Vespertilio 17: 157–159, 2014
ISSN 1213-6123

Are bats karst-dependent?

Paul A. Racey[1] & Neil M. Furey[2]

[1] *Centre for Ecology and Conservation, University of Exeter, Penryn campus, TR16 9FE, UK*
[2] *Fauna & Flora International (Cambodia Programme), PO Box 1380, No. 19, Street 360, Boeng Keng Kang 1, Phnom Penh, Cambodia, 12000*

Jiri Gaisler and his colleagues have made major contributions to knowledge of bats roosting in the Moravian karst. These include one of the longest running studies of any group of mammals, involving 50 years of monitoring (Gaisler et al. 2003). When we recently reviewed the literature on conservation of cave bats (Furey & Racey, in press), we frequently encountered reference to bats as 'karst-dependent'. The word 'dependent' means 'reliant on' or 'unable to do without'. Here we consider whether the term is correctly applied to bats or whether bats and karst are simply co-located because what bats need in winter is a situation with a low and constant environmental temperature, low light levels and high relative humidity. These physical requirements could be as equally well met in a brick/stone railway tunnel (as in Dielik, Slovakia; P. A. Racey, unpubl.) or an iron ore mine (in Luxemburg; Harbusch et al. 2002) or a concrete tunnel built as a wartime fortification (Kokurewicz 2013) as in a karst cave.

A similar term applied to several terrestrial mammal species is karst-restricted – mammals that are found living above karst and seldom if ever found elsewhere (Table 1). This refers principally to their distribution and for many of these species it remains unclear to what extent their present restriction to karst landscapes is due to the fact that these now frequently represent refugia in agriculturally dominated landscapes. Others such as *Trachypithecus* langurs use caves for shelter and can therefore be regarded at least as facultative karst dwellers. However, while there are several poorly known bat species with very limited distributions consisting of karst areas e.g. *Rhinolophus xinanzhongguoensis* (Zhou et al. 2009), we know of few well-documented bats restricted to karst. Examples are Kitti's hog-nosed bat *Craseonycteris thonglongyai* found in karstic caves in Burma and Thailand (Puechmaille et al. 2009, 2011), and the great evening bat *Ia io*, exclusively recorded from karstic caves in Nepal eastwards to China (Csorba et al. 2013). While proving the absence of a species in other habitats is very difficult, the fact remains that few well-studied bat species appear to be known exclusively from karst areas.

The defining characteristic of karst areas − the abundance of calcium as the cation of calcium carbonate − has been suggested as a driver of the use of karstic caves by insectivorous bats. Insects contain little calcium and several studies have shown that calcium levels in the bones of female bats are lowest during lactation, as calcium is transferred to the young in milk (Kwiecinski et al. 1987). This led Barclay (1994, 1995) to suggest that shortage of calcium may be a greater constraint on reproduction in bats than meeting its energy demands and that one of the reasons that they roost in karst caves is that they acquire calcium by licking the walls, which is a common observation (Codd et al. 1999). There has been only one study to test this hypothesis, which was not supported by the evidence, since bats were distributed across all underground sites in a wide range of geological formations and were not concentrated in karst landscapes (Bernard & Davison

