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Commentary

Are caves true habitats for anurans or more a favorable rocky environment? A discussion of habitat occupation by frogs in Neotropical caves

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Caves are by definition a subterranean environment ranging from very small spaces such as canaliculi of a few millimeters to large spaces that allow human entry and transit (Tobin et al. 2013). Its characteristics are very peculiar when compared to the surface environment, such as the permanent absence of light (and consequently little or no primary productivity), humidity that tends to saturation, mild temperature, and energy resources of allochthonous origin (Barr 1968).

It is important to note that caves are formed in the most varied types of rock, mainly by the mechanical and chemical factors caused by the action of water on the matrix rock in landscapes known as karst (Ortuño et al. 2013). Water also acts directly in the transport of trophic resources to subterranean environments, coming from its entire water recharge area (Souza-Silva et al. 2012). Furthermore, it can remain stored in these environments for prolonged periods due to underground water dynamics, attracting organisms that take advantage of the more stable and less disturbed environment (Souza-Silva et al. 2012). Thus, caves form a favorable environment for amphibians, for instance, to shelter due to the high relative humidity and low incidence of sunlight (Eterovick et al. 2010; Matavelli et al. 2015; Andrade et al. 2021), factors that prevent skin dryness. Moreover, the subterranean environment provides conditions for other fundamental activities in the life cycle of anurans, such as feeding (due to the wide range of diversity and abundance of invertebrates; Bernarde 2012) and reproduction (due to the frequent presence of water bodies in caves), in addition to reducing the exposure of these species to predators (Faraone and Lo Valvo 2018).

However, studies on reptiles and amphibians linked to speleology in South America are still scarce, so much so that the works focused on this type of habitat occupation recorded about 6% of the 1144 Brazilian frog species (Segalla et al. 2021) inside caves (Matavelli et al. 2015; Bichuette et al. 2022; dos Santos et al. 2022). The reason for this scarcity of studies is also linked to the fact that frogs are considered accidental animals in the subterranean environment, that is, they eventually enter the cave and do not stay there, leaving in a short period; or failing to get out, dying inside the cave (Trajano and Bichuette 2006).

But are frogs merely accidental inside caves? Through the evidence obtained during our research, we observed that they are not, and for this reason, we consider that several species can be classified as trogloxenes. Following the Schiner-Racovitza classification and adapted by Sket (2008), trogloxenes are animals that can inhabit the cave environment for reproduction, food, or shelter. In the latter case, it resembles the group of anurans with cryptozoic habits (hidden in galleries or small cavities in the ground or ravines) and rheophilic (on rocks located next to or besides small streams or rapids). Preliminary studies already show signs that anurans become inhabitants that are more suited to being classed as trogloxenes rather than accidents, and are already treated in this way in other parts of the world (Luría-Manzano and Ramírez-Bautista 2017; Suwannapoom et al. 2018; dos Santos et al. 2022).

Allied to this thought, our records and those of partners in the area of research in biospeleology show us several species of frogs found in caves of four different types of lithologies, distributed from the north to the south of Brazil, in the Amazon, Atlantic Forest, Caatinga, Cerrado, and nearby Pantanal (Figs 1–4). Given this, we are faced with several important questions to be investigated by biospeleology in the future, such as: are frogs able to complete their entire life cycle inside caves? Can they maintain a diet without a nutritional deficit in this environment? Are they preyed upon, and if so, by whom? How does the use of cave habitat differ from the rocky environment? To answer these and other questions, studies in controlled laboratory environments can bring new evidence to fill the knowledge gap (due to the impossibility of systematically following the life cycle of an anuran in this difficult-to-access environment), as well as an increase in long-term population studies with frogs in caves would help to improve the ecological understanding of the taxon (Andrade et al. 2021).

Finally, thinking about conservation, there is a huge problem when all anurans are considered accidental fauna, precisely because of the lack of support for these species in the environmental legislation for subterranean environments in force in Brazil (Brasil 2008, 2017). Currently, there is no legal obligation to collect and register anurans in caves, and the companies responsible for the projects are optional to register these species in studies of relevance, impacts, and environmental monitoring. Thus, anurans are going against the grain of other groups, such as Chiroptera and invertebrates, which served as the basis for studies that leveraged research in subterranean biology from Decree 6640 (Brasil 2008). For these groups, there has since been a significant increase in descriptions of cave invertebrates, research of paramount importance for bats, in addition to the description of hotspots of subterranean fauna in various regions of Brazil (Souza-Silva and Ferreira 2016; Trajano et al. 2016). Despite these advances in research on different groups, the herpetofauna remains completely neglected.

