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Terrestrial fauna of the largest granitic cave from Southern Hemisphere, southeastern Brazil: A neglected habitat

Fauna terrestre da maior cavidade em granito do Hemisfério Sul, sudeste do Brasil: um habitat negligenciado

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Abstract

Studies focusing cave fauna on granitic caves are relatively rare when compared to carbonatic ones and no one considered replicas in the sampling to test fauna distribution patterns. We describe the terrestrial fauna of Riacho Subterrâneo cave through four sampling occasions (replicas) in different seasons. We analyzed seasonality and substrate preference of terrestrial invertebrates and discussed the importance of this neglected habitat as a refuge for fauna. Furthermore, we stressed the importance of the replicas in order to detect subterranean biodiversity patterns. The cave represents the greatest richness considering igneous rocks in Brazil (199 taxa) and has an important role as refuge for epigean fauna, besides the maintenance of troglophilic and trogloxene populations.

Keywords: subterranean microhabitats, igneous rock, Neotropical Region, seasonality, refuge.

Resumo

Estudos com foco em fauna de cavidades graníticas são relativamente raros comparados àqueles em rochas carbonáticas, e nenhum deles considerou a realização de réplicas para teste de padrões de distribuição da fauna. Descrevemos a fauna terrestre da Gruta do Riacho Subterrâneo por meio de quatro ocasiões de amostragem (réplicas) em diferentes estações do ano. Analisamos a influência da sazonalidade e a preferência por substratos da comunidade de invertebrados terrestres e discutimos a importância deste habitat negligenciado como refúgio para a fauna. Ainda, discutimos a importância da realização de réplicas para detectar padrões de biodiversidade subterrânea. A cavidade apresenta a maior riqueza biológica dentre as cavidades em rochas ígneas no Brasil (199 táxons) e desempenha um papel importante como refúgio para fauna epígea, além de manutenção de populações troglófilas e trogloxenas.

Palavras-chave: micro-habitats subterrâneos, rocha ígnea, Região Neotropical, sazonalidade, refúgio.

Introduction

In the worldwide literature, studies on granitic caves are relatively rare when compared to carbonatic ones (Juberthie, 2000). Usually, granitic (an igneous rock) caves are small, may vary in shape (Twidale and Bourne, 2008) and their final structure is shaped mainly by the power of water (Romaní *et al.*, 2010).

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They are often formed by large agglomerates of blocks with many openings to surface. In this context, granitic caves can offer microhabitats for the establishment of communities with surface faunistic components (Romaní *et al.*, 2010). Granitic caves are formed by marine/fluvial erosion or talus deposits, with possibility of chemical dissolution (Finlayson, 1986). Granitic and gnaissic caves represent about 3.4% of the Brazilian recorded caves (216 caves) (Cadastro Nacional de Cavidades, 2016). Besides the small sizes compared to other lithologies (*e.g.*, limestone), granitic caves are capable to harbor complexes biological systems (Willems *et al.*, 2002).

Studies comparing granitic caves with other lithologies regarding fauna composition are rare in Brazil (*e.g.*, Gnaspini and Trajano, 1994; Souza-Silva *et al.*, 2011; Bernardi *et al.*, 2012), most conducted in small caves (less than 190 m) and without replicas along annual cycles, which bring limited data to propose faunistic patterns and protection policies.

Subterranean fauna is classified by three categories, associated to the different habitats in according to its ecological and/or evolutionary characteristics. In this context, the troglobites are the most specialized and restricted to subterranean habitats, showing autapomorphies related to their isolation (the classical troglomorphisms are reduction until absence of eyes and body melanic pigmentation *sensu* Christiansen, 2005); troglophiles are facultative species with established populations inside and outside caves and trogloxenes are those animals utilizing the subterranean habitats as shelters and completing their life cycle outside caves (modified from Holsinger and Culver, 1988).

The topography and mapping, mandatory in environmental studies of relevance which is based on Decree 6640 (Brasil, 2008), are not easy to perform in granitic caves. As consequence, these habitats are frequently neglected considering fauna and physical attributes. Indeed, the demand for extraction of igneous rocks for economic purposes in Brazil is high, which represents a threat to this habitat.

We describe herein the subterranean biodiversity of terrestrial invertebrates in the largest granitic cave of the Southern Hemisphere, the Riacho Subterrâneo cave, testing the influence of seasonality in the taxa distribution and the substrate preference.

Material and methods

Study area

Riacho Subterrâneo cave is inserted in the Itu's post-orogenic granite suite (Martins, 2011), in the state of São Paulo, southeastern Brazil (Figure 1) in an altitude of 583 m. The climate is classified as wet and sub warm (Nimer, 1989) with the rainy and warm season between October and March and dry and cold season from April to September (Nimer, 1989). The average temperature is ca. 15°C and the annual precipitation between 1,000 and 1,500 mm (Instituto Nacional de Meteorologia, 2014).

