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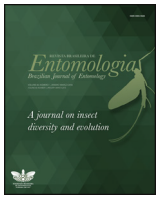

Scarabs in the dark: occurrence of Scarabaeoidea beetles (Insecta: Coleoptera) in Brazilian caves

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ABSTRACT

Scarabeoidea (Insecta: Coleoptera) present more than 2000 species recorded from all over Brazil. They have been scarcely recorded from caves, and truly troglobitic species are yet to be found in the country. In this study, we carried out a review of all existing scarab beetles deposited until 2017 in the Coleção de Invertebrados Subterrâneos de Lavras (ISLA), at the Universidade Federal de Lavras (UFLA) (Minas Gerais, Brazil), one of the most important collections of subterranean invertebrates in South America. Ninety-two individuals belonging to 52 species were recorded, distributed in six families (Cetoniidae, Hybosoridae, Melolonthidae, Passalidae, Scarabaeidae and Trogidae). Scarabaeidae was the most diverse of them, representing more than 50% of the total of species recorded. We found Scarabeoidea beetles in 51 of the ~ 1600 caves examined, distributed in nine Brazilian states: Alagoas, Bahia, Distrito Federal, Espírito Santo, Goiás, Minas Gerais, Pará, Piauí, and Tocantins. Our results provide evidence that Scarabaeoidea beetles are not frequent in Brazilian caves, and their records in this kind of environment are mostly accidental. Exceptions include Trogidae and Aphodiinae species, which may be associated with bat guano. Our study presents the first list of Scarabaeoidea species sampled in Brazilian caves.

Introduction

Beetles of the superfamily Scarabeoidea are highly diverse in life histories. While countless species can act as pollinators and other as decomposers of organic matter, others still are considered severe agricultural pests (Morón and Aragón, 2003). The 35,000 species of scarabs (Schoolmeesters, 2022) are distributed in 14 families worldwide (see Bouchard et al., 2011; Cherman and Morón, 2014), nine of which with records from Brazil, numbering more than 2,000 species in the country (Vaz-de-Mello and Grossi, 2022). Although Scarabaeoidea beetles are reported throughout the Brazilian territory in several terrestrial environments, there are few records of this superfamily in Brazilian caves. These records are only for the states of Mato Grosso do Sul, Minas Gerais, Pará and São Paulo, with beetles all belonging to the Scarabaeidae family (Pinto-da-Rocha, 1995; Ferreira and Martins, 1999; Gnaspini and Trajano, 2001, Cajaíba et al., 2016; Pacheco and Vaz-de-Mello, 2019).

Caves are simplified, stable environments when compared to the surface (Cajaíba et al., 2016), and they may present many types of microhabitats (e.g. small cracks and interstices, gravel, sand, clay) and organic resources (e.g. trunks, leaves, fine vegetable debris, roots, guano and carcasses) (Lunghi et al., 2017; Lunghi and Manenti, 2020). However, caves are unique environments with fragile fauna, being highly vulnerable to the impacts caused by human actions (Souza-Silva et al., 2021). Knowing the biodiversity of Scarabaeoidea beetles in Brazilian caves is important to understand how this subterranean habitat may contribute to both local and regional distribution of these beetles. Here, we review the diversity of Scarabaeoidea beetles in Brazilian caves and discuss our findings in light of published data.

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Materials and methods

We carried out a review of all Scarabaeoidea beetles deposited in the Coleção de Invertebrados Subterrâneos de Lavras (ISLA; curator R. L. Ferreira), Universidade Federal de Lavras (UFLA) (Lavras, Minas Gerais, Brazil), up to 2017. Currently, this collection is considered, both quantitatively and qualitatively, as one of the largest and most important collections of subterranean invertebrates of South America, with specimens sampled from all regions of Brazil and worldwide. Thanks to these characteristics, it was possible to assemble a list of species from caves of the different Brazilian states. In our review, we found beetles that were captured by the 'hand searching' method, which consists of manual collection throughout the accessible length of the cave – also known as direct intuitive search (see Wynne et al., 2019). Overall, we revised Scarabaeoidea beetles from invertebrate samplings carried out in approximately 1,600 caves.