The cave environment is one of the most threatened habitats in the face of mineral exploration and urban development, even though it is classified as a Brazilian cultural, biological and geological heritage (Ferreira et al. 2022). More

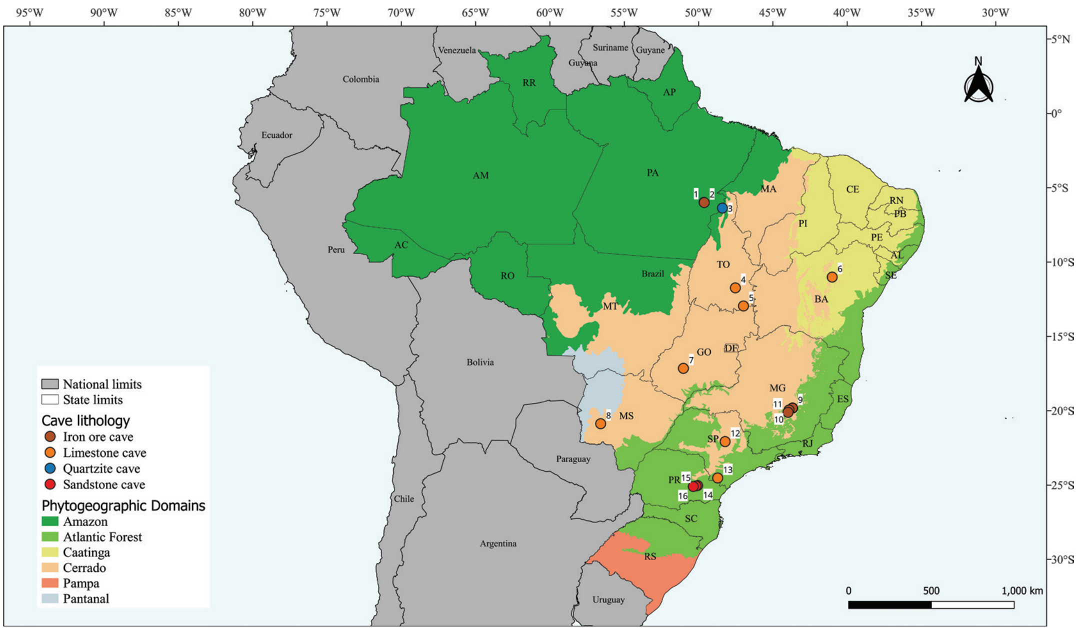

Figure 1. Map of the geographical location of anurans records found in caves of four different types of lithologies (iron ore, limestone, quartzite, and sandstone) distributed from north to south of Brazil, in the Amazon, Atlantic Forest, Caatinga, Cerrado, and nearby Pantanal. The boundaries of Brazilian phytogeographic domains were adapted from shapefiles available from the Instituto Brasileiro de Geografia e Estatística (2022) and the global ecoregions of Dinerstein et al. (2017). Points: 1–2 = Parauapebas, PA. 3 = Caverna do Remanso dos Botos, PA. 4 = Natividade, TO. 5 = Arraias, TO. 6 = Ourolândia, BA. 7 = Caverna da Ponte de Pedra, GO. 8 = Caverna das Pitangueiras, MS. 9 = Serra da Piedade, MG. 10 = Belo Horizonte, MG. 11 = Serra do Rola Moça State Park, MG. 12 = Ribeirão Bonito, SP. 13 = Caverna do Cafezal, SP. 14–16 = Caverna do Zé, PR. Map design: Cássio Cardoso Pereira.