Table 1. Old World karst-restricted mammals

species	distribution	references
Rodentia		
lowland red forest rat *Nesomys lambertoni*	Madagascar	Goodman & Schutz 2003
Laotian rock rat *Laonastes aenigmamus*	Laos	Jenkins et al. 2005
Paulina's limestone rat *Saxatilomys paulinae*	Laos	Sanamxay et al. 2013
limestone niviventer *Niviventer hinpoon*	Laos	Latinne 2012
Neill's leopoldamys *Leopoldamys neilli*	Thailand, Laos	Latinne 2012
Balkan snow vole *Dinaromys bogdanovi*	Croatia, Bosnia, Serbia, Montenegro, Macedonia	Kryštufek 2008
Laotian giant flying squirrel *Biswamoyopterus laoensis*	Laos	Sanamxay et al. 2013
Daovantien's limestone rat *Tonkinomys daovantieni*	Vietnam	Lunde & Musser 2008
Eulipotyphla		
long-eared gymnure *Hylomys megalotis*	Laos	Chiozza 2008
Carnivora		
Vietnam ferret-badger *Melogale cucphuongensis*	Vietnam	Nadler et al. 2011
Primates		
Cao-vit crested gibbon *Nomascus nasutus*	Vietnam, China	Mittermeier et al. 2012
Tonkin snub-nosed monkey *Rhinopithecus avunculus*	Vietnam	Mittermeier et al. 2012
white-headed langur *Trachypithecus poliocephalus*	Vietnam, China	Bleisch et al. 2008
Delacour's langur *Trachypithecus delacouri*	Vietnam	Mittermeier et al. 2012
Francois's langur *Trachypithecus francoisi*	Vietnam, China	Mittermeier et al. 2012

1996). Nevertheless, the fact that Adams at al. (2003) captured more female and juvenile bats over water holes with harder water (indicating higher calcium levels) suggests that environmental calcium is important, particularly for reproducing females and their young.

Although the calcium hypothesis requires further testing, we must presently conclude that bats are roost-dependent and the fact that such roosts are so often provided by karstic caves reflects the global abundance of carbonate in the earth's crust and its solubility and not a specific dependence.

References

Adams R. A., Pedersen S. C., Thibault K. M., Jadin J. & Petru B., 2003: Calcium as a limiting resource to insectivorous bats: can water holes provide a supplemental mineral source? *Journal of Zoology, London*, **260**: 189–184.

Barclay R. M. R., 1994: Constraint on reproduction by flying vertebrates: energy and calcium. *American Naturalist*, **144**: 1021–1031.

Barclay R. M. R., 1995: Does energy or calcium availability constrain reproduction in bats? Pp.: 245–258. In: Racey P. A. & Swift S. M. (eds.): *Ecology, Evolution, and Behaviour of Bats*. Clarendon Press, Oxford, 448 pp.

Bernard R. T. F. & Davison A., 1996: Does calcium constrain reproductive activity in insectivorous bats? Some empirical evidence for Schreiber's long fingered bat (*Miniopterus schreibersii*). *South African Journal of Zoology*, **31**: 218–220.

Bleisch B., Xuan Canh L., Covert B. & Yongcheng L., 2008: *Trachypithecus poliocephalus*. In: *IUCN 2013. IUCN Red List of Threatened Species*. Version 2013.2. URL: www.iucnredlist.org. Downloaded on 3 April 2014.

Chiozza F., 2008: *Hylomys megalotis*. In: *IUCN 2013. IUCN Red List of Threatened Species*. Version 2013.2. URL: www.iucnredlist.org. Downloaded on 7 April 2014.

Codd J., Clark B. & Sanderson K., 1999: Drinking by the common bent-winged bat *Miniopterus schreibersii* and calcium in cave water. *Bat Research News*, **40**: 9–10.

Csorba G., Bumrungsri S., Bates P., Molur, S. & Srinivasulu C., 2013: *Ia io*. In: *IUCN 2013. IUCN Red List of Threatened Species*. Version 2013.2. URL: www.iucnredlist.org. Downloaded on 15 April 2014.

Furey N. & Racey P. A., in press: Conservation ecology of cave bats. In: Kingston T. & Voigt C. C. (eds.): *Bats in Anthropocene – Conservation of Bats in a Changing World*. Springer, Berlin.

Gaisler J., Hanák V., Hanzal V. & Jarský V., 2003: Results of bat banding in the Czech and Slovak Republics (1948–2000). *Vespertilio*, **7**: 3–61 (in Czech, with an abstract in English).

Goodman S. M. & Shutz H., 2003: Specimen evidence of the continued existence of the Malagasy rodent *Nesomys lambertoni* (Muridae: Nesomyinae). *Mammalia*, **67**: 445–449.

