Subterranean Biology 29: 1–33 (2019)
doi: 10.3897/subtbiol.29.30418
http://subtbiol.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
Subterranean Biology
Published by The International Society for Subterranean Biology

Richness and taxonomic distinctness of cave invertebrates from the northeastern state of Goiás, central Brazil: a vulnerable and singular area

Maria Elina Bichuette[1], Luiza Bertelli Simões[2], Tamires Zepon[1], Diego Monteiro von Schimonsky[1], Jonas Eduardo Gallão[1]

1 *Laboratório de Estudos Subterrâneos, Departamento de Ecologia e Biologia Evolutiva, Universidade Federal de São Carlos, Via Washington Luís, km 235, 13565-905, Caixa Postal 676, São Carlos, SP, Brazil* **2** *Universidade Estadual Paulista, Rio Claro, Brazil*

Corresponding author: *Maria Elina Bichuette* (lina.cave@gmail.com)

Academic editor: *Oana Moldovan* | Received 9 October 2018 | Accepted 17 December 2018 | Published 3 January 2019

http://zoobank.org/68B9D5FD-48F8-4374-8203-57A34FF91FFB

Citation: Bichuette ME, Simões LB, Zepon T, von Schimonsky DM, Gallão JE (2019) Richness and taxonomic distinctness of cave invertebrates from the northeastern state of Goiás, central Brazil: a vulnerable and singular area. Subterranean Biology 29: 1–33. https://doi.org/10.3897/subtbiol.29.30418

Abstract

The karst area of the northeastern state of Goiás comprises two main municipalities: São Domingos and Posse. São Domingos is inside the limits of a Full Protection Conservation Unit known as Parque Estadual de Terra Ronca (PETeR), where a high number of caves occurs, some of them surpassing 10 km in length. Despite their protection by law, uncontrolled tourism has been threatening the integrity of the unique and fragile cave systems of São Domingos. On the other hand, the caves of Posse are much less visited, with its subterranean fauna poorly unknown and are strongly threatened by the urban areas and mining activities in the vicinity. We conducted six systematic surveys of invertebrates in 12 caves, seven of which are located in São Domingos and five in Posse, between 2010 and 2012. Immediately outside the caves, we sampled several microhabitats for comparison. We estimated richness, abundance, and taxonomic distinctness of the communities. We recorded 1,941 individuals of 344 morphospecies. Caves from São Domingos showed a higher species richness and were more taxonomic distinct than caves from Posse. Most morphospecies were considered troglophiles (188). We also found one trogloxene and one troglobite, as well as nine troglomorphic taxa that possibly are troglobitic as well. Both regions have markedly singular caves regarding its subterranean fauna, with high values of taxonomic distinctness. However, the richer caves were not necessarily the most taxonomic distinct. Conservation measures are especially necessary in the region of Posse, where caves are not legally protected and are within an area of significant urbanization. Cave entrances of Posse are near deforested vicinities, in some cases with domestic wastes and cement plants nearby.

Keywords
caves, conservation, phylogenetic diversity, subterranean fauna, São Domingos, Posse, Goiás

Introduction

The subterranean fauna consists of organisms able to survive in peculiar conditions of the environment, as the permanent darkness, the high relative humidity of the air and stable temperatures at the deepest zones (Barr 1968). These inherent features may act as an environmental filter (see Fernandes et al. 2016 to opposite view) in such a way that only part of the epigean taxa is capable to colonize and establish hypogean populations. So, the organisms found inside caves can be sorted in three ecological-evolutionary categories, considering its degree of specialization and dependence of surface environments: trogloxenes, troglophiles and troglobites.

Because of its unique conditions and the high degree of endemism, subterranean environments are fragile and sensitive to environmental changes, especially those regarding anthropic activities (Culver 1986, Gibert and Deharveng 2002, Trajano and Bichuette 2006). Among the main human interference in Brazilian caves, we may stress mining, construction of hydroelectric dams, deforestation for agriculture and uncontrolled tourism (Ferreira et al. 2014, Gallão and Bichuette 2018).

Brazil has about 17,000 registered caves (CECAV 2018). Some heterogeneity exists in the knowledge about the subterranean fauna regarding different Brazilian karst and non-karst areas. Some are well known, as the Vale do Ribeira (southeastern) (e.g., Trajano 1991, Bichuette and Trajano 2003, Rodrigues et al. 2014) and Chapada Diamantina (eastern-northeastern) (Gregorin and Mendes 1999, Bockmann and Castro 2010, Gallão and Bichuette 2015). Others, however, have its knowledge limited to preliminary data about species richness and abundance, which was obtained on a few sampling occasions (e.g. Altamira, northern) (Trajano and Moreira 2001). Besides this, only a few approaches covered long-term samplings, with replicas enough to contemplate more than one annual cycle (e.g. Trajano 1991, Gallão and Bichuette 2015, Resende and Bichuette 2016, Zepon and Bichuette 2017). Most often in tropical caves, the seasonal oscillation is of great importance in the dynamics of the subterranean environments (Trajano 2000).

Some studies have shown that phylogenetic diversity, a measure of species relatedness considering the phylogenetic relationship among species, are more sensitive to detecting responses of communities to environmental changes (Cianciaruso et al. 2009). This is because traditional diversity indexes have limited prediction about ecosystems functioning. According to Faith (1992), the emphasis on conservation regards preserving as much of this hierarchical variation as possible, no matter what the taxonomic identity involved. In this sense, a phylogenetic diversity index has been shown more efficient to proposals of conservation strategies than traditional indexes (Cianciaruso et al. 2009) and was used also for conservation purposes comparing taxonomic distinctness with α indexes (Gallão and Bichuette 2015).

In the present study, we sampled subterranean invertebrates at the karst area of the northeastern Goiás state, central Brazil, encompassing the municipalities of São Domingos and Posse. We estimated species richness and abundance by each cave and by each region, as well as by the karst area. Finally, we compared the fauna of these caves regarding geographical position and taxonomic distinctness of the communities. We expected that phylogenetic component of diversity would indicate those most singular caves in the region better than traditional indexes of diversity. Our purpose was to improve the knowledge about components of biological diversity in the region and, through a better knowledge of the ecological-evolutionary processes underlying these communities, provide best arguments for better conservation decisions.

Methods

Study Area

The karst area at northeastern Goiás represents one of the regional expressions of Bambuí geomorphological Unit, the largest set of limestone in Brazil, comprising approximately 105,200 km^2 (Auler et al. 2001). Surficial rivers belonging to the Paranã basin (Alto Tocantins) permeate the limestone after draining an extensive sandstone area, forming large cave systems (Karmann and Setúbal 1984, Auler and Farrant 1996).

Part of São Domingos region is inside the limits of a Conservation Unit, the Parque Estadual de Terra Ronca (PETeR, Figure 1), which was created in 1989, but still with many land ownership conflicts and inspection problems, resulting in timber harvesting and trampling by cattle near the headwaters. Additionally, it is aggravating the fact that the headwaters of the main rivers that flow through the cave systems are outside the limits of the Conservation Unit (Gallão and Bichuette 2012). São Domingos possess complex systems of surficial and subterranean drainage, with high potential of organic matter carriage and accumulation of debris in some caves. Based upon this, these caves present high richness of subterranean fauna, whether terrestrial or aquatic (Pinto-da-Rocha 1995, Rheims and Pelegatti-Franco 2003, Majer et al. 2003, Simões et al. 2013). Seven troglobitic species of fishes have been recorded so far, configuring a high diversity for this group (Bichuette 2003, Bichuette and Trajano 2003).

Posse, which represents the southernmost part of the same limestone outcrop, is 200 km from PETeR (Figure 1). In there, the systems and subterranean drainage are not as well developed as they are in São Domingos. Not all caves from Posse in this study are mapped yet, or their maps are still being produced; the Russão cave, which is currently being mapped, have an estimated development of, at least, 4 km (E.C. Igual pers. comm.).

Both regions are inside the limits of Cerrado Domain (Ab'Saber 1977), with a dry season between March and September, which may extend until October (Nimer 1979). Rainfall pattern is marked by floods in the rainiest periods (October to March), which bring large amounts of organic matter inside the caves.

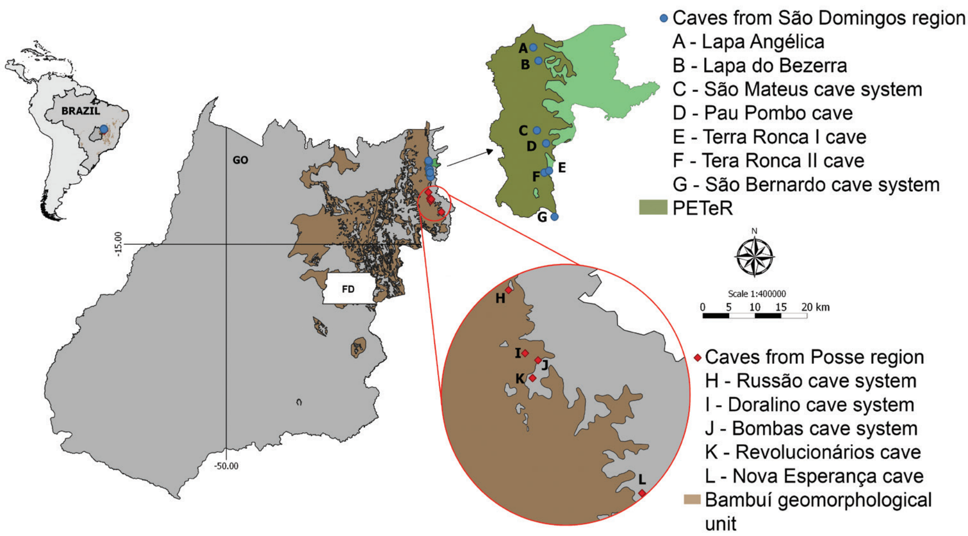

Figure 1. Map showing sampled caves from the São Domingos karst area (blue circles) within Terra Ronca State Park (PETeR, green area) and from the Posse karst area (red diamonds). FD, Federal District.

