

Cave Ecosystems of Turkey and Northern Cyprus: A Hidden World for Bats

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Abstract: Cave ecosystems along with particularly its unique and fragile biota are very sensitive to degradation and destructions caused by humans. Bats are one of the considerable component of the cave biota and classified as troglonenes. Most of the bat species mainly prefers karstic caves for forming clusters. Thirty-nine and 22 bat species are distributed in Turkey and Cyprus, respectively. Egyptian fruit bat, Greater and lesser mouse-eared bats, bent-winged bat, Kuhl's pipistrelle and Greater horseshoe bat are the most abundant species encountered in the field trips. Two major periods are mostly important for bat life cycle; gestation along with lactating periods that formed in spring and summer months and hibernation period in winter months. Besides, many invertebrate species adapted to living in the permanent darkness are also detected from various caves in this study. Major threats to both caves and cave biota in Turkey and North Cyprus are recorded as; use of cave entrances as animal shelters, wastewater drainage and dump, marble quarrying, inappropriate guano mining, cave tourism, cure for illness, dam construction and mushroom cultivation. Studies were initiated for the conservation of caves in both countries.

Keywords: *Chiroptera, cave biota, caustic caves, invertebrates, Turkey, TRNC*

Introduction

In general, natural underground or underwater habitats with an opening called caves. However, artificial underground sites such as abandoned mines and tunnels are not included into this definition. Natural caves are divided as caustic, sandstone, hydrothermal, lava, and glacier or tectonic based on its geological formations (Romero, 2009). In Europe, about 130.000 caves are reported (Juberthie, 2000). In addition Turkey is rich with respect to extensive and widespread karstic caves (Bayari & Özbek, 1995). However, only 42 of 85 determined caves are investigated thoroughly in Northern Cyprus (Nazik *et al.*, 2007).

The cave biota is divided into four categories; troglonent, eutroglophic, subtroglophile and troglonene. According to these latest categories; bats are included in subtroglophile, named previously as troglonene in the Barr system or troglonophile in the Schiner-Racoviță system. Subtroglophile species are obligate or facultative terrestrial cave dwellers and connected obligatory to outside of the caves for feeding or reproducing (Sket, 2008; Culver & Pipan, 2009). Many bat species mostly prefer caves with respect to the appropriate abiotic factors such as light, air flow, temperature and humidity for hibernation, breeding, growing youngs and a temporary roosts from predators and climatic changes occurring outside (Romero, 2009; Furey & Racey, 2016). Thirty-nine (one frugivorous and 38 insectivorous) and 22 (one frugivorous and 21 insectivorous) bat species are distributed in Turkey and North Cyprus, respectively (Benda & Horacek, 1998; Benda *et al.*, 2007; Çoraman *et al.*, 2013).

The aim of this study was to present some of the cave-dweller bat and invertebrate species determined in various caves from Turkey and Northern Cyprus and to emphasize the importance of the cave conservation for the biota that live in those caves.

Material and Methods

This study was carried out in a total of 9 caves from Turkey and T.R.N.C. between the years 2014 and 2016. Caves were selected on the basis of earlier records according to Benda & Horacek, (1998) and Benda *et al.*, (2007) (Figure 1).

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Figure 1. Locations of investigated caves in Turkey and T.R.N.C.

Photographs of the bat colonies and invertebrate species were taken without direct lighting except for the briefest illumination. Bat species were captured by hand or hand nests and identified according to Dietz & Kiefer (2014). For determining the species living on guano piles, guano was collected in sterile petri dishes from some of the caves and the mites and insects were separated under a stereoscopic microscope, photographed and identified. Some of the invertebrate species has been identified only in order rank.

Results and Discussion

The most abundant species were recorded as *Rousettus aegyptiacus* (Egyptian fruit bat), *Myotis myotis* (Greater mouse-eared bat), *M. blythii* (Lesser Mouse-eared bat), *M. capaccinii* (Long-fingered bat), *Rhinolophus ferrumequinum* (Greater horseshoe bat), *R. hipposideros* (Lesser horseshoe bat) and *R. euryale* (Mediterranean horseshoe bat) in the field trips. The species are in agreement with those as stated by Aşan Baydemir (2014) previously (Figures 2-7).