Harbusch C., Engel E. & Pir J. B., 2002: Die Fledermäuse Luxemburgs. *Ferrantia*, **33**: 7–149.

Jenkins J. D., Kilpatrick C. W., Robinson M. F. & Timmins R. J., 2005: Morphological and molecular investigations of a new family, genus and species of rodent (Mammalia: Rodentia: Hystricognatha) from Lao PDR. *Systematics and Biodiversity*, **2**: 419–454.

Kokurewicz T., Rusiński M. & Weigle A., 2013: *12th International winter bat census in Natura 2000 site* "*Nietoperek*" (*PLH080003*) (*Lubuskie County*) *– 12th January 2013. Report from the census and the results*. National Foundation for Environmental Protection, Warszawa, 30 pp (in Polish).

Kryštufek B., 2008: *Dinaromys bogdanovi*. In: *IUCN 2013. IUCN Red List of Threatened Species*. Version 2013.2. URL: www.iucnredlist.org. Downloaded on 15 April 2014.

Kwiecinski G. G., Krook L. & Wimsatt W. A., 1987: Annual skeletal changes in the little brown bat *Myotis lucifugus lucufugus* with particular reference to pregnancy and lactation. *American Journal of Anatomy*, **178**: 410–420.

Latinne A., 2012: *Diversity and Endemism of Murinae Rodents in Thai Limestone Karsts*: *A Genetic Approach*. Unpubl. PhD Thesis. University de Liege, 254 pp.

Lunde D. & Musser G., 2008: *Tonkinomys daovantieni*. In: *IUCN 2013. IUCN Red List of Threatened Species*. Version 2013.2. URL: www.iucnredlist.org. Downloaded on 7 April 2014.

Mittermeier R. A., Schwitzer C., Rylands A. B., Taylor L. A., Chiozza F., Williamson E. A. & Wallis J. (eds.), 2012: *Primates in Peril*: *The World's 25 Most Endangered Primates 2012–2014*. IUCN/SSC Primate Specialist Group, International Primatological Society, Conservation International, and Bristol Conservation and Science Foundation, Bristol, UK, 40 pp.

Nadler T., Streicher U., Stefen C., Schwierz E. & Roos C., 2011: A new species of ferret-badger, Genus *Melogale*, from Vietnam. *Der Zoologische Garten*, **80**: 271–286.

Puechmaille S. J., Soisook P., Yokubol M., Piyapan P., ArGouilh M., Khin Mie Mie, Khin Khin Kyaw, Mackie I., Bumrungsri S., Dejtaradol A., Tin Nwe, Si Si Hla Bu, Satasook C., Bates P. J. & Teeling E. C., 2009: Population size, distribution, threats and conservation status of two endangered bat species *Craseonycteris thonglongyai* and *Hipposideros turpis*. *Endangered Species Research*, **8**: 15–23.

Puechmaille S. J., Ar Gouilh M., Piyapan P., Yokubol M., Khin Mie Mie, Bates P. J., Satasook C., Tin Nwe, Si Si Hla Bu, Mackie I., Petit E. J. & Teeling E. C., 2011: The evolution of sensory divergence in the context of limited gene flow in the bumblebee bat. *Nature Communications*, **2**(573): 1–9+1–34.

Sanamxay D., Douangboubpha B., Bumrungsri S., Xayavong S., Xayaphet V., Satasook C. & Bates P. J. J., 2013: Rediscovery of *Biswamoyopterus* (Mammalia: Rodentia: Sciuridae: Pteromyini) in Asia, with the description of a new species from Lao PDR. *Zootaxa*, **3686**: 471–481.

Zhou Z.-M., Guillén-Servent A., Lim B. K., Eger J. L., Wang Y. Y. & Jiang X.-L., 2009: A new horseshoe bat, in the Afro-Palearctic lineage, from southwestern China. *Journal of Mammalogy*, **90**: 57–73.

received on 28 April 2014