Sampling

In São Domingos, we sampled the following caves / cave systems: Lapa Angélica cave, Lapa do Bezerra cave, Pau Pombo cave, São Bernardo cave system, São Mateus cave system, Terra Ronca I cave and Terra Ronca II cave. In Posse, we sampled Doralino cave system, Nova Esperança cave, Bombas cave system, Russão cave system, and Revolucionários cave (Figure 1).

We visited the study area on six occasions, three during the raining season (April 2010, April 2011 and February 2012) and three during the dry season (October 2011, June and October 2012). Caves varied with respect to the number of visits: two visits, one during the dry season and other during the raining season in Lapa do Bezerra, São Bernardo and Terra Ronca I, two during the raining season in São Mateus, two during the dry season in Terra Ronca II, one during the dry season in Pau Pombo and Revolucionários, and one during the raining season in Bombas, Doralino, Nova Esperança and Russão. Lapa Angélica was the only cave monitored on all occasions.

We sampled terrestrial substrates and streams mainly by active search in all potential microhabitats, including piles of leaf litter, trunks, guano deposits, under rocks, among others, where specimens were collected with tweezers and brushes and immediately euthanized and preserved in 70% alcohol. In two caves, Lapa Angélica and Terra Ronca II, we also used 0.25 m^2 quadrats (Bichuette et al. 2015). For comparative purposes, i.e., to define ecological-evolutionary categories of taxa, we also sampled in surface habitats near the caves (ca 50 to 100 m from entrance). The collections were performed during night and daytime by active search in leaf litter piles, tree trunks, and fallen trunks, and by transects (10 m of length). We also removed soil by excavation method for more accurate evaluation at the laboratory, and we used Winkler extractor to collect fauna associated with leaf litter.

We identified collected specimens to the least inclusive taxonomic level possible (Operational Taxonomic Units / OTUs) using specific literature as a guide (Borror and DeLong 1969, Adis 2002, Brescovit et al. 2002, Zeppelini and Bellini 2004, Rafael et al. 2012). Part of the material was sent to taxonomic specialists for confirmation and more accurate identification. In cases when identification to the species level could not be obtained, we used higher-level hierarchies and classified specimens into morphotypes and, thus, they are reliable taxonomic categories. Immature individuals that could not be clearly attributed to adults already collected were excluded from all analyses.

Data analysis

All taxa we found were listed for each cave and study area (Appendix 1). Additionally, we defined ecological-evolutionary categories of the better-known taxa following the proposal of Trajano (2012) comparing with the epigean fauna, personal knowledge, and literature data. We also generated histograms of species richness and abundance towards a better understanding of the faunistic composition by region as well as by the Goiás karst area.

We determined the taxonomic distinctness of each cave using the index of phylogenetic diversity known as taxonomic distinctness (TD, Δ^*) (Warwick and Clarke 1995), using the package Vegan (Oksanen et al. 2018) in the software R (version 3.4.0) (R Core Team 2017). This index compares the phylogenetic relationship in a community considering each locality (in our case, the caves). Thus, caves with closely phylogenetic species show lower TD in relation to caves with species phylogenetic distinct. Higher TD values show singularity of an environment. Index of TD is calculated as the number of estimated nodes to connect two different species in a community, while the randomization estimates the confidence interval. This index is applicable to our data because it does not depend on the number of samples or abundance. Then, we did a simple linear regression in the software R (version 3.4.0) (R Core Team 2017) correlating richness and TD values for each area, in order to verify if these data are related.

Results

We collected a total of 1,941 individuals of 344 morphospecies belonging to 128 families, 37 orders and ten classes (Appendix 1) in both regions: 287 morphospecies and 1,554 individuals were from São Domingos and 122 morphospecies and 387 individuals were from Posse. Whether we consider São Domingos and Posse singly or combined as a larger karst area, insects and arachnids were the richest and more abundant taxa (Figure 2–4).

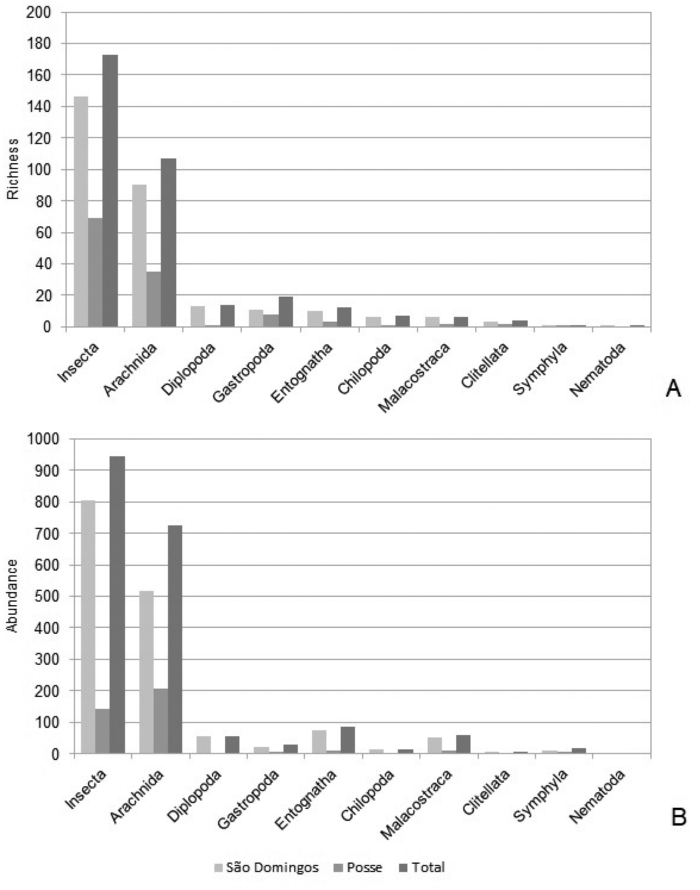

Figure 2. A Richness and **B** abundance of subterranean terrestrial invertebrate (by Class) from the São Domingos and Posse karst areas, state of Goiás, and from both regions combined.

Of the 344 morphospecies, we classified one as a trogloxene (TX) (Araneae: Ctenidae: *Enoploctenus* sp.), 188 as troglophiles (TF), one as a troglobite (TB) (Pseudoscorpiones: Chernetidae: *Spelaeochernes* sp.), nine as troglomorphic and, being such, possibly troglobitic (TM/TB?) and 48 as accidentals (AC). Due to lack of data, we considered the classification of 97 morphospecies as uncertain concerning their ecological-evolutionary relationship with caves.

In São Domingos, Lapa Angélica was the richest and most abundant cave, with 203 morphospecies and 865 individuals, followed by Terra Ronca II cave with 88 morphospecies and 274 individuals. Pau Pombo cave was the least rich and abundant with 11 morphospecies and 22 individuals (Table 1). In Posse, Revolucionários cave was the richest and the most abundant, with 43 morphospecies and 112 individuals, followed by Doralino cave system with 40 morphospecies and 95 individuals. The least rich and abundant was Nova Esperança cave with 17 morphospecies and 42 individuals.

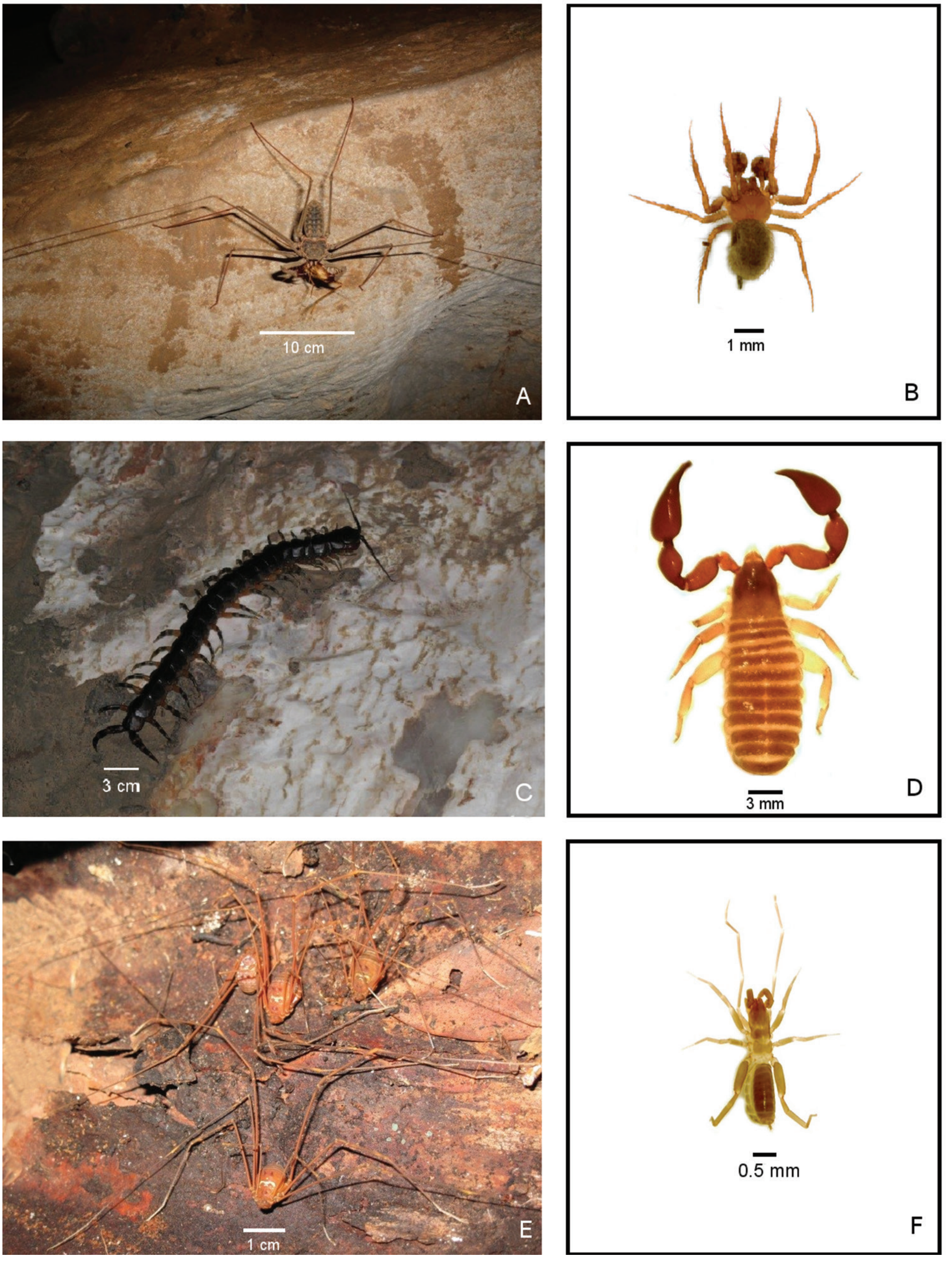

Figure 3. Fauna from caves of northeastern Goiás, central Brazil: **A** *Heterophrynus longicornis* (Amblypygi) preying a cricket *Endecous* sp. (Orthoptera: Phalangopsidae) **B** *Nesticodes rufipes* (Araneae: Theridiidae) **C** *Scolopendra viridicornis* (Chilopoda: Scolopendromorpha) **D** Chernetidae (Pseudoscorpiones) **E** *Flirtea batman* (Opiliones: Cosmetidae) **F** *Stenochrus portoricensis* (Schizomida: Hubbardiidae).