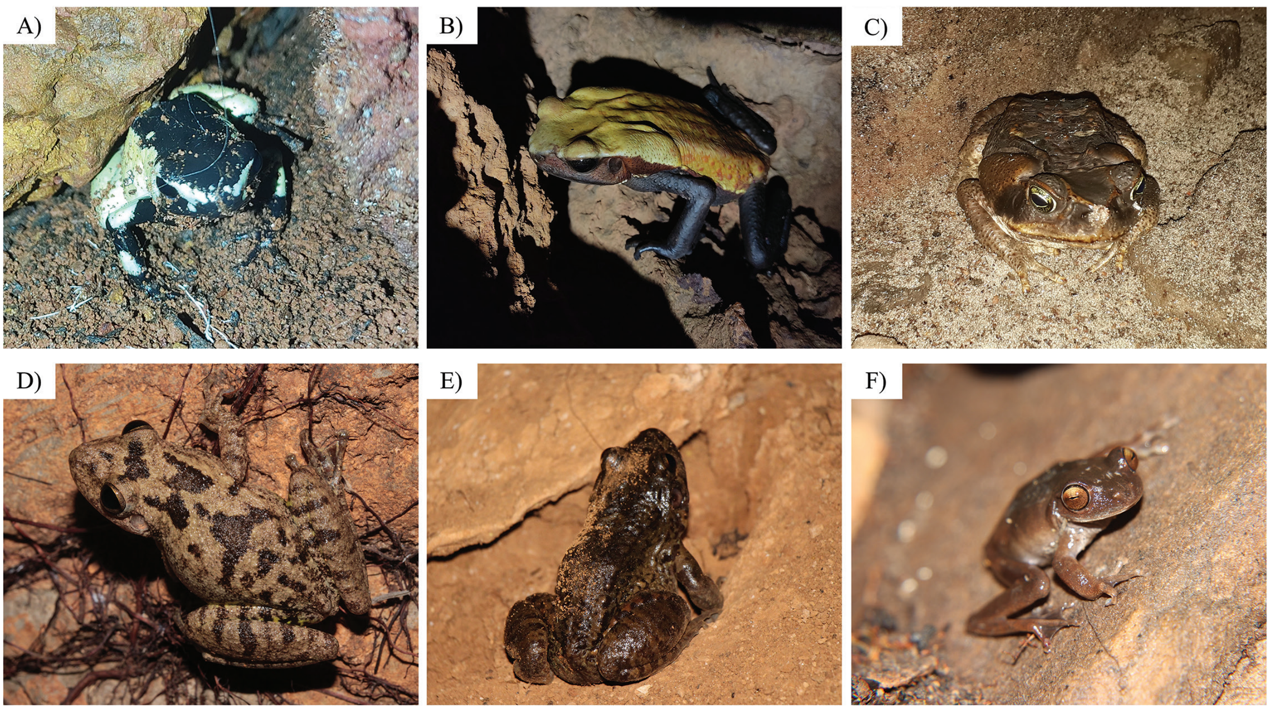

Figure 2. Anuran species found in Brazilian caves. The specimens correspond to records numbered 1 to 6 shown in Fig. 1, respectively. (**A, B**) *Adelphobates galactonotus* (Steindachner, 1864), and *Rhaebo guttatus* (Schneider, 1799). Photo credits: Marcel Araújo. (**C–F**) *Rhinella diptycha* (Cope, 1862), *Scinax x-signatus* (Spix, 1824), *Leptodactylus labyrinthicus* (Spix, 1824), and *Bokermannohyla* sp. Photo credits: Vinícius Sperandei.