This is the largest cave in igneous rock of the Southern Hemisphere with approximately 1,500 meters of development in mapped passageways (Igual, 2011) (Figures 1 and 2). Most recorded granitic caves are small and Riacho Subterrâneo cave did not follow this pattern comparing to the recorded in Brazilian databases (*e.g.*, CNC/SBE). The innumerable entrances of Riacho Subterrâneo cave (Figure 3A) implies in potential colonization ways for the surface fauna to the cave habitat besides food input for the established cave communities.

The vegetal physiognomies are composed mainly by a Semidecidual Seasonal Forest, interspersed by Atlantic Rainforest and Cerrado (Savannah-like vegetation) (Kronka *et al.*, 2005). The surroundings of the cave are hardly impacted by anthropogenic activities (plantations, pasture and housings) (Figure 3B) and, in 2010, we observed a drastic fire in its surroundings (Figure 3C), representing a punctual disturbance.

Samplings

Four samplings were conducted in total. The first one occurred in October 2010, beginning of rainy season; in that occasion, the cave surrounding vegetation was drastically burnt (Figure 3C). The second and third samplings were in August 2012 (dry season) and November 2012 (rainy season). The fourth sampling occurred in March 2013 (end of rainy season), when the cave surrounding was in an advanced regeneration (vegetation) (M.E. Bichuette, pers. obs.) (Table 1).

The cave possesses as main substrates: huge rock blocks (rocky substrate), sediment degraded from the cement among the blocks (unconsolidated), innumerable roots crossing the openings in the ceiling (Figure 2); litter carried from the epigean environment (Figures 3D-E) and few guano piles, and, also, a mix of them (details in the next paragraph). The cave is predominated by twilight and entrance zones, with aphotic zones. There is a small permanent drainage crossing the cave, which has communication with the epigean drainage. Resources (food input) are carried by the drainage and rains through the ceilings openings and also by the penetrating roots.

Samplings were carried out by direct search qualitative method, *i.e.*, to search for fauna in potential areas for their occurrence (Weinstein and Slaney, 1995; Bichuette *et al.*, 2015), in the available substrates: rocky, rocky with litter, unconsolidated sediment (sand and clay), litter, unconsolidated sediment and litter. In total, we sampled 110 hours by each collector in all samplings, since three people along 3-4 days per occasion formed the team. For analysis purposes and considering the main components, we grouped