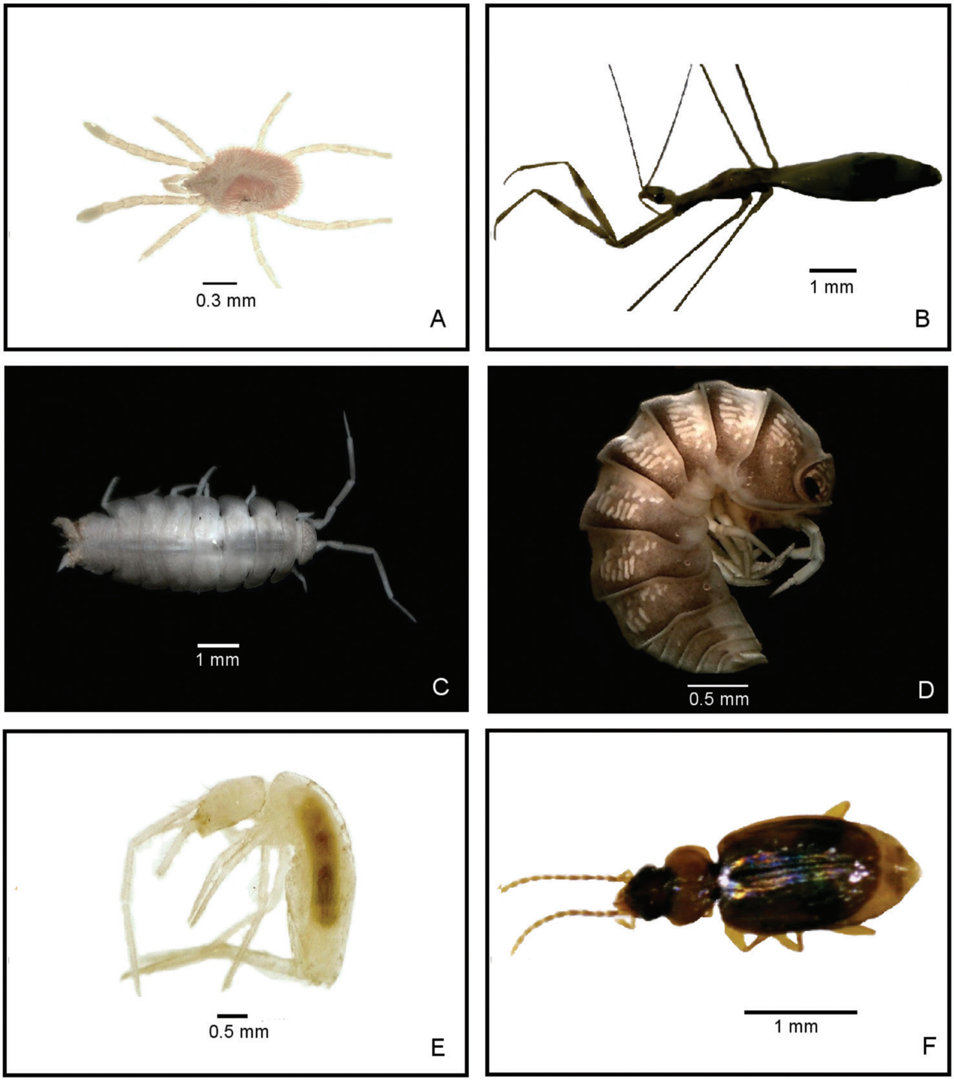

Figure 4. Fauna from caves of northeastern Goiás, central Brazil: **A** Mesostigmata (Acari) **B** Emesinae (Hemiptera: Reduviidae) **C** *Venezillo congener* (Isopoda: Armadillidae) **D** Dubioniscidae (Isopoda) **E** *Trogolaphysa* (Collembola: Paronellidae) **F** *Paratachys* sp. (Coleoptera: Carabidae).

For São Domingos, the expected TD (Δ+) value was 72.517, and the cave with the highest TD was São Bernardo (Δ+= 73.566), followed by Terra Ronca I (Δ+=72.110), Lapa Angélica (Δ+= 71.966), Lapa do Bezerra (Δ+= 71.760), São Mateus (Δ+=71.541), Terra Ronca II (Δ+= 69.669) and Pau Pombo (Δ+= 69.237) (Figure 5A, Table 1). Values of TD close to expected as shown herein revealed that caves from São Domingos share many taxa (morphospecies). One exception is São Bernardo, which shows higher TD in relation to other caves, above the expected value, which means that São Bernardo is the

Table 1. Species richness, individual abundance, and taxonomic distinctness (TD) of caves from north-eastern Goiás karst area (São Domingos and Posse). Legend: SBer= São Bernardo cave system, Ang= Lapa Angélica, Bez= Lapa do Bezerra, SMat= São Mateus cave system, TR_I= Terra Ronca I cave, TR_II= Terra Ronca II cave, PPom= Pau Pombo cave, Rus= Russão cave system, Bom= Bombas cave system, Dor= Doralino cave system, NEsp= Nova Esperança cave, Rev= Revolucionários cave.

	Caves	Species Richness	Individual Abundance	TD
São Domingo	SBer	28	72	73.566
	Ang	203	865	71.966
	Bez	52	179	71.760
	SMat	37	66	71.541
	TR I	42	76	72.110
	TR II	88	274	69.669
	Ppom	11	22	69.237
Posse	Rus	40	90	67.847
	Bom	24	48	73.006
	Dor	40	95	67.955
	NEsp	17	42	64.680
	Revo	43	112	78.649

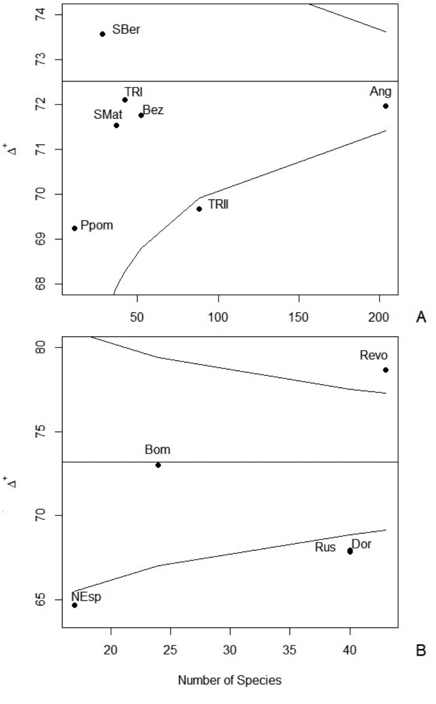

Figure 5. Taxonomic distinctness (TD) for caves from **A** São Domingos and **B** Posse karst areas. Horinzontal line presents the expected TD for the region and funnel graph means 95% confidence limits. Legend: SBer= São Bernardo cave system, Ang= Lapa Angélica, Bez= Lapa do Bezerra, SMat= São Mateus cave system, TR_I= Terra Ronca I cave, TR_II= Terra Ronca II cave, PPom= Pau Pombo cave, Rus= Russão cave system, Bom= Bombas cave system, Dor= Doralino cave system, NEsp= Nova Esperança cave, Rev= Revolucionários cave.

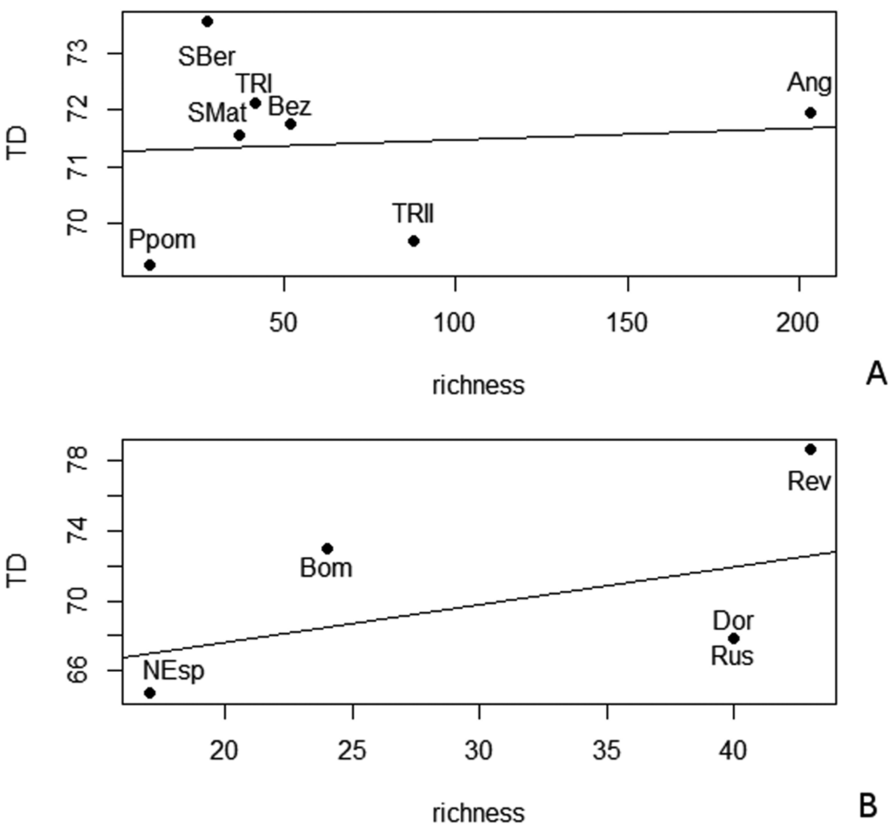

Figure 6. Simple linear regression between richness and Taxonomic distinctness (TD) values of caves from **A** São Domingos and **B** Posse karst areas. Legend: SBer= São Bernardo cave system, Ang= Lapa Angélica, Bez= Lapa do Bezerra, SMat= São Mateus cave system, TR_I= Terra Ronca I cave, TR_II= Terra Ronca II cave, PPom= Pau Pombo cave, Rus= Russão cave system, Bom= Bombas cave system, Dor= Doralino cave system, NEsp= Nova Esperança cave, Rev= Revolucionários cave.