Scarabeoidea beetles were identified to species levels by the co-authors Fernando Z. Vaz-de-Mello and Paschoal C. Grossi**.** Voucher specimens were transferred from the ISLA to Seção Entomológica da Coleção Zoológica (CEMT) at the Universidade Federal de Mato Grosso (UFMT; Cuiabá, Mato Grosso, Brazil) and Coleção Entomológica da Universidade Federal Rural de Pernambuco (CERPE) (Recife, Pernambuco, Brazil).

Results

We found records of scarab beetles from 51 caves distributed in the following Brazilian states: Alagoas, Bahia, Distrito Federal, Espírito Santo, Goiás, Minas Gerais, Pará, Piauí, and Tocantins (Table 1). We recorded a total of 92 Scarabaeoidea individuals belonging to 52 species (in some cases, not identified with a binomen) distributed in six families: Cetoniidae, Hybosoridae, Melolonthidae, Passalidae, Scarabaeidae and Trogidae (Table 1). Illustrative pictures of some of these species found in different caves are shown in Figure 1.

Scarabaeidae was the most diverse family, representing more than 50% of the total species recorded in Brazilian caves (27 spp.)

Table 1
Abundance, richness and occurrence of Scarabaeoidea beetles in caves of different states of Brazil as recorded in our museum studies. AL = Alagoas; BA = Bahia, DF = Distrito Federal, ES = Espírito Santo; GO = Goiás, MG = Minas Gerais, PA = Pará, PI = Piauí, and TO = Tocantins.

Taxon	Abundance	Occurrence
Cetoniidae		
Cetoniinae		
Gymnetis pantherina Blanchard, 1837	5	PA
Gymnetis strigosa (Olivier, 1789)	2	PA
Hybosoridae		
Ceratocanthinae		
Germarostes sp.	1	MG
Hybosorinae		
Taisia cornitermitis Frolov et al. 2017	1	TO
Melolonthidae		
Dynastinae		
Archophileurus oedipus (Prell, 1912)	1	MG
Archophileurus sp.	1	MG
Coelosis bicornis (Leske, 1779)	2	DF, MG
Coelosis biloba (Linnaeus, 1767)	1	MG
Coelosis denticornis Arrow, 1937	1	MG
Coelosis inermis (Sternberg, 1908)	1	MG
Enema pan (Fabricius, 1775)	1	MG
Megaceras morpheus Burmeister, 1847	1	MG
Melolonthinae		
Agaocnemis pruina Moser, 1918	1	MG
Astaena sp.	1	MG
Blepharotoma sp.	1	GO
Dicrania sp.	1	MG
Isonychus sp.	2	MG
Liogenys sp.	1	MG
Macrodactilini sp.	2	MG
Macrodactylus suturalis Mannerheim, 1829	2	MG
Phyllophoga sp.	1	TO
Rhinaspis aenea (Bilberg, 1820)	1	ES
Passalidae		
Passalinae		
Verres furcilabris (Eschscholtz, 1829)	1	PA
Scarabaeidae		
Aphodiinae		
Ataenius aff. *blapoides*	1	MG
Ataenius sp. 1	2	MG
Ataenius sp. 2	8	PA
Odontolytes sp. 1	2	MG

Table 1
Continued...