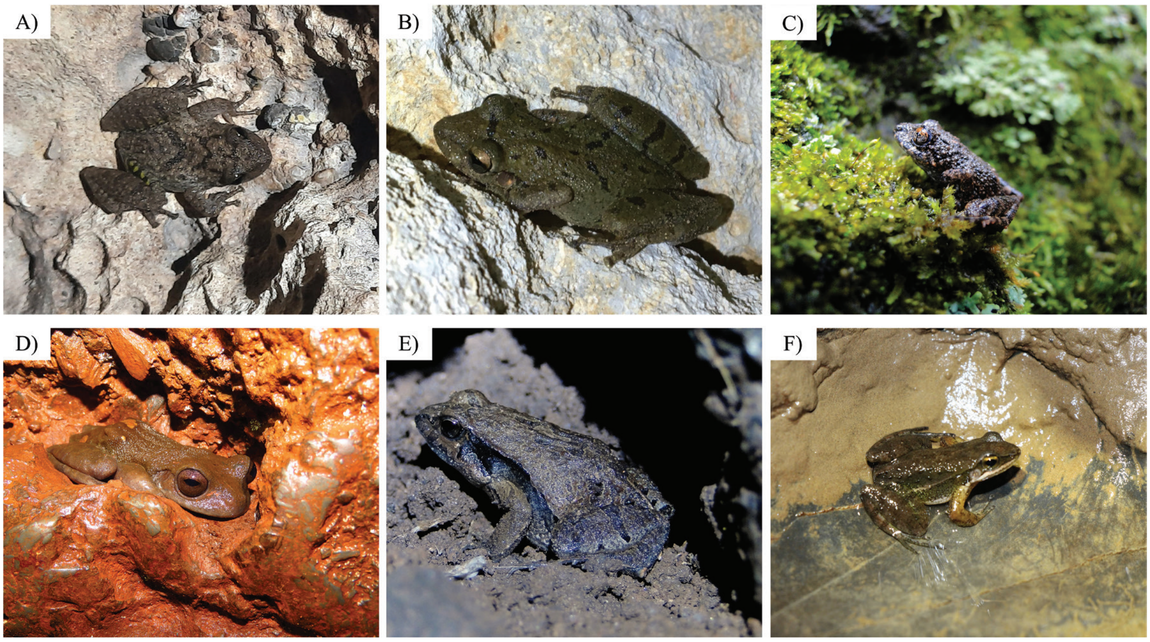

Figure 3. Anuran species found in Brazilian caves. The specimens correspond to records numbered 7 to 12 shown in Fig. 1, respectively. (**A, B**) *Scinax fuscovarius* (Lutz, 1925). Photo credits: Vinícius Sperandei. (**C, D**) *Ischnocnema verrucosa* (Reinhardt & Lütken, 1862), and *Physalaemus cuvieri* Fitzinger, 1826. Photo credits: Opilião grupo de estudos espeleológicos (OGrEE). (**E**) *Bokermannohyla martinsi* (Bokermann, 1964). Photo credit: Gabriele Pacheco. (**F**) *Crossodactylus caramaschii* Bastos & Pombal, 1995. Photo credit: Vinícius Sperandei.