Figure 2. Two male *Rousettus aegyptiacus* specimens from a cave in Northern Cyprus



Figure 3. A mixed colony composed of *Myotis myotis/blythii* from Kırıkkale province, Turkey



Figure 4. A male specimen of *Myotis capaccinii* from Hatay province, Turkey



Figure 5. A specimen of *Rhinolophus ferrumequinum* from Kırıkkale province, Turkey



Figure 6. Hibernating specimens of *Rhinolophus hipposideros* from Karabük province, Turkey



Figure 7. *Rhinolophus euryale* and *Myotis myotis* specimens from Kırklareli province, Turkey

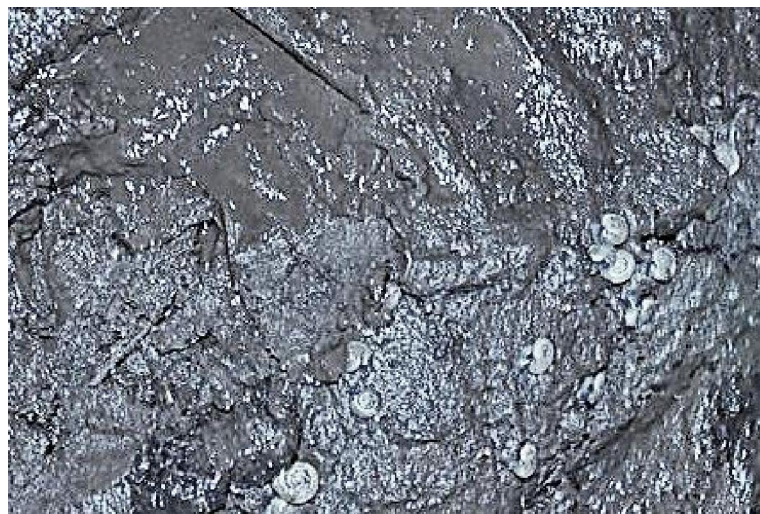


Figure 8. *Oxychilus* sp., a gastropod genus that exists in caves, from Hatay province, Turkey

Dipterans, butterflies, trichopterans, spiders and opilionids can be found on cave walls and ceilings from the entrance to the beginning of aphotic zone. In addition, guano is an important source for guanophiles or guanobites composed by earthworms, mites, collembolans, woodlice, millipedes, beetles and dipterans in cave ecosystems (Kováč, 2008).

However, studies on cave dweller invertebrates are very scarce from Turkey and North Cyprus (Kunt *et al.*, 2010; 2016). Kunt *et al.*, (2010) examined the invertebrates of caves in detailed with 203 species, including phylum Mollusca, subclassis Oligochaeta and Hirudinea, classis Arachnida, Diplopoda, Chilipoda and Insecta and subphylum Crustaceae in Turkey, and of them, 104 species are determined as endemic to Anatolia. In this preliminary study, we recorded species from the phylum Mollusca, orders Araneae and Orthoptera, Amblypygi, Ophilonies and Coleoptera from the caves (Figures 8-9). Kunt *et al.*, (2010) recorded *Meta bourneti* from the caves in Yalova and Bursa provinces, *Tegeneria faniapollinis* from Hatay province and *Holocnemus pluchei* from Elazığ and Kahramanmaraş. However the localities, given in the present study from Sakarya, Kırıkkale provinces and Northern Cyprus, are recorded for the first time. In addition, individuals in hibernation from the order Lepidoptera and cave crickets are also recorded near the entrances of the caves from Karabük and Sakarya provinces, respectively (Figure 10).



Figure 9. *Meta bourneti* (A) from Sakarya province, *Tegeneria faniapollinis* (B) from Kırıkkale province, *Holocnemus pluchei* (C) from Northern Cyprus and opiliones (D) from Sakarya province.



