of bat species distributions. We analyzed the importance of geographic referencing and error correction in species distribution modeling (SDM) using occurrence records of hoary bats (*Lasiurus cinereus*). This species is known to migrate long distances and is a species of increasing concern due to fatalities documented at wind energy facilities in North America. We used 3,215 museum occurrence records collected from 1950–2000 for hoary bats in North America. We compared SDM performance using five approaches: generalized linear models, multivariate adaptive regression splines, boosted regression trees, random forest, and maximum entropy models. We evaluated results using three SDM performance metrics (AUC, sensitivity, and specificity) and two data sets: one comprised of the original occurrence data, and a second data set consisting of these same records after the locations were adjusted to correct for identifiable spatial errors. The increase in precision improved the mean estimated spatial error associated with hoary bat records from 5.11 km to 1.58 km, and this reduction in error resulted in a slight increase in all three SDM performance metrics. These results provide insights into the importance of geographic referencing and the value of correcting spatial errors in modeling the distribution of a wide-ranging bat species. We conclude that the considerable time and effort invested in carefully increasing the precision of the occurrence locations in this data set was not worth the marginal gains in improved SDM performance, and it seems likely that gains would be similar for other bat species that range across large areas of the continent, migrate, and are habitat generalists.

Key words: bioclimatic modeling, Chiroptera, ecological niche modeling, occurrence data, positional uncertainty

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Estimating colony size of the wrinkle-lipped bat, *Chaerephon plicatus* (Chiroptera: Molossidae) at Gomantong, Sabah, by quantitative image analysis

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The Gomantong cave system, Kinabatangan, Sabah (Malaysia) hosts one of the largest bat colonies known from north Borneo. The nightly exodus of *Chaerophon plicatus* from this site is an economically valuable tourist attraction, and must impose significant controls on the regional ecology. Monitoring ecosystem health requires monitoring bat population size, but no quantitative assessments for the Gomantong colony are available in the literature. Traditional censusing techniques (based on packing density and roost area or on roost exodus counts) yield notoriously unreliable results. Here we have applied innovative image analysis and counting techniques to videographic, photographic and terrestrial laser scanning data obtained in July 2012. The colony exits in a consistent stream along a narrow exit trajectory. The laser scanning of the large cave entrance allowed precise measurement of bat position. Video data provided 0.02-second time resolution. Average flight speed was calculated (10.38 ± 0.85 m/sec), bat exit rate was estimated at three minute intervals (peaking at 14,000 bats/minute) and then summed over the 40 minutes of bat flight. The resultant colony size estimate of 275,625–276,939 (95% confidence interval) individuals of *C. plicatus* in Gomantong Caves in 2012 demonstrates that the technique is viable, provides a realistic basis for ecosystem management, and can be repeated to monitor ecosystem change. The estimated insect consumption by the colony of this size is 927 ± 191 metric tons of insects per year over an estimated 270 km^2 area, a very important component in maintaining ecosystem stability in the Gomantong Forest Reserve and the Kinabatangan Wildlife Sanctuary, as well as pest control over the large agricultural tracts of the region.

Key words: Borneo, Kinabatangan, bats, caves, colony size, image analysis, terrestrial laser scanning

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Regional analysis of wind turbine-caused bat mortality

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Wind energy has been the fastest-growing renewable energy source in the world. Studies have estimated bat fatalities at wind facilities, but direct comparisons of results is difficult and can be misleading due to numerous differences in protocols and methods used. We had a unique opportunity to compare fatality estimates from three wind facilities in southeastern Wisconsin. These three facilities are located within two neighboring counties with similar land use and land cover, used similar post-construction study methodologies, have turbine models that are close in size and nameplate capacity, and all became operational within seven months of each other. Our objectives were to analyze bat mortality data across all three wind facilities to: 1) examine species composition; and 2) investigate whether select structural, habitat, and landscape features influence mortality at a fine and broad scale. Corrected estimates of bat mortality were higher than reported in most other previous research in Midwestern agricultural lands in the United States. Similarities within the data were shared by all three wind facilities, but differences across them included species composition of bat mortalities and raw and corrected number of bat carcasses recovered. Our analysis suggested that select habitat and landscape features were among the predictor variables that explained bat mortality at the broad scale. Given heterogeneity in mortality estimates within the upper Midwest region, we recommend that individual wind facilities conduct project-specific pre- and post-construction monitoring rather than infer mortality effects based on published results from other wind facilities.

Key words: bats, meta-analysis, mortality, turbines, wind energy

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Conjoined twins in a wild bat: a case report

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There are numerous records of conjoined twinning in humans and domesticated animals, but many fewer for wild animals because of the early death of conjoined twins. We here describe the incidental discovery and skeletal anatomy of a wild-caught bat fetus with two heads. To our knowledge, this is only the second conjoined bat fetus described, and the first conjoined *Artibeus phaeotis*. We also revisit the anatomy of the first conjoined bat that was described, a stillborn *Eptesicus fuscus*.

Key words: *Artibeus phaeotis*, dicephalus parapagus, fetus, head, Chiroptera

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Ultraviolet vision may be widespread in bats

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Insectivorous bats are well known for their abilities to find and pursue flying insect prey at close range using echolocation, but they also rely heavily on vision. For example, at night bats use vision to orient across landscapes, avoid large obstacles, and locate roosts. Although lacking sharp visual acuity, the eyes of bats evolved to function at very low levels of illumination. Recent evidence based on genetics, immunohistochemistry, and laboratory behavioral trials indicated that many bats can see ultraviolet light (UV), at least at illumination levels similar to or brighter than those before twilight. Despite this growing evidence for potentially widespread UV vision in bats, the prevalence of UV vision among bats remains unknown and has not been studied outside of the laboratory. We used a Y-maze to test whether wild-caught bats could see reflected UV light and whether such UV vision functions at the dim lighting conditions typically experienced by night-flying bats. Seven insectivorous species of bats, representing five genera and three families, showed a statistically significant 'escape-toward-the-light' behavior when placed in the Y-maze. Our results provide compelling evidence of widespread dim-light UV vision in bats.

Key words: Chiroptera, ultraviolet vision, orientation, perception, photoreceptors, retina, rods, sensory ecology, short-wave sensitive cones