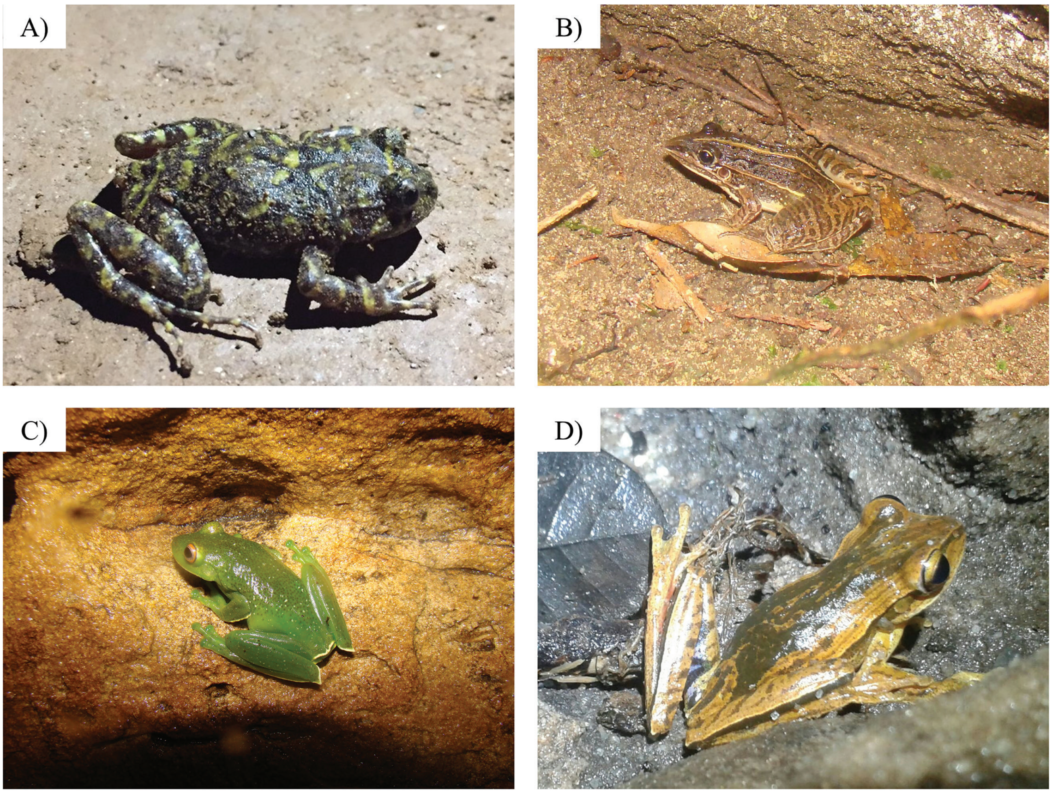

Figure 4. Anuran species found in Brazilian caves. The specimens correspond to records numbered 13 to 16 shown in Fig. 1, respectively. (**A**) *Cycloramphus eleutherodactylus* (Miranda-Ribeiro, 1920). Photo credit: Vinícius Sperandei. (**B, C**) *Leptodactylus labyrinthicus* (Spix, 1824), and *Aplastodiscus albosignatus* (Lutz & Lutz, 1938). Photo credits: Henrique Simão Pontes. (**D**) *Boana bischoffi* (Boulenger, 1887). Photo credit: Kawany Lohmann Schwebel.

and more on the margins of the impacts of human activities, today Brazilian caves are under high pressure for licensing, including those classified as of maximum relevance, hitherto prevented from being impacted. The diversification of ecological and conservation studies expanded to other groups, such as herpetofauna, can bring new insights into subterranean environments and increasingly consolidate the paths for the recognition of their ecological importance.

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Additional information

Conflict of interest

No conflict of interest was declared.

Ethical statement

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Author contributions

Vinícius Sperandei and Cássio Pereira conceived the ideas; Cássio Pereira made the figures. All authors contributed equally to the writing of the commentary.

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

References

Andrade MCM, Costa JCR, Eterovick PC (2021) Fidelity in the use of iron caves by *Bokermannohyla martinsi* (Anura: Hylidae): a step further in unveiling the importance of Brazilian caves for the herpetofauna. Salamandra (Frankfurt) 57(4): 502–512.

Barr TC (1968) Ecological studies in the Mammoth Cave ecosystems of Kentucky. International Journal of Speleology 3(1/2): 147–204. https://doi.org/10.5038/1827-806X.3.1.10

Bernarde PS (2012) Anfíbios e répteis: introdução ao estudo da herpetofauna brasileira. Anolis books, São Paulo, 320 pp.

Bichuette ME, Sperandei VDF, Bertolini DLV, Simão PX, Sabbag AF (2022) Frogs of seven granitic caves on Santa Catarina Island, Florianópolis Municipality, Santa Catarina State, southern Brazil. Herpetology Notes 15: 353–359.

Brasil (2008) Decreto lei No. 6640 of November 7, 2008. https://www.planalto.gov.br/ccivil_03/_ato2007-2010/2008/decreto/d6640.htm

Brasil (2017) Ministério do Meio Ambiente. Instrução Normativa N°2 of August 30, 2017. http://www.ibama.gov.br/sophia/cnia/legislacao/MMA/IN0002-300817.pdf

Dinerstein E, Olson D, Joshi A, Vynne C, Burgess ND, Wikramanayake E, Hahn N, Palminteri S, Hedao P, Noss R, Hansen M, Locke H, Ellis EC, Jones B, Barber CV, Hayes R, Kormos C, Martin V, Crist E, Sechrest W, Price L, Baillie JEM, Weeden D, Suckling K, Davis C, Sizer N, Moore R, Thau D, Birch T, Potapov P, Turubanova S, Tyukavina A, Souza N, Pintea L, Brito JC, Llewellyn OA, Miller AG, Patzelt A, Ghazanfar SA, Timberlake J, Klöser H, Shennan-Farpón Y, Kindt R, Lillesø JPB, van Breugel P, Graudal L, Voge M, Al-Shammari KF, Saleem M (2017) An ecoregion-based approach to protecting half the terrestrial realm. Bioscience 67(6): 534–545. https://doi.org/10.1093/biosci/bix014

dos Santos T, de Souza AM, Bondezan FL, Eterovick PC (2022) Going underground: What the natural history traits of cave users can tell us about cave use propensity. Journal of Herpetology 56(2): 153–163. https://doi.org/10.1670/20-055

Eterovick PC, Rievers CR, Kopp K, Wachlevski M, Franco BP, Dias CJ, Barata IM, Ferreira ADM, Afonso LG (2010) Lack of phylogenetic signal in the variation in anuran microhabitat use in southeastern Brazil. Evolutionary Ecology 24(1): 1–24. https://doi.org/10.1007/s10682-008-9286-9

Faraone FP, Lo Valvo M (2018) First data on cave breeding in *Discoglossus pictus* Otth, 1837 (Anura, Alytidae). Alytes 35(1–4): 43–47.