Taxon	Abundance	Occurrence
Odontolytes sp. 2	1	MG
Odontolytes sp. 3	3	MG
Odontolytes sp. 4	1	MG
Trichiopsammobius brasiliensis Petrovitz, 1963	1	MG
Scarabaeinae		
Ateuchus aff. *vigilans*	1	MG
Canthidium sp. 1	1	MG
Canthidium sp. 2	1	MG
Canthon cinctellus (Germar, 1824)	1	MG
Canthon sp.	2	MG, PI
Dichotomius aff. *carbonarius*	3	DF, MG
Dichotomius aff. *semiaeneus*	1	MG
Dichotomius bicuspis (Germar, 1824)	1	MG
Dichotomius bos (Blanchard, 1845)	1	MG
Dichotomius reichei (Harold, 1869)	1	MG
Digitonthophagus gazella (Fabricius, 1775)	1	AL
Hansreia affinis (Fabricius, 1801)	1	PA
Sylvicanthon sp.	1	PA
Uroxys aff. *bahianus*	2	MG
Uroxys aterrimus Harold, 1867	1	MG
Uroxys sp. 1	1	TO
Uroxys sp. 2	1	BA
Uroxys sp. 3	1	MG
Uroxys sp. 4	1	BA
Trogidae		
Omorginae		
Omorgus batesi (Harold, 1872)	4	PA
Polynoncus gemmingeri (Harold, 1872)	14	MG

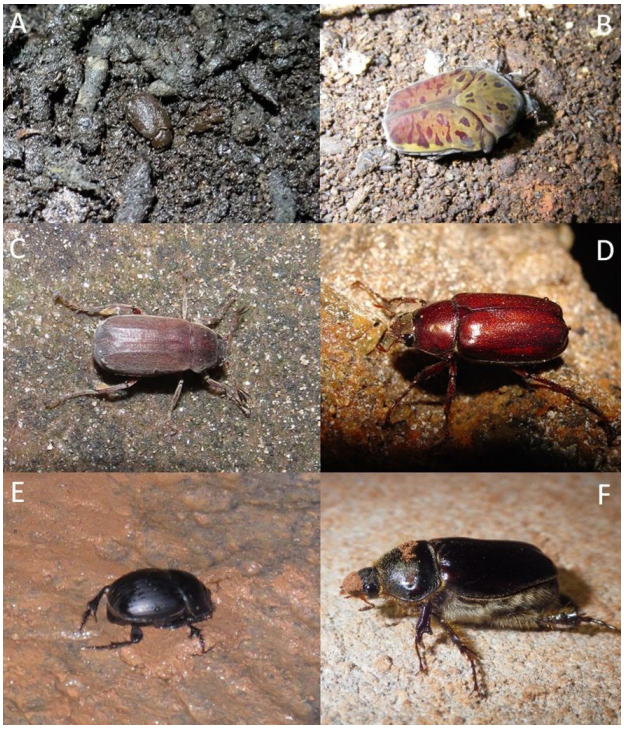

Figure 1. Some Scarabaeoidea beetle species and the localization where they are found in Brazilian caves. A) *Polynoncus gemmingeri* (Trogidae) found in Andrelândia, MG (Quartzite cave); B) *Gymnetis pantherina* (Cetoniidae) found in Curionópolis, PA (Iron ore cave); C) *Agaocnemis pruina* (Melolonthidae) found in Carrancas, MG (Quartzite cave); D) *Rhinaspis aenea* (Melolonthidae) found in Santa Teresa, ES (Granite cave); E) *Dichotomius* aff. *carbonarius* (Scarabaeidae) found in Lassance, MG (Limestone cave) and F) *Dicrania* sp. (Melolonthidae) found in Montalvânia, MG (Limestone cave).

and 30% of the total number of individuals (42 specimens), followed by Melolonthidae (18 spp. and 22 individuals). We also recorded two species and 18 individuals belonging to family Trogidae, two species and seven individuals of Cetoniidae, two species and two individuals of Hybosoridae and only one species and one individual of family Passalidae (Figure 2). The three most abundant species in Brazilian caves were *Polynoncus gemmingeri* (Harold, 1872) (Trogidae – n = 14 individuals; 15.2% of total beetle abundance), *Ataenius* sp. 2 (Scarabaeidae – n = 8 individuals; 8.6%), and *Gymnetis pantherina* Blanchard, 1842 (Cetoniidae – n = 5 individuals; 5.4%) (Table 1). Among the species recorded, most of them (49 species – 94% of the total) were rare (comprising less than 1% of total beetle abundance), corresponding to *singletons* and *doubletons* (Table 1).