most singular cave in São Domingos. In this cave some morphospecies were unique: one isopod (Dubioniscidae sp. 1), one spider (*Mysmena* sp. 1), one millipede (Pseudonannolenidae sp. 1), one dipteran (Mycetophilidae sp. 1), one Nematoda (sp.1) (Appendix 1).

For Posse, the expected TD (Δ+) value was 73.206, and the cave with the highest TD was Revolucionários (Δ+=78.649), followed by Bombas system (Δ+= 73.006), Russão (Δ+= 67.847), Doralino system (Δ+= 67.955) and Nova Esperança (Δ+= 64.680) (Figure 5B, Table 1). Contrasting to observed to São Domingos, most TD values for Posse caves were far from expected, with some caves showing TDs much lower than expected (Russão, Doralino and Nova Esperança caves), sharing many taxa (morphospecies). Bombas cave presented a TD value near the expected, showing a singularity in relation to the others and Revolucionários cave showed the highest TD value, being the most singular cave in the region (unique taxa/morphospecies). In this cave some morphospecies were unique: one centipede (*Newportia* (*Tidops*) *balzanii*), one pseudoscorpiones (Chthoniidae sp. 1), two isopods (Platyarthridae sp. 1 and Dubioniscidae sp. 2), one orthopteran (*Endecous* sp. 1), one opilionid (Pachylinae sp. 2), one scorpion (*Tityus* sp.), one collembolan (*Trogolaphysa* sp. 3), one coleopteran (*Tachys* sp. 1) and eight gastropods (Appendix 1).

According to simple linear regression, the richness and TD values are not correlated in both areas: São Domingos ($r = 0.001972$, $r^2 = 0.007384$, $F = 0.03719$, $p = 0.8547$) and Posse ($r = 0.2147$, $r^2 = 0.2044$, $F = 0.7708$, $p = 0.4446$), *i.e.*, the richest caves not necessarily present the higher TD value, as observed in the São Domingos area (Figure 6A, B).

Discussion

Our data show high species richness for both the São Domingos and Posse karst areas, which has been also observed for other Brazilian karst areas, such as Chapada Diamantina with c.a. 160 morphospecies (Gallão and Bichuette 2015) and Presidente Olegário with 382 morphospecies (Zepon and Bichuette 2017). Many species that we found during this study were often reported from other limestone caves whether in the same karst area or in other Brazilian karst areas (Trajano 1987, Pinto-da-Rocha 1995, Zepon and Bichuette 2017). As expected for Brazilian caves, most species we found are troglophiles (Trajano and Bichuette 2010).

In São Domingos karst area, Lapa Angélica cave was the richest and the most abundant. Although we sampled this cave on more occasions, its high richness is likely due to the high input of nutrients brought by the extense rivers crossing the cave systems and, consequently, to the high amount of dissolved organic carbon in subterranean terrestrial substrates (62.2 $mgC.L^{-1}$); the same was observed for Terra Ronca II cave (111.12 $mgC.L^{-1}$) (Paula 2018), which, in addition, has skylights along its length through which more organic matter may enter the system (Bichuette et al. 2017). In relation to Pau Pombo cave, the low richness and abundance values may be explained by the limited habitat we searched compared to other caves, as well as this is a typicall dry cave.

In Posse karst area, the higher species richness and abundance we found inside the cave Revolucionários is also attributable to the drainage traversing its length, as well as the high humidity of the terrestrial substrates and the high amount of trophic resources, composed mainly of leaf litter, frugivorous and hematophagous bat guano (Gnaspini-Neto 1992, Poulson and Lavoie 2000). Low diversity and abundance at Nova Esperança can be attributed to low amount of organic matter found inside the cave, mainly leaf litter and guano (ME Bichuette pers. obs). It is a small cave, crossed by a river and with few terrestrial habitats available for fauna, most of which contain rocky or clay substrates. There are several skylights at the ceiling and its epigean environs are impacted by the presence of cattle and pastures.

São Bernardo (São Domingos region) and Revolucionários (Posse region) were the most singular caves in Goiás karst area. Gallão and Bichuette (2015) also observed a high singularity for two caves from Bahia state, northeastern Brazil (Gruna Parede Vermelha and Morro de Alvo caves). Not necessarily the richest caves had higher TD. In other words, the richest caves hadn't the highest singularities in their faunistic compositions. For instance, Lapa Angélica, the richest cave of São Domingos, had a value of TD lower than the estimated mean for the region. This is related to the great number of morphospecies shared with other caves in the region. Our results reinforce that is inadequate to consider only the observed local diversity as the sole criterion for relevance attribution of an area, as this index by itself is not effective to compare different environments, regions, nor taxa (Pärtel et al. 2011). Numerical values of alpha diversity do not reflect the obvious singularities of the subterranean habitats, which is the main justification for its conservation (Trajano et al. 2012).

Lapa Angélica is also one of the most visited caves from PETeR and, on some occasions, visitors traverse its entire length. There has been no effective control of the number and frequency of tourist groups in the region since 2000 (ME Bichuette pers. obs.). We noted that there is only a few sparsely guano spots along the cave, probably reduced as a consequence of anthropic impacts (ground trampling and noise pollution, which drives off the bats). Disturbance diminishes the environmental heterogeneity and, consequently, reduces the offer of microhabitats and resources to the local community, as observed in Lapa Angélica in relation to bat guano along years (M.E. Bichuette pers. obs.). Environmental impacts (contamination) also cause reduction of taxonomic distinctness in marine species communities, while richness remained constant (Warwick and Clarke 1998).

We observed that some of the other richest caves which do not have high taxonomic distinctness, possibly because of anthropic impacts in the region. Taxonomic distinctness in the region may still be related to the trophic diversity of the community, in such a way that when there is a reduction in the number of guilds, TD decays (Clarke and Warwick 1999). The type of habitat affects trophic diversity. Consequently, more impacted areas are also more subject to a decrease in taxonomic distinctness.

Terra Ronca II cave, even with the second higher species richness, presented the lowest TD. The stretch of the cave we sampled has basically the same substratum type, which is predominantly composed of banks of sand and pebbles deposited at riverside. Despite its high species richness, the species are not taxonomically very distinct from each other (e.g., several morphospecies are from the beetle families Carabidae and Staphylinidae) when compared to other subterranean communities of the same region. In Posse, the richest cave (Revolucionários) also had the highest TD. Its high faunistic singularity is related to the presence of species and genera belonging to different families. Nova Esperança presented several common taxa and, therefore, low faunistic singularity.

Conservation remarks

São Domingos is remarkable for its high richness in troglobitic species of fishes that exhibit various degrees of specialization to subterranean life, including one species of Loricariidae catfish, four Trichomycteridae catfishes, one Heptapteridae catfish and one Sternopygidae electric fish (Reis 1987, Triques 1996, Fernández and Bichuette 2002, Bichuette and Trajano 2004, Trajano et al. 2004). Terrestrial invertebrates, such as Ctenidae, Scytodidae, and Symphytognathidae spiders, are also ubiquitous (Rheims and Pellegatti-Franco 2001). In Posse, only two troglobitic taxa are described to date: two catfishes of the families Callichthyidae and Trichomycteridae (Bichuette and Trajano 2008, Tencatt and Bichuette 2017).

If we excluded the troglophilic taxa and considered only troglobitic terrestrial invertebrates, species diversity recorded in northeastern Goiás would be considered poor when compared to other Brazilian regions, as has been demonstrated in this and in previous studies (Trajano and Bichuette 2010, Trajano et al. 2016). This poor troglobitic diversity can be related to the fact that this area comprises a relatively stable paleoclimatic zone (Barr 1973, Moore 1964). Under this model of climate fluctuations, areas where drastic climate fluctuations occurred in the past had greater troglobitic diversification, as can be found in the subterranean fauna in the northern Hemisphere (Barr 1968, Peck 1980). The most specialized Brazilian troglobites are found in caves of semiarid regions of Bahia state, as Chapada Diamantina and Campo Formoso (Trajano 1995).

As we corroborated in our study, a high degree of singularity is usually present in caves, even among those, which are geographically near other caves and inserted in the same rocky massif. To preserve as many singular caves as possible is urgent, because the ideal of environmental compensation is not applicable to these unique environments.

Even the caves from São Domingos are inside a legally protected area (PETeR), the tourist flow is intense and, several times, there is no adequate inspection. Thus, intense visitation may be affecting the subterranean communities we studied. Besides, part of the headwaters of rivers that crosses caves of São Domingos is outside the State Park limits. There, extensive cattle farming and monocultures are causing silting and pollution of rivers, bringing noxious materials to the caves and impacting the community (Simões et al. 2013). In February 2013, intense sedimentation occurred at the headwater of the São Vicente River (São Domingos), as a consequence of intensive agriculture upstream of the spring. In view of the above, it is difficult to preserve natural areas, even when legal reserve areas and parks are delimited. In Posse, the surroundings outside the caves are deforested and replaced by pastures and urban areas, while the rivers are being discharged from domestic sewage. Worryingly, Brazilian environmental laws do not legally protect the caves suffering these impacts.

