

Structure of bat guano communities in a dry Brazilian cave

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Bat guano communities

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The most abundant orders were generally concentrated relatively close to the cave entrance (~ 40-50 m; Fig. 2A). Mites (Fig. 2B), silverfish (Fig. 2C) and barklice (Fig. 2D) were very abundant in the first 40 m of the cave.

Distinct groups have different preferences for the types of guano. Only one family of Lepidoptera (Pyrilidae) and two of Coleoptera (Dermestidae and Leiodidae) were found exclusively in frugivorous bat guano. Conversely many families were found exclusively on haematophagous bat guano, such as Sicariidae (*Sicarius tropicus*) and Corinidae (Araneida), Chernetidae (Pseudoescorpionida), Platyarthridae (*Isopoda*), Entomobryidae (Collembola), Psychodidae, Phoridae, Cecidomyiidae, Streblidae (Diptera), Pulicidae (Siphonaptera) and Nasutitermitidae (Isoptera). The other groups were found both in haematophagous and frugivorous bat guano (Table 4).

Invertebrate preferences for different guano types (insectivorous, frugivorous or hematophagous guano) proposed by GNASPINI-NETTO (1989) for some Brazilian caves do not apply to Morrinho Cave. Dermestids, which he considered to be specific to insectivorous bat guano, were also found in frugivorous guano. *Isopods* and psocopterans, considered to be specific to frugivorous guano, were also found in haematophagous guano. Finally, pseudoscorpions and mites were considered specific to insectivorous guano, whereas we found these organisms on haematophagous bat guano. Many invertebrates associated with guano piles are generalistic detritivores, able to consume different types of organic resources (FERREIRA & MARTINS 1999a, 1999b). Therefore, the dependence of some invertebrate groups on specif-

Trophic structure and natural history of bat guano invertebrate communities, with special reference to Brazilian caves

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The basis of the food web in bat guano communities in the sampled caves are detritivorous organisms that directly consume guano and microorganisms that live off deposits (Figs 1-4). These include mites, the most common organisms on guano, and other invertebrates including: springtails (e.g. Entomobryidae, Hypogastruridae, Isotomidae and Arrhopalitidae); booklice (mainly Psyllipsocidae); beetles, specifically larvae (Dermestidae, Tenebrionidae, and Leiodidae, the most abundant families, followed by Carabidae, Trogidae, and Histeridae); moths (mainly Tineidae larvae); and fly larvae in fresh guano (Drosophilidae, Phoridae, Milichiidae, and Fanniidae). Facultative detritivores are also common, forming large populations, when other organic substrata, such as vegetable debris, become scarce, as in permanently dry caves. Examples are *isopods* (e.g. Armadillidae, Platyarthridae, and Styloniscidae), diplopods (mainly Spirostrepida), chilopods (mainly Geophylomorpha), cockroaches, crickets (mainly Phalangopsidae), and silverfish (Lepismatidae, Nicoletiidae). Other detritivores, like flatworms, earthworms, gastropods and harvestmen, were rarely found.

Several *isopods* can be found in guano piles both in tropical and temperate caves (DECOU & DECOU 1964, DECOU et al. 1974, DECU 1986, SOUZA-KURY 1993, FERREIRA & POMPEU 1997, FERREIRA & MARTINS in press). GNASPINI & TRAJANO (in press) cited three families found in guano deposits in Brazilian caves (Phylosciidae, Scleropactidae and Armadillidae), the latter having been observed in north Minas Gerais State, in addition to Platyarthridae and Styloniscidae. The remarkable preferences among families are certainly the consequence of their distinct biological cycles.

Millipedes

Observations of millipedes in Kitley cave, Devon, including the first confirmed British record of *Polydesmus asthenestatus* Pocock, 1894

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On 21st November 2020, a visit to several caves in the Yealm Valley, close to Plymouth, was undertaken to carry out some net sampling for stygobitic Crustacea. Amongst these sites was Kitley Cave (SX575512, VC 3) once developed as a show cave in the 1970s and 80s, but which has been closed since 2000 (Fig. 1). During this visit large numbers of pale *millipedes* were noted throughout the cave on most moist stalagmite and rock surfaces, with concentrations on occasional piles of bat guano.



Figure 2: *Polydesmus asthenestatus* in Kitley Cave.

A) Specimens on bat guano, November 2020; B) Close up of an individual (images Lee Knight)

Spiders

Diversity and distribution of spiders associated with bat guano piles in Morrinho cave (Bahia State, Brazil)

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Five species of spiders from the families Theridiidae (*Nesticoides rufipes*), Sicariidae (*Loxosceles similis* and *Sicarius tropicus*), Oecobidae (*Oecobius annulipes*) and Corinnidae were found on bat guano piles in the Morrinho cave (Bahia state, Brazil). Species richness of spiders was positively correlated with the area of the guano piles and silverfish abundance, and negatively correlated with the distance from the cave entrance. The positive relationship found between spider richness and diversity with area of the piles is presumably because prey abundance is positively correlated with pile size. The relationship

Cockroaches

Trophic structure and natural history of bat guano invertebrate communities, with special reference to Brazilian caves

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The trophic structure and natural history of bat guano invertebrate communities in Brazilian caves was compared with information concerning bat guano communities in other caves throughout the world. The basis of Brazilian cave guano communities are detritivorous organisms that directly consume guano, and microorganisms that live off deposits. These include mites, the most common organisms on guano, and others such as springtails (*Acherontides eleonora* Palacios-Vargas & Gnaspini-Netto 1992), booklice (e.g. Psyllipsocidae), beetles (e.g. Dermestidae, Cholevidae), moths (e.g. Tineidae) and flies (e.g. Phoridae, Milichiidae). Facultative detritivores are also common, forming large populations when other organic substrata, such as vegetable debris, become scarce, as in the case of permanently dry caves. These are *isopods* (e.g. *Trichorrhina* sp.), diplopods (e.g. *Pseudonannolene* sp.), *cockroaches*, crickets (e.g. *Endecous* sp.), and silverfish (e.g. *Coletinia brasiliensis* Mendes & Ferreira in press). Other detritivores, like flatworms, earthworms, gastropods and harvestmen, are rarely found. Detritivores are in turn consumed by a wide range of predators, like pseudoscorpions (e.g. Chernetidae), spiders (e.g. *Loxosceles similis* Moenkhaus 1898, *Oecobius annulipes* Lucas 1846), and heteropterans (Reduviidae *Zelurus variegatus* Costa-Lima 1940). Facultative predators, like scorpions and whip-scorpions attracted by prey items, are also occasionally abundant. Food webs of bat guano communities in Brazilian caves are richer in species than those elsewhere.