Discussion

Despite their wide distribution in eleven states throughout the country, the presence of scarabs in Brazilian caves is probably occasional or accidental, as already observed in caves in the United States and Canada (Slay et al., 2012). We observed the presence of these beetles in only approximately 0.5% of the sampled caves and their abundance is apparently always very low. Most of the sampled species are rare, being "singletons" or "doubletons", where only one or two individuals were found, respectively.

From all the sampled families, only Scarabaeidae, Hybosoridae, Trogidae and Passalidae have the potential to use the trophic resources found inside caves. These families are mainly detritivores, feeding on feces, carcasses, and decaying wood (Halffter and Matthews, 1966; Reyes-Castillo and Halffter, 1984; Morón and Aragón 2003; Correa et al.

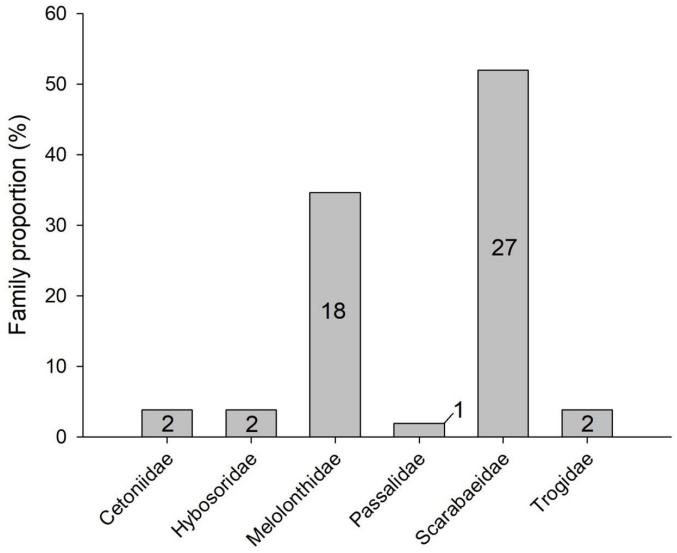

Figure 2. Proportion of Scarabaeoidea families sampled in Brazilian caves. Numbers inside the figure represent the species numbers in each Scarabaeoidea family.

2013). However, due the low abundance, most species are probably not maintaining populations in caves. Differently, specimens of the families Cetoniidae (e.g., genus *Gymnetis*) and Melolonthidae feed on plants (e.g. flowers, roots and fruits) (Morón and Aragón, 2003; Ratcliffe, 2018), a trophic resource that is not found in caves (Culver and Pipan, 2009). This just reinforces the hypothesis that species of these families (Cetoniidae – *Gymnetis* genus and Melolonthidae) found in our study, were only found in caves by accident.

Recently, a new genus of dung beetle, *Isacanthon* Pacheco & Vaz-de-Mello, 2019 (Scarabaeoidea: Scarabaeidae: Scarabaeinae), was described from a Brazilian cave (Pacheco and Vaz-de-Mello, 2019). However, after the species was described, more individuals were found in the epigean environment and distant from caves, suggesting that the occurrence of this species inside a cave was accidental (Vaz-de-Mello personal observation). Indeed, most available records of dung beetles specimens from caves are deemed the result of accidental collection (Slay et al., 2012). In South America, the only dung beetle species that is known exclusively from cave is *Deltochilum bordoni* Halffter & Martínez, 1976 (Halffter and Martínez, 1976). In the present study, we collected a total of 23 dung beetle specimens belonging to seven genera and 19 species. However, the low number of individuals reinforces the hypothesis that they were accidentally collected in the subterranean environment. An exception are the eight individuals of the Aphodiinae species *Ataenius* sp. 2, all of them found in a single natural Amazonian cavity in Pará state. This higher number of individuals sampled in the same cave could be an indication that this species can have a close association with caves. Similarly, the species *Ataenius gracilis* (Melsheimer, 1844) was found in moist bat guano in caves of Cuba and is considered a troglophile species (Peck et al., 1998). Nonetheless, more information is needed to confirm that our *Ataenius* species uses bat guano in Brazilian caves.