In conclusion, caves of São Domingos and Posse karst areas exhibited a high taxonomic distinctness for terrestrial fauna, influenced by the high proportion of troglophilic, accidental and undetermined taxa. Our data show the relevance to considerer not only troglobitic taxa. Besides non-troglobionts, both areas showed a high diversity of troglobitic fish (Bichuette and Trajano 2003) and shelters highly important for bats (Bichuette et al. 2018). Anthropogenic impacts cause reduction of environmental heterogeneity and trophic diversity, and, consequently, diminishes faunistic singularity. Besides, these karst areas have high faunistic diversity when compared with other Brazilian regions. Therefore, protective measures should be taken, since the region is not totally preserved, even in the São Domingos area, where the surroundings of the headspring of rivers that enter on the caves (responsible for carrying food resources and increasing heterogeneity of habitats), are still outside the protection limits of the Park.

Acknowledgments

We are thankful to our colleagues of Laboratório de Estudos Subterrâneos who help in the field trips (CS Fernandes; PP Rizzato); to the helpful field guide in Terra Ronca, RH dos Santos; to the specialists who help in the identification of part of the material: A Brescovit (Araneae), JLC Mineiro (Acari), R Bessi (Carabidae), E Caron (Staphylinidae); RL Falaschi (Diptera), F Moreira (Hemiptera), H Gil-Santana (Heteroptera, Reduviidae), MP Bolfarini (Orthoptera), D Zeppelini (Collembola), JG Palacios-Vargas (Collembola), A Chagas-Jr. (Chilopoda), CS Fernandes (Isopoda), M Bartz (Haplotaxida), LRL Simone and R Salvador (Gastropoda), LP Prado (Formicidae), and JS Gallo (Diplopoda); to Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for the financial support to MEB (processes 98/13858-1 and 2010/08459-4), to Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the Master scholarship to LBS (process 132981/2011-4) and productivity scholarships to MEB (processes 303715/2011-1, 308557/2014-0 and 310378/2017-6); to CS Fernandes for use permission of isopod images (Figures 3C and 3D); to Programa de Pós-Graduação em Ecologia e Recursos Naturais (PPGERN), for the infrastructure to develop part of this work (Master project of LBS). Collections were made in accordance with Brazilian environmental laws - State (authorization number SEMARH 063/2012) and Federal (authorization number SISBIO 28992). We also thank CS Fernandes for revision of the manuscript and English, and S Mammola, ML Niemiller and O Moldovan for the valuable suggestions to improve this work.

References

Ab'Saber A (1977) Os domínios morfoclimáticos da América do Sul. Geomorfologia 52: 1–21.

Adis J (2002) Amazonian Arachnida and Myriapoda. Pensoft, Sofia and Moscow, 500 pp.

Auler A, Farrant AR (1996) A brief introduction to karst and caves in Brazil. Proceedings of University of Bristol Spelaeological Society 20(3): 187–200.

Auler A, Rubbioli E, Brandi R (2001) As grandes cavernas do Brasil. Grupo Bambuí de Pesquisas Espeleológicas, Belo Horizonte, 228 pp.

Barr TC (1968) Cave ecology and the evolution of troglobites. Evolutionary Biology 2: 35–102. https://doi.org/10.1007/978-1-4684-8094-8_2

Barr TC (1973) Refugees of the ice age. Natural History 82(5): 26–35.

Bichuette ME, Gimenez EA, Arnone IS, Trajano E (2018) An important site for conservation of bats in Brazil: Passa Três cave, São Domingos karst area, with an updated checklist for Distrito Federal (DF) and Goiás state. Subterranean Biology 28: 39–51. https://doi.org/10.3897/subtbiol.28.31801

Bichuette ME, Nascimento AR, von Schimonsky DM, Gallão JE, Resende LP, Zepon T (2017) Terrestrial fauna of the largest granitic cave from Southern Hemisphere, southeastern Brazil: A neglected habitat. Neotropical Biology and Conservation 12(2): 75–90. https://doi.org/10.4013/nbc.2017.122.01

Bichuette ME, Simões LB, Von Schimonsky DM, Gallão JE (2015) Effectiveness of quadrat sampling on terrestrial cave fauna survey-a case study in a Neotropical cave. Acta Scientiarum. Biological Sciences 37: 345–351. https://doi.org/10.4025/actascibiolsci.v37i3.28374

Bichuette ME, Trajano E (2003a) A population study of epigean and subterranean Potamolithus snails from southeast Brazil (Mollusca: Gastropoda: Hydrobiidae). Hydrobiologia 505: 107–117. https://doi.org/10.1023/B:HYDR.0000007299.26220.b8

Bichuette ME, Trajano E (2003b) Epigean and subterranean ichthyofauna from São Domingos karst area, upper Tocantins river basin, Central Brazil. Journal of Fish Biology 63(5): 1100–1121. https://doi.org/10.1590/S1679-62252008000100002

Bichuette ME, Trajano E (2004) The new subterranean species of *Ituglanis* from Central Brazil (Siluriformes: Trichomycteridae). Ichthyological Exploration of Freshwaters 15(3): 243–256.

Bichuette ME, Trajano E (2008) *Ituglanis mambai*, a new subterranean catfish from the karst area of Central Brazil, rio Tocantins basin (Siluriformes: Trichomycteridae). Neotropical Ichthyology 6(1): 9–15. https://doi.org/10.1590/S1679-62252008000100002

Bockmann FA, Castro RMC (2010) The blind catfish from the caves of Chapada Diamantina, Bahia, Brazil (Siluriformes: Heptapteridae): description, anatomy, phylogenetic relationships, natural history, and biogeography. Neotropical Ichthyology 8(4): 673–706. https://doi.org/10.1590/S1679-62252010000400001

Borror DJ, Delong DM (1969) Introdução ao estudo dos insetos. Agência norte-americana para o desenvolvimento internacional, Rio de Janeiro, 653 pp.

Brescovit AD, Bonaldo AB, Bertani R, Rheims CA (2002) Araneae. In: Adis J (Ed.) Amazonian Arachnida and Myriapoda. Pensoft Publishers, Sofia and Moscow, 303–343.

Cardoso P (2012) Diversity and community assembly patterns of epigean vs. troglobiont spiders in the Iberian Peninsula. International Journal of Speleology 41(1): 83–94. https://doi.org/10.5038/1827-806X.41.1.9

CECAV (2018) Centro Nacional de Pesquisa e Conservação de Cavernas. http://www.icmbio.gov.br/cecav/canie.html [Accesed October 2018]

Cianciaruso MV, Silva IA, Batalha MA (2009) Diversidades filogenética e funcional: novas abordagens para a Ecologia de comunidades. Biota Neotropica 9(3): 93–103. https://doi.org/10.1590/S1676-06032009000300008

Clarke KR, Warwick RM (1999) The taxonomic distinctness measure of biodiversity: weighting of step lengths between hierarchical levels. Marine Ecology Progress Series 184: 21–29. https://doi.org/10.3354/meps184021

Cordeiro LM, Borghezan R, Trajano E (2014) Subterranean biodiversity in the Serra da Bodoquena karst area, Paraguay river basin, Mato Grosso do Sul, Southwestern Brazil. Biota Neotropica 14(3): e20140114. https://doi.org/10.1590/1676-06032014011414

Culver DC (1986) Cave faunas. In: Soule ME (Ed.) Conservation Biology: The Science of Scarcity and Diversity. Sinauer Associates, Sunderland, Massachusetts, 427–443

Fernandes CS, Batalha MA, Bichuette ME (2016) Does the Cave Environment Reduce Functional Diversity? PLoS ONE 11(3): e0151958. https://doi.org/10.1371/journal.pone.0151958

Fernández L, Bichuette ME (2002) A new cave dwelling species of *Ituglanis* from the São Domingos karst, central Brazil (Siluriformes: Trichomycteridae). Ichthyological Exploration of Freshwaters 13(3): 273–278. https://doi.org/10.1590/S1679-62252008000100002

Ferreira J, Aragão LEOC, Barlow J, Barreto P, Berenguer E, Bustamante M, Gardner TA, Lees AC, Lima A, Louzada J, Pardini R, Parry L, Peres CA, Pompeu PS, Tabarelli M, Zuanon J (2014) Brazil's environmental leadership at risk. Science 346(6210): 706–707. https://doi.org/10.1126/science.1260194

Gallão JE, Bichuette ME (2012) A lista de fauna ameaçada de extinção e os entraves para a inclusão de espécies – o exemplo dos peixes troglóbios brasileiros. Natureza & Conservação 10(1): 83–87. https://doi.org/10.4322/natcon.2012.014

Gallão JE, Bichuette ME (2015) Taxonomic distinctness and conservation of a new high biodiversity subterranean area in Brazil. Anais da Academia Brasileira de Ciências 87(1): 209–217. https://doi.org/10.1590/0001-3765201520140312

Gallão JE, Bichuette ME (2018) Brazilian obligatory subterranean fauna and threats to the hypogean environment. ZooKeys 746: 1–23. https://doi.org/10.3897/zookeys.746.15140

Gibert J, Deharveng L (2002) Subterranean ecosystems: a truncated functional biodiversity. BioScience 52: 473–481. https://doi.org/10.1641/0006-3568(2002)052[0473:SEATFB]2.0.CO;2

Gnaspini-Neto P (1992) Bat guano ecosystems. A new classification and some considerations, with special references to neotropical data. Mémoires de Biospéologie 19: 135–138. http://www.ib.usp.br/~gnaspini/p-p07.htm

Gregorin R, Mendes LF (1999) Sobre quirópteros (Emballonuridae, Phylostomidae, Natalidae) de duas cavernas da Chapada Diamantina, Bahia, Brasil. Iheringia, Série Zoológica 86: 121–124.