Figure 10. Lepidoptera (A-C) and Orthoptera (D) species from Karabük and Sakarya provinces, Turkey

Staphylinids, mites, and other arthropods were found to be abundant in bat guano deposits. *Atheta triangulum* and a cave mite (*Veigaia* sp.) were extracted from the guano from a cave in Konya province (Aşan Baydemir et al., 2015) (Figure 11). A microscopic fungus on the guano (*Mucor* sp.) was also detected in many caves from Turkey. The fungus is an essential food source for many cave-dweller animals as stated by Kováč, (2008) (Figure 12).

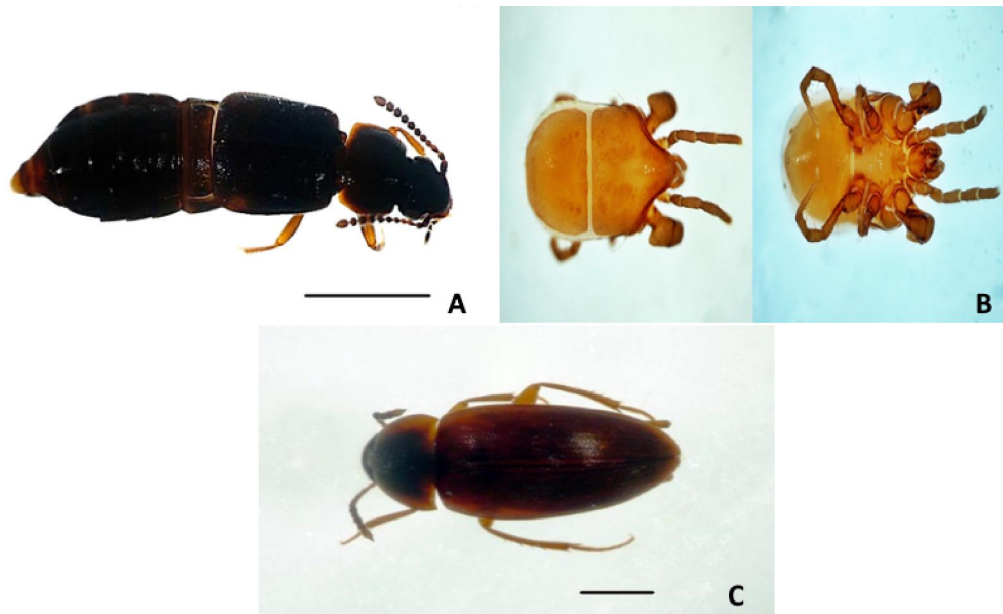


Figure 11. *Atheta triangulum* (A), *Veigaia* sp. (B) and a Coleoptera species (C) extracted from guano from Konya province



Figure 12. *Mucor* sp. covering the bat guano from Kırıkkale province.

Conclusion

Cave ecosystems are known to be one of the most fragile terrestrial ecosystems due to the particular and unique inhabitants. The presence of the bat and invertebrate species in a cave, is determined by the ecological factors of the caves (Wyne & Pleytezw, 2005; Kováč, 2008). The continuity of bat species depends on quality of natural and artificial caves. Bat species are very vulnerable to sudden human disturbances particularly in hibernation, pregnancy, lactation and weaning of young periods (Furey & Racey, 2016). In Turkey, the gestation and lactation periods of the bat

species are recorded as May-June and June-September. In addition, various bat species hibernate in December, January and February (Aşan Baydemir & Albayrak, 2006). Nowadays, subterranean roosts and populations of some bat species are dramatically decreasing worldwide because of destructions of roost sites (Aşan Baydemir, 2014). Major threats to bats and cave ecosystems in Turkey and North Cyprus are reported as habitat loss due to increasing urbanization, improperly designed cave gates, environmental pollution, illegal killing of bats with pesticides, cave tourism, limestone quarrying and discrete deterioration of cave ecosystems due to guano harvesting. Some of the changes could affect the cave ecosystems irreversibly and therefore, we began to collaborate with the competent authorities for the protection of these damaged caves. In addition, biology, distribution, ecology, habitat preferences of each bat and invertebrate species should be known for an efficient conservation of cave ecosystems. Furthermore, bat preferred designed gates at the entrances of the caves should be constructed for preventing humans disturbances as stated by Furey & Racey (2016).

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