Polynoncus gemmingeri and *Omorgus batesi* (Harold, 1872), both belonging to Trogidae, were hand sampled in bat guano, so they may also be truly associated with caves. Indeed, it has been reported that many trogids occur in natural caves, where they exploit bat guano (Scholtz, 1990). Thus, as organisms that live in caves, these species may also be classified as 'troglophiles' (i.e., species that are frequently found in caves and that can complete their life cycle in both external and subterranean environments) (Culver and Pipan, 2009). The scarce knowledge about the biology of the Trogidae has limited the explanations for their development in caves, and hindered studies on the ecology of the species and their distribution patterns in nature (Correa et al., 2013).

Conclusions

This study provides evidence that Scarabaeoidea beetles are not frequent in Brazilian caves, and their occurrences are probably accidental or at least occasional. Caves seem to be an inadequate habitat for the majority of the scarabs, and only species adapted to certain environmental conditions (e.g. darkness, temperature and humidity) may able to use this subterranean habitat as a shelter or as a residence (Culver and Pipan, 2009; Souza-Silva et al., 2021). Although Trogidae and some Aphodiinae species feed on bat guano, more information about their biology is necessary to understand their strategies in using caves to obtain resources or shelter. Finally, we provide the first list of Scarabaeoidea species sampled in Brazilian caves, a subterranean habitat that is still poorly accessed by scarab researchers. This species list will probably increase in the future with new records.

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Conflicts of interest

The authors declare that they have no conflict of interest.

Author contribution statement

All – conceptualization and writing original draft. FZVM and PCG - data curation and validation. RLF - funding acquisition. CMAC, LDA and LMR – investigation. CMAC, LDA, LMR and RLF – methodology.

References

Bouchard, P., Bousquet, Y., Davies, A.E., Alonso-Zaragaza, M.A., Lawrence, J.F., Lyal, C.H.C., Newton, A.F., Reid, C.A.M., Schmitt, M., Ślipiński, S.A., Smith, A.B.T., 2011. Family-group names in Coleoptera (Insecta). ZooKeys 88, 1-972.

Cajaíba, R.L., Cabral, J.A., Santos, M., 2016. A minimal invasive method to forecast the effects of anthropogenic disturbance on tropical cave beetle communities. Neotrop. Entomol. 45, 139–147.

Cherman, M.A., Morón, M.A., 2014. Validación de la família melolonthidae leach, 1819 (Coleoptera: scarabaeoidea). Acta Zool. Mex. 30, 201–220.

Correa, C.M.A., Puker, A., Korasaki, V., Ferreira, K.R., 2013. *Omorgus suberosus* and *Polynoncus bifurcatus* (Coleoptera: Scarabaeoidea: Trogidae) in exotic and native environments of Brazil. Zoologia 30, 238–241.

Culver, D.C., Pipan, T., 2009. Biology of Caves and Other Subterranean Habitats, 1st ed. Oxford, New York.

Ferreira, R.L., Martins, R.P., 1999. Trophic structure and natural history of bat guano invertebrate communities, with special reference to Brazilian caves. Trop. Zool. 12, 231–252.

Gnaspini, P., Trajano, E., 2001. Guano communities in tropical caves. Case study: Brazilian caves. In: Wilkens, H., Culver, D.C., Humphreys, W.F. (Eds.), Ecosystems of the World: Subterranean Ecosystems. Amsterdam: Elsevier Science

Halffter, G., Martínez, A., 1976. *Deltochilum bordoni*, una nueva especie de Scarabaeinae de la Meseta de Sarisariñama, Estado Bolivar, Venezuela (Coleoptera, Scarabaeidae). Bol. Soc. Venez. Espel. 7, 38–45.