Karmann I, Setúbal JC (1984) Conjunto espeleológico São Mateus-lmbira: principais aspectos físicos e históricos da exploração. Espeleo-Tema 14: 43–53.

Majer AP, Santos FB, Basile PA, Trajano E (2003) Invertebrados aquáticos de cavernas da área cárstica de São Domingos, nordeste de Goiás. O Carste 15(4): 126–131.

Moore BP (1964) Present-day cave beetle fauna of Australia: a pointer to past climatic change. Helictite 3: 3–9.

Nimer E (1979) Climatologia do Brasil. Fundação Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro, 422 pp.

Oksanen J, Blanchet FG, Kindt R, Legendre P, Minchin PR, O'hara RB, Simpson GL, Solymos P, Henry M, Stevens H, Wagner H (2018) Vegan: community ecology package. R package version 2.0–7. 2013. http://CRAN.R-project.org/package=vegan

Pärtel M, Szava-Kovats R, Zobel M (2011) Dark diversity: shedding light on absent species. Trends in Ecology & Evolution 26 (3): 124–128. https://doi.org/10.1016/j.tree.2010.12.004

Paula CCP (2018) Dinâmica e diversidade das comunidades microbianas em cavernas tropicais. Doctor's Degree thesis, Programa de Pós-Graduação em Ecologia e Recursos Naturais, Universidade Federal de São Carlos.

Peck SB (1980) Climatic change and the evolution of cave invertebrates in the Grand Canyon, Arizona. National Speleological Society Bulletin 42: 53–60.

Pinto-da-Rocha R (1995) Sinopse da fauna cavernícola do Brasil (1907–1994). Papéis Avulsos de Zoologia 39(6): 61–173.

Poulson TL, Lavoie KH (2000) The trophic basis of subsurface ecosystems. In: Wilkens H, Culver DC, Humphreys WF (Eds) Ecosystems of the World 30. Subterranean Ecosystems. Amsterdam, Elsevier, 231–249.

Rafael JA, Melo GAR, Carvalho CLB, Constantino R (2012) Insetos do Brasil, Diversidade e Taxonomia. Holos Editora, Ribeirão Preto, 810 pp.

R Core Team (2017) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Resende LPA, Bichuette ME (2016) Sharing the space: coexistence among terrestrial predators in Neotropical caves. Journal of Natural History 50(33–34): 2107–2128. https://doi.org/10.1080/00222933.2016.1193641

Reis RE (1987) *Ancistrus cryptophthalmus* sp. n. a blind mailed catfish from the Tocantins river basin, Brasil (Pisces, Siluriformes, Loricariidae). Revue Française d'Aquariologie 14(3): 81–84.

Rheims CA, Pellegatti-Franco F (2001) Synopsis of the araneofauna from Brazil. Abstracts of the XVth International Symposium of Biospeleology, 66.

Rheims CA, Pellegatti-Franco F (2003) Invertebrados terrestres de cavernas da área cárstica de São Domingos, nordeste de Goiás. O Carste 15(4): 132–137.

Rodrigues SG, Bueno AAP, Ferreira RL (2014) A new troglobiotic species of *Hyalella* (Crustacea, Amphipoda, Hyalellidae) with a taxonomic key for the Brazilian species. Zootaxa 3815(2): 200–214. https://doi.org/10.11646/zootaxa.3815.2.2

Simões L, Ferreira T, Bichuette ME (2013) Aquatic biota of different karst habitats in epigean and subterranean systems of Central Brazil – visibility versus relevance of taxa. Subterranean Biology 11: 55–74. https://doi.org/10.3897/subtbiol.11.5981

Tencatt LFC, Bichuette ME (2017) Aspidoras mephisto, new species: The first troglobitic Callichthyidae (Teleostei: Siluriformes) from South America. PLoS ONE 12(3): e0171309. https://doi.org/10.1371/journal.pone.0171309

Trajano E (1987) Fauna Cavernícola Brasileira: Composição e Caracterização Preliminar. Revista Brasileira de Zoologia 3(8): 533–561. https://doi.org/10.1590/S0101-81751986000400004

Trajano E (1991) Population ecology of *Pimelodella kronei*, troglobitic catfish from Southeastern Brazil (Siluriformes, Pimelodidae). Environmental Biology of Fishes 30: 407–421. https://doi.org/10.1007/BF02027984

Trajano E (1995) Evolution of tropical troglobites: Applicability of the model of Quaternary climatic fluctuations. Mémoires de Biospéologie 22: 203–209.

Trajano E (2000) Cave Faunas in the Atlantic Tropical Rain Forest: Composition, Ecology, and Conservation. Biotropica 32(4b): 882–893. https://doi.org/10.1111/j.1744-7429.2000.tb00626.x

Trajano E (2012) Ecological classification of subterranean organisms. In: White WB, Culver DC (Eds) Encyclopedia of Caves. Elsevier, Amsterdam, 275–277.

Trajano E, Reis RE, Bichuette ME (2004) *Pimelodella spelaea*: a new cave catfish from Central Brazil, with data on ecology and evolutionary considerations (Siluriformes: Heptapteridae). Copeia 2: 315–325. https://doi.org/10.1643/CI-03-144R1

Trajano E, Bichuette ME (2006) Biologia Subterrânea: Introdução. Redespeleo Brasil, São Paulo, 92 pp.

Trajano E, Bichuette ME (2010) Diversity of Brazilian subterranean invertebrates, with a list of troglomorphic taxa. Subterranean Biology 7: 1–16.

Trajano E, Bichuette ME, Batalha MA (2012) Estudos ambientais em cavernas: os problemas da coleta, da identificação, da inclusão e dos índices. Espeleo-Tema 23(1): 13–22.

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: 1805–1828. http://doi.org/10.1007/s10531-016-1151-5

Trajano E, Moreira JRA (2001) Estudo da fauna de cavernas da Província Espeleológica Arenítica Altamira-Itaituba, Pará. Revista Brasileira de Zoologia 51(1): 13–29.

Triques ML (1996) *Eigenmannia vicentespelaea*, a new species of cave dwelling electrogenic Neotropical fish (Ostariophysi: Gymnotiformes: Sternopygidae). Revue Française d'Aquariologie 23(1–2): 1–4.

Warwick RM, Clarke KR (1995) New 'biodiversity' measures reveal a decrease in taxonomic distinctness with increasing stress. Marine Ecology Progress Series 129: 301–305. https://doi.org/10.3354/meps129301

Warwick RM, Clarke KR (1998) Taxonomic distinctness and environmental assessment. Journal of Applied Ecology, 35: 532–543. https://doi.org/10.1046/j.1365-2664.1998.3540532.x

Zeppelini DF, Bellini BC (2004) Introdução ao estudo dos Collembola. Editora Universitária, João Pessoa, 82 pp.

Zepon T, Bichuette ME (2017) Influence of substrate on the richness and composition of Neotropical cave fauna. Anais da Academia Brasileira de Ciências 89(3): 1615–1628. https://doi.org/10.1590/0001-3765201720160452

Appendix I

Individual abundance of cave invertebrates in São Domingos and Posse karst areas, state of Goiás, central Brazil, and their status according to relationship with the subterranean environment. Legend: Caves: SBer= São Bernardo cave system , Ang= Lapa Angélica, Bez= Lapa do Bezerra, SMat= São Mateus cave system, TR_I= Terra Ronca I cave, TR_II= Terra Ronca II cave, PPom= Pau Pombo cave, Rus= Russão cave system, Bom= Bombas cave system, Dor= Doralino cave system, NEsp= Nova Esperança cave, Rev= Revolucionários cave. Status: TX= trogloxene, TF=troglophile, TB= troglobite, TM/TB?= troglomorphic/ possibly troglobitic, AC= accidental, ?= undetermined classification.

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
F. Arthropoda														
C. Arachnida														
Sc. Acari														
O. Ixodida														
Fa. Ixodidae														
Sf. Amblyomminae	*Amblyomma* sp. 1	?		1										
Fa. Argasidae	sp. 1	?												1
O. Mesostigmata	sp. 1	?								1				
	sp. 2	TF		1										
	sp. 3	?										1		
	sp. 4	?												6
	sp. 5	TF		1										
	sp. 6	?					2							
Fa. Laelapidae	sp. 1	?										1		
	sp. 2	?		1		1								
Fa. Tetranychidae	sp. 1	?		3										
O. Oribatida														
Fa. Galumnidae	sp. 1	?		1										
O. Amblypygi														F
Fa. Phrynidae	*Heterophrynus longicornis* (Butler, 1873)	TF		1										
O. Araneae														
So. Araneomorphae														
Fa. Anapidae	sp. 1	AC					2							

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Fa. Araneidae	*Alpaida* sp. 1	TF		9		1		1		2		8	1	1
	Eustala sp. 1	TF										1		
	Micrathena sp. 1	TF									2			
	Ocrepeira sp. 1	TF		1										
	Pronous sp. 1	TF		4										
Fa. Caponiidae	*Nops* sp. 1	TF		2			1							
Fa. Corinnidae	sp. 1	TF		2	4									
Fa. Ctenidae	*Enoploctenus* sp. 1	TX		4										
	Isoctenus sp. 1	TF		1		2	1	11	2	2	1	3	2	5
	Isoctenus sp.2	TF			3									6
Fa. Filistatidae	sp. 1	TF		1										
Fa. Linyphiidae	*Agyneta* sp. 1	TF		8	1	1								1
Fa. Lycosidae	sp. 1	AC			2									
	sp. 2	AC				1		1						
	Allocosa sp. 1	AC		2										
Sfa. Mysmenidae	sp. 1	?		3										
	Mysmena sp. 1	?	2											
Fa. Nesticidae	*Nesticus* sp. 1	TF								4		1		
Fa. Oonopidae	sp. 1	TF		5										
	sp. 2	TF		3										
	sp. 3	TF						2						
	Triaeris stenaspsis Simon, 1891	TF		2				1						
Fa. Palpimanidae	*Fernandezina* sp. 1	AC						1						
Fa. Pisauridae	sp. 1	TF										1		
Fa. Pholcidae														
Sfa. Ninetinae	sp. 1	TF	1	22										
	Ibotyporanga sp. 1	TF						1						
Sfa. Pholcinae	*Leptopholcus* sp. 1	TF										1		
Sfa. Modisiminae	*Mesobolivar* sp. 1	TF	7	10	27	1	1	7		4	5	13	8	
Fa. Salticidae	sp. 1	AC		1	3									
	sp. 2	AC						1						
	sp. 3	AC				1								