Ferreira RL, Bernard E, da Cruz Júnior FW, Piló LB, Calux A, Souza-Silva M, Barlow J, Pompeu PS, Cardoso P, Mammola S, García AM, Jeffery WR, Shear W, Medellín RA, Wynne JJ, Borges PAV, Kimimura Y, Pipan T, Hanja NZ, Sendra A, Peck S, Onac BP, Culver DC, Hoch H, Flot JF, Stoch F, Pavlek M, Niemiller ML, Manchi S (2022) Brazilian cave heritage under siege. Science 375(6586): 1238–1239. https://doi.org/10.1126/science.abo1973

Instituto Brasileiro de Geografia e Estatística (2022) Biomas. https://www.ibge.gov.br

Luría-Manzano R, Ramírez-Bautista A (2017) Diet comparison between rainforest and cave populations of *Craugastor alfredi* (Anura: Craugastoridae): does diet vary in contrasting habitats? Journal of Natural History 51(39): 2345–2354. https://doi.org/10.1080/00222933.2017.1366573

Matavelli R, Campos AM, Feio RN, Ferreira RL (2015) Occurrence of anurans in Brazilian caves. Acta Carsologica 44(1): 107–120. https://doi.org/10.3986/ac.v44i1.649

Ortuño VM, Gilgado JD, Jiménez-Valverde A, Sendra A, Pérez-Suárez G, Herrero-Borgoñón JJ (2013) The "Alluvial Mesovoid Shallow Substratum", a New Subterranean Habitat. PLoS ONE 8: e76311. https://doi.org/10.1371/journal.pone.0076311

Segalla MV, Berneck B, Canedo C, Caramaschi U, Cruz CAG, Garcia PCA, Grant T, Haddad CFB, Lourenço ACC, Mângia S, Mott T, Nascimento LB, Toledo LF, Werneck FP, Langone JA (2021) Brazilian amphibians: list of species, 1–96. https://storage.build-erall.com/franquias/2/6437879/editor-html/9025935.pdf

Sket B (2008) Can we agree on an ecological classification of subterranean animals? Journal of Natural History 42(21): 1549–1563. https://doi.org/10.1080/00222930801995762

Souza-Silva M, Ferreira RL (2016) The first two hotspots of subterranean biodiversity in South America. Subterranean Biology 19(1): 1–21. https://doi.org/10.3897/subtbiol.19.8207

Souza-Silva M, Bernardi LFO, Martins RP, Ferreira RL (2012) Transport and consumption of organic detritus in a Neotropical limestone cave. Acta Carsologica 41(1): 139–150. https://doi.org/10.3986/ac.v41i1.54

Suwannapoom C, Sumontha M, Tunprasert J, Ruangsuwan T, Pawangkhanant P, Korost DV, Poyarkov NA (2018) A striking new genus and species of cave-dwelling frog (Amphibia: Anura: Microhylidae: Asterophryinae) from Thailand. PeerJ 6: e4422. https://doi.org/10.7717/peerj.4422

Tobin BW, Hutchins BT, Schwartz BF (2013) Spatial and temporal changes in invertebrate assemblage structure from the entrance to deep-cave zone of a temperate marble cave. International Journal of Speleology 42(3): 203–214. https://doi.org/10.5038/1827-806X.42.3.4

Trajano E, Bichuette M (2006) Biologia subterrânea: introdução. Redespeleo Brasil, São Paulo, 92 pp.

Trajano E, Gallão JE, Bichuette ME (2016) Spots of high diversity of troglobites in Brazil: The challenge of measuring subterranean diversity. Biodiversity and Conservation 25(10): 1805–1828. https://doi.org/10.1007/s10531-016-1151-5