Halffter, G., Matthews, E.G., 1966. The natural history of dung beetles of the subfamily Scarabaeinae. Folia Entomol. Mex. 12–14, 1–312.

Lunghi, E., Manenti, R., 2020. Cave communities: from the surface border to the deep darkness. Diversity (Basel) 12, 167.

Lunghi, E., Manenti, R., Ficetola, G.F., 2017. Cave features, seasonality, and subterranean distribution of non-obligate cave dwellers. PeerJ 5, e3169.

Morón, M., Aragón, A., 2003. Importancia ecológica de las especies americanas de Coleoptera Scarabaeoidea. Dugesiana 10, 13–29.

Pacheco, T.L., Vaz-de-Mello, F.Z., 2019. New dung beetle genus and species from a cave in the Espinhaço mountain range, Brazil (Coleoptera: Scarabaeidae: Scarabaeinae). J. Nat. Hist. 53, 1247–1253.

Peck, S.B., Ruiz-Baliú, A.E., Gonzáles, G.F.G., 1998. The cave-inhabiting beetles of Cuba (Insecta: Coleoptera): diversity, distribution and ecology. J. Caves Karst Stud. 60, 156–166.

Pinto-da-Rocha, R., 1995. Sinopse da fauna cavernícola do Brasil (1907-1994). Pap. Avulsos Zool. 39, 61–173.

Ratcliffe, B.C., 2018. A monographic revision of the genus *Gymnetis* MacLeay, 1819 (Coleoptera: Scarabaeidae: Cetoniinae). Bull. Univ. Nebr. State Mus. 31, 1–250.

Reyes-Castillo, P., Halffter, G., 1984. La estructura social de los Passalidae (Coleoptera: lamellicornia). Folia Entomol. Mex. 61, 49–72.

Scholtz, C.H., 1990. Revision of the Trogidae of South America (Coleoptera: scarabaeoidea). J. Nat. Hist. 24, 1391–1456.

Schoolmeesters, P., 2022. Scarabs: World Scarabaeidae Database (version Jan 2022). In: Roskov, Y., Ower, G., Orrell, T., Nicolson, D., Bailly, N., Kirk, P.M., Bourgoin, T., DeWalt, R.E., Decock, W., van Nieukerken, E., Zarucchi, J., Penev, L. (Eds.), Species 2000 & ITIS Catalogue of Life. Naturalis, Leiden. Available in: http://www.catalogueoflife.org/col (accessed 13 June 2022).

Slay, M.E., Skelley, P.E., Taylor, S.J., 2012. New Records of *Onthophagus cavernicollis* Howden and Cartwright (Coleoptera: Scarabaeidae) from Ozark Caves, with a review of scarabaeoids reported from North American Caves. Coleopt. Bull. 66, 187–199.

Souza-Silva, M., Cerqueira, R.F.V., Pellegrini, T.G., Ferreira, R.L., 2021. Habitat selection of caverestricted fauna in a new hotspot of subterranean biodiversity in Neotropics. Biodivers. Conserv. 30, 4223–4250.

Vaz-de-Mello, F.Z., Grossi, P.C., 2022. Scarabaeoidea. In: PNUD. Catálogo taxonômico da fauna do Brasil. Programa das Nações Unidas para o Desenvolvimento, Rio de Janeiro, Brazil. Available in: http://fauna.jbrj.gov.br/fauna/faunadobrasil/192654 (accessed 14 Jan 2022).

Wynne, J.J., Howarth, F.G., Sommer, S., Dickson, B.G., 2019. Fifty years of cave arthropod sampling: techniques and best practices. Int. J. Speleol. 48, 33–48.