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Fa. Scytodidae	*Scytodes* sp. 1	TF		16	1		2	3						
	Scytodes sp. 2	TF		1										
	Scytodes aff. *eleonorae* Rheims & Brescovit, 2001	TF		2										
Fa. Segestriidae	sp. 1	TF		1										
Fa. Selenopidae	sp. 1	TF			1									
Fa. Sicariidae	*Loxosceles* sp. 1	TF		29	3	1	4	5						13
	Loxosceles sp. 2	TF		1					4					
	Loxosceles sp. 3	TF		11							3		6	
	Sicarius sp. 1	TF					1							
Fa. Symphytognathidae	*Anapistula* sp. 1	TF		1										
Fa. Tetragnathidae	sp. 1	TF	1	1					1					
	Crysometa sp. 1	?										1		
	Glenognatha sp. 1	?					5							
	Leucage sp. 1	TF		1			3							
	Leucage sp. 2	TF						1						
Fa. Theridiidae	sp. 1	TF		3		5								
	sp. 2	TF	1	1										
	sp. 3	TF		1	4									
	sp. 4	TF		1										
	sp. 5	TF		1										
	sp. 6	TF					1	6						
	Achaearanea sp. 1	TF	2		3									
	Chrysso sp. 1	TF		1										
	Latrodectus geometricus Koch 1841	TF			1									
	Nesticodes rufipes (Lucas, 1846)	TF		6							5			
	Theridion sp. 1	TF		5	1			2		3		6	3	
Fa. Theridiosomatidae	*Plato* sp. 1	TF	3	22	7			1	3				5	2
	Plato sp. 2	TF		15				2		2		6		
	Plato sp. 3	TF		2				4				1		
	Steatoda sp. 1	TF					1							
Fa. Thomisiidae	sp. 1	?		1										

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Fa. Trechaleidae	sp. 1	TF			1	1								
Fa. Uloboridae	sp. 1	TF					1							
Fa. Zodaridae	sp. 1	TF		3				1						
So. Mygalomorphae														
Fa. Dipluridae	sp. 1	?												2
	Ischnothele annulata Tullgren, 1905	?			1									
Fa. Idiopidae	sp. 1	TF		1										
Fa. Theraphosidae	sp. 1	?		2										
O. Opiliones														
So. Laniatores														
Fa. Phalangodidae						1								
Sfa. Phalangodinae	gen. n. sp. n.	TF												
Fa. Cosmetidae														
Sfa. Cosmetinae	*Flirtea batman* (Pinto-da-Rocha & Yamaguti, 2013)	TF	1	14	12	1	2	5	1		3	4		
	sp. 1	TF		1										
Fa. Gonyleptidae														
Sfa. Pachylinae	sp. 1	TF				1								
	sp. 2	TF												5
	Eusarcus sp. 1	TF		7	6	4	1	2		4		5		7
Fa. Tricommatidae														
Sfa. Tricommatinae	sp. 1	TF		1										
Fa. Stygnidae														
Sfa. Stygninae	sp. 1	TF		1										
So. Eupnoi														
Fa. Sclerosomatidae														
Sfa. Gagrellinae	sp. 1	TF		10	1		2	1	1	1		2		6
	sp. 2	TF								3		1		
O. Pseudoscorpiones														
Fa. Chthoniidae	sp. 1	TF	1	1	2		1							1
Fa. Atemnidae														
Sfa. Atemninae	*Paratemnoides* sp. 1	TF		6	1									

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Fa. Cheiridiidae														
Sfa. Cheiridiinae	*Cheiridium* sp. 1	TF		1										
Fa. Cheliferidae	sp. 1	TF				3				1				
Fa. Chernetidae	sp. 1	TF			3									
	sp. 2	TF										1		
Fa. Chernetinae														
T. Chernetini	*Spelaeochernes* sp. 1	TB				1	1					3		4
Fa. Geogarypidae	*Geogarypus* sp. 1	TF		1										
Fa. Olpiidae	sp. 1	TF					1	1						
	sp. 2	TF								16				
	sp. 3	TF	3	1										
Sfa. Hesperolpiinae	*Progarypus* sp. 1	TF		4										
O. Schizomida														
Fa. Hubbardiidae														
Sfa.Hubbardiinae														
T. Hubbardiinii	*Stenochrus portoricensis* Chamberlin, 1922	TF					3	8						
O. Scorpiones														
Fa. Buthidae														
Sfa. Buthinae														
T. Buthinii	*Tityus* sp. 1	TF												1
C. Chilopoda														
O. Geophilomorpha														
Fa. Ballophilidae	*Ityphilus* sp. 1	?					1							
Fa. Schendylidae	*Schendylops* sp. 1	?		1										
	Schendylops sp. 2	?						1						
O. Lithobiomorpha														
Fa. Henicopidae	*Lamyctes* sp. 1	?		1										
O. Scolopendromorpha														
Fa. Scolopocryptopidae														
Sfa. Newportiinae	*Newportia (Tidops) balzanii* (Silvestri, 1895)	?												1

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse			
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Fa. Scolopendridae														
Sfa. Scolopendrinae	*Scolopendra viridicornis* Newport, 1844	?			1									
O. Scutigeromorpha														
Sfa. Pselliodidae	*Sphendononema guildingii* (Newport, 1845)	TF		5	2	1		1						
C. Diplopoda														
O. Polydesmida	sp. 1	TM/TB?					3	1						
	sp. 2	?									1			
	sp. 3	?			1									
O. Spirostreptida														
Fa. Pseudonannolenidae	*Pseudonannolene* aff. *imbirensis* Fontanetti, 1996	TF		1		2								
	sp. 1	TM/TB?	3											
	sp. 2	TF			5	1								
	sp. 3	TF			4		1	9	1					
	sp. 4	TM/TB?			3	1								
	sp. 5	TF	1			2		2						
	sp. 6	TF			4			1						
	sp. 7	?						3						
	sp. 8	?							1					
Fa. Spirostreptidae	sp. 1	TF		2			1	1						
O. Siphonophorida	sp. 1	?			1									
C. Symphyla														
Fa. Scutigereliidae	*Hanseniella* sp. 1	TF		8				2		3		1		2
C. Entognatha														
O. Diplura	sp. 1	TF		3		1								
O. Collembola														
So. Entomobryomorpha														
Fa. Lepidocyrtidae														
Sfa. Cyphoderinae	*Cyphoderus* sp. 1	TM/TB?		19			1							

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Fa. Entomobryidae	sp. 1	TF	1			2		1		1				
	sp. 2	TF		11	6	1	1	4						
	sp. 3	?		1										
	sp. 4	?						2						
Sfa. Entomobryinae	*Entomobrya* sp. 1	?		1										
Fa. Paronellidae	sp. 1	TF		1		6								
	sp. 2	?		1										
	Trogolaphysa sp. 1	TM/TB?									4			
	Trogolaphysa sp. 2	TM/TB?	1	7	4									
	Trogolaphysa sp. 3	TF												5
C. Insecta														
O. Blattaria														
Fa. Blaberidae	sp. 1	TF		5										
Fa. Blattellidae	sp. 1	TF	1	48	3	4	2	4		1	3	3	1	1
	sp. 2	TF	7	7	2	3				1				
	sp. 3	TF		6										
Fa. Corydiidae	sp. 1	AC		3										
O. Coleoptera														
So. Adephaga														
Fa. Carabidae	sp. 1	?		2					1					
Sfa. Harpalinae														
T. Pentagonicini	*Pentagonicina* sp. 1	TF		3			1	1		2				
T. Platynini														
SubT Platynina	*Platynus* sp. 1	AC		1										
T. Pterostichini	sp. 1	TF						1			2			
SubT. Agonina	sp. 1	TF		29			1	21		1				
	sp. 2	AC		1										
SubT. Lozandrina	*Loxandrus* sp. 1	?		3										
Sfa.Trechinae														
T. Bembidiini														

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Subt. Tachyina	*Paratachys* sp. 1	TF		48	1			19		4	1			1
	Paratachys sp. 2	?		1				1						
	Pericompsus sp. 1	TF		2			1	4		4	1			
	Polyderis sp. 1	?		1				1						
	Tachys sp. 1	TF		1				2						1
T. Zuphiini	sp. 1	TF					2							
Fa. Dytiscidae	sp. 1	?		1										
So. Myxophaga														
Fa. Hydroscaphidae	sp. 1	?								1				
So. Polyphaga														
Fa. Cantharidae	sp. 1	AC		2										
	sp. 2	AC		1										
	sp. 3	AC		1										
Fa. Chrysomelidae	sp. 1	AC		2										
	sp. 2	AC		1				1						
Fa. Curculionidae	sp. 1	AC		1										
	sp. 2	AC						1						
Fa. Dryopidae	sp. 1	AC		1										
Fa. Elmidae	*Macrelmis* sp. 1	TF		9										
	Macrelmis sp. 2	TF		1										
	Hexacylloepus sp. 1	TF		1										
Fa. Lampyridae	sp. 1	AC		2	4	2						1		
Fa. Ptiliidae	*Micridium* sp. 1	TF								1				
Fa. Ptilodactylidae	sp. 1	TF										1		
	sp. 2	TF		3	1			1						
	sp. 3	?												1
Fa. Scarabaeidae	*Canthon* sp. 1	AC						1						
Fa. Scydmaenidae	sp. 1	?						1						

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse			
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Fa. Staphylinidae	sp. 1	TF		19				20				2		
	sp. 2	?				1		5						
	sp. 3	TF		1	1	1		3						
	sp. 4	AC				1								
	sp. 5	AC		1										
	sp. 6	AC		1										
	sp. 7	TF		2				7						
	sp. 8	AC						2						
	sp. 9	?					1	4						
	sp. 10	AC						1						
Fa. Aleocharinae	sp. 1	?		2				1						
Sfa. Osoriinae	*Holotrochus* sp. 1	?		1										
Sfa. Oxytelinae	sp. 1	TF		18				18			2			
	sp. 2	TF		2	1									
Sfa.Paederinae	sp. 1	TF						1		1				
	sp. 2	?		2				1						1
	Homeotarsus sp. 1	?								3				
	Homeotarsus sp. 2	?												2
	Homeotarsus sp. 3	?			2									1
Sfa. Pselaphinae	sp. 1	TM/TB?			1	1								
Sfa. Staphylininae														
T. Staphilinini	sp. 1	TF		2										
	sp. 2	?						1						
T. Xantholinini	sp. 1	?		1										
Sfa. Steninae	*Stenus* sp. 1	TF		2										
	Stenus sp. 2	?					1							
Sfa. Tachyporinae	sp. 1	?						1		1				
	sp. 2	TF		2										
	sp. 3	TF		1										
Sfa. Tenebrionidae	sp. 1	TF	3				1							
	sp. 2	TF												1

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
O. Diptera														
So. Brachycera														
Io. Muscomorpha/ Acalyptratae	sp. 1	?										2		
	sp. 2	?										2		
	sp. 3	?		1								1		
F. Drosophilidae	*Drosophila* sp. 1	TF	6					1				2		1
	Drosophila sp. 2	TF		2										
	Drosophila sp. 3	TF									1			
Fa. Muscidae	sp. 1	TF		2										
Fa. Phoridae	sp. 1	TF					1					1		
	sp. 2	TF						1						
	sp. 3	TF		1										
So. Nematocera														
Io. Bibionomorpha														
Fa. Cecidomyiidae	sp. 1	TF	2	2		1								
	sp. 2	TF	1			3		2						
	sp. 3	?		1										
Io. Culicomorpha														
Fa. Ceratopogonidae	sp. 1	?		2			1				3			
	sp. 2	?		1										
Fa. Chironomidae	sp. 1	?		3									2	
	sp. 2	?		6				1				1		
	sp. 3	?		6										
Fa. Culicidae	sp. 1	?									1			
	sp. 2	?						1				2		
Io. Tipulomorpha														
Fa. Limoniidae	sp. 1	?											1	
	sp. 2	?											1	
Io. Bibionomorpha														
Fa. Mycetophilidae	sp. 1	?	1											
	sp. 2	?		9										
	sp. 3	?		3										

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Io. Psychodomorpha														
Fa. Psychodidae	sp. 1	?		1										
Sfa. Phlebotominae	sp. 1	TF		7	15					4		1		
Io. Bibionomorpha														
Fa. Sciaridae	sp. 1	TF		6										
	sp. 2	TF		2							1			
	sp. 3	TF		1				1						
	sp. 4	TF		8										
Io. Culicomorpha														
Fa. Simulidae	sp. 1	?								1				
Io. Tipulomorpha														
Fa. Tipulidae	sp. 1	AC											1	
O. Ephemeroptera														
Fa. Baetidae	*Cloeodes* sp. 1	TF								1				
Fa. Leptophlebiidae	sp. 1	TF	2	12			8			1				
	Miroculis sp. 1	TF		3									1	
O. Hemiptera														
So. Auchenorrhyncha														
Fa. Cicadellidae	sp. 1	AC		2										
	sp. 2	AC		1										
Fa. Cixiidae	sp. 1	TF		6						1				
So. Heteroptera														
Fa. Belostomatidae	sp. 1	TF								1				
Fa. Gelastocoridae	sp. 1	TF		2				2						
	sp. 2	AC		1										
Fa. Notonectidae	sp. 1	AC			1									
Fa. Hydrometridae	sp. 1	?						2						
Fa. Coreidae														
Sfa. Coreinae	*Zicca* sp. 1	AC		1										
Lygaeidae	sp. 1	TF		1				7			2			
	sp. 2	?						1						
	sp. 3	?						1						

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Fa. Reduviidae	sp. 1	TF		8						1				
	sp. 2	TF	2	1	1									
	sp. 3	TF				1								
	sp. 4	TF		1										
Sfa. Ectrichodiinae	*Pothea furtadoi* Gil-Santana & Costa, 2005	AC								1				
Sfa. Emesinae	sp. 1	TF		3						1		3		
	sp. 2	TF		4				1						
	sp. 3	TF		1										
Sfa. Reduviinae	sp. 1	?		1						1				
	Zelurus sp. 1	TF		13	3			2					3	
Sfa. Harpactocorinae	sp. 1	AC		1										
Fa. Veliidae	sp. 1	TF		2										
O. Hymenoptera														
Fa. Formicidae														
Sfa. Cerapachyinae	*Acanthostichus kirbyi* Emery, 1895	AC		3										
Sfa. Ecitoninae	*Labidus coecus* (Latreille, 1802)	AC		1										
Sfa. Formicinae	*Nylanderia* sp. 1	AC												1
Sfa. Myrmicinae	*Pheidole* sp. 1	TF		1										
	Pheidole sp. 2	TF		6								3		
	Pheidole sp. 3	TF								2				
	Pheidole sp. 4	TF		16										
	Pheidole sp. 5	TF											1	
	Solenopsis sp. 1	TF		3										
	Wasmannia auropunctata (Roger, 1863)	AC								3				
Sfa. Ponerinae	*Hypoponera* sp. 1	TF		1										
	Hypoponera sp. 2	TF		1				11						
	Hypoponera sp. 3	TF												2
	Hypoponera sp. 4	TF		2										
	Leptogenys sp. 1	AC		1										

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Fa. Vespidae	sp. 1	AC		1										
SF.Ichneumonoidea	sp. 1	AC		1										
O. Isoptera														
Fa. Termitidae														
Sfa. Nasutitermitinae	sp. 1	TF		11				1				1		2
O. Lepidoptera														
Fa. Noctuidae	sp. 1	TF		3						1		4		
	sp. 2	TF										1		
Fa. Tineidae	sp. 1	TF	2	7				2	4		1			
O. Megaloptera														
Fa. Megalopteridae	sp. 1	?			2									
O. Neuroptera														
Fa. Myrmeleontidae	sp. 1	AC		1										
O. Odonata	sp. 1	AC						1						
O. Orthoptera														
So. Ensifera														
Fa. Phalangopsidae	sp. 1	TF		6	3	3	1							1
	sp. 2	TF		1		2								
Sfa. Luzarinae	*Endecous* sp. 1	TF	1	1	5			3						7
	Endecous sp. n. 1	TF		15					3	3		1		
	Endecous sp. n. 2	TF									2			
	Eidmanacris sp. 1	TF		3						1		1	3	3
Fa. Trigonidiidae														
Sfa. Trigonidiinae	*Cyrtoxipha* sp. 1	AC			1									
O. Plecoptera														
Fa. Perlidae	sp. 1	TF			1		1							
	sp. 2	TF		4										
Fa. Perlodidae	sp. 1	TF		3										
O. Psocoptera	sp. 1	TF		4								1	2	
	sp. 2	TF		8										
	sp. 3	TF		2										

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
O. Thysanoptera														
Fa. Lepismatidae	sp. 1	AC		2				1						
	sp. 2	AC		4				1						
	sp. 3	AC		1										
O. Trichoptera														
Fa. Calamoceratidae	sp. 1	TF									1			
Fa. Hydropsychidae	*Leptonema* sp. 1	TF		2									1	
Fa. Hydropsychidae	*Smicridae* sp. 1	TF		7				2						
Fa. Philopotamidae	*Chimarra* sp. 1	TF	1	8				3						
Fa. Odontoceridae	sp. 1	TF									1			
C. Malacostraca														
O. Isopoda														
Fa. Armadillidae	*Venezillo congener* (Budde-Lund, 1904)	TF		11	11									
Fa. Dubioniscidae	sp. 1	TM/TB?	14											
	sp. 2	TF					1	2						4
	sp. 3	TF					8	1						
Fa. Platyarthridae	sp. 1	TF						1						5
Fa. Styloniscidae	sp. 1	TM/TB?		2										
F. Mollusca														
C. Gastropoda														
O. Pulmonata														
So. Stylommatophora	sp. 1	?		1										
	sp. 2	?		2										
	sp. 3	?		4										
	sp. 4	?		1										
	sp. 5	?		5										
	sp. 6	?		2										
	sp. 7	?		1										
	sp. 8	?		1										
	sp. 9	?		2										
	sp. 10	?		1										
	sp. 11	?					1							

Taxa	Gen. sp./ morphotype	Status	Caves - São Domingos							Caves - Posse				
			SBer	Ang	Bez	SMat	TR I	TR II	Ppom	Rus	Bom	Dor	NEsp	Revo
Fa. Gastrocoptidae	*Gastrocopta sharae* Salvador, Cavallari & Simone, 2017	?												1
Fa. Charopidae	*Radiodiscus* sp. 1	?												1
Fa. Ferussaciidae	*Cecilioides consobrina* (d'Orbigny, 1842)	?												1
Fa. Scolodontidae	*Entodina jekylli* Baker, 1913	?												1
	Prohappia besckei (Dunker, 1847)	?												1
Fa. Systrophiidae	*Happia glaberrima* Thiele, 1927	?												1
Fa. Subulinidae	*Leptinaria concentrica* (Reeve, 1849)	?												1
Fa. Valloniidae	*Pupisoma dioscoricola* (Adams, 1845)	?												1
F. Annelida														
C. Clitellata														
O. Haplotaxida														
Fa. Glossoscolecidae	*Pontoscolex corethrurus* (Müller, 1857)	TF		1	1									
Fa. Megascolecidae	*Dichogaster saliens* (Beddard, 1893)	?		1							1			
	Dichogaster gracilis (Michaelsen, 1892)	TF									1			
Sc. Hirudinea	sp. 1	AC						2						
F. Nematoda	sp. 1	?	1											