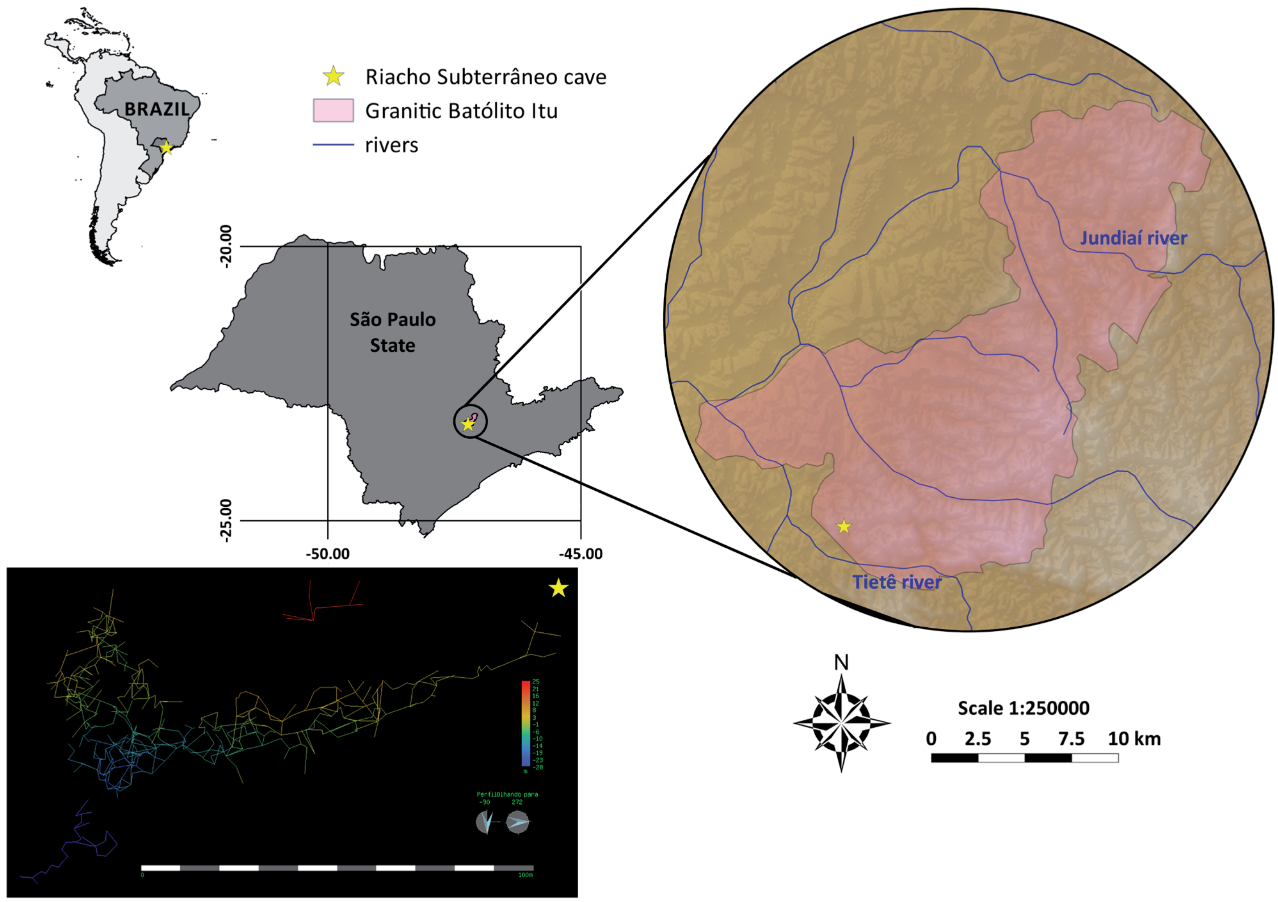

Figure 1. Map location of Riacho Subterrâneo granitic cave with a detailed map of the passageways conduits, Itu municipality, southeastern Brazil.

Source: Diego M. von Schimonsky and Grupo Pierre Martin de Espeleologia (GPME).

the substrates in seven categories: Rocky (RO); Unconsolidated (UN); Litter (LI); Unconsolidated and Rocky (URO); Unconsolidated and Litter (ULI); Rocky and Litter (RLI) and a mix of Rocky, Unconsolidated and Litter (RULI) (see details at Figures 2 and 3).

The same team conducted epigean collections in the surroundings of the cave in the same occasions of the cave fauna collections. Based on this information and on literature data, a proposition of classification of the cave fauna status was proposed (troglobitic, troglophilic or trogloxene animals).

Individuals were fixed *in loco* in formalina 4% (Oligochaeta and Turbellaria), ethanol 50% (Diplopoda) and ethanol 70% (remaining taxa). Juvenile individuals that might not have the identification compared to adult forms were not considered in the species counts and analysis. The vouchers are deposited in the reference collections of the Instituto Butantan (IBSP), Laboratório de Estudos Subterrâneos da Universidade Federal de São Carlos (LES/UFSCar) and Museu de Zoologia da Universidade de São Paulo (MZUSP).

Because the taxonomic impediment for some groups and the needs of robust classification to apply the ecological analysis, we use parataxonomy, grouping similar individuals, based on features of external morphology (*sensu* Majka and Bondrup-Nielsen, 2006). To avoid cascade errors, we use classical literature (Adis, 2002; Brusca and Brusca, 2003; Borror *et al*., 1989, Rafael *et al*., 2012) allied to specialists confirmation.

Data analysis

To verify possible seasonality in the distribution of taxa, graphics were constructed for every collection occasion and a Kruskal-Wallis nonparametric test (Kruskal and Wallis, 1952) followed by Mann-Whitney pairwise comparisons with abundance data was realized to verify significant differences among the seasons/occasions. To analyze the sampling effort and sampling efficiency Mao-tau sample-based rarefaction curves and Jackknife 1 and Chao 2 estimators was applied (Colwell *et al*., 2004). These es-

Figure 2. Detail of rock blocks and roots in a large gallery of Riacho Subterrâneo granitic cave, Itu municipality, southeastern Brazil.

Source: Adriano Gambarini.

timators consider, in the samplings, the uniques (Jacknife 1) and uniques and duplicates (Chao 2). Singletons and doubletons were also calculated.

Box-Plots diagrams with richness and abundance per substrate were constructed to verify possible preferences per substrates. A Kruskal-Wallis nonparametric test (Kruskal and Wallis, 1952) followed by Mann-Whitney pairwise comparisons with richness data was realized to verify significant differences among the substrates. Besides, a nonparametric multivariate analysis of variance (NP-MANOVA) using Bray-Curtis distance and 9999 permuts (Anderson, 2001) was applied to verify if the fauna composition differs among substrates. These analyses were performed in Estimates (v 9.1) (Colwell, 2013) and PAST (v 3.07) (Hammer *et al.*, 2001) softwares.

Results

A taxonomic list and a proposition of classification of the terrestrial fauna of Riacho Subterrâneo cave are presented on Appendix 1. The total observed richness is the highest recorded for granitic caves in Brazil (199 species/morphospecies), distributed in eight invertebrate classes (Arachnida, Insecta, Entognatha, Myriapoda, Malacostraca, Gastropoda, Oligochaeta and Turbellaria, Figure 4). Insecta was the richest (98 distributed in nine orders and 48 families), followed by Arachnida (72 in five orders and 33 families). The other classes showed lowest richness (<20): Diplopoda (13 distributed in three orders and four families), Chilopoda (two orders), Symphyla (one), Entognatha (four Entomobryomorpha), Malacostraca (two Isopoda), Gastropoda (five Pulmonata), Oligochaeta (one Haplotaxida) and Turbellaria (one Tricladida). Considering the ecological evolutionary cave status we recorded 82 troglophiles, three (3) trogloxenes, 44 with undetermined categorization due high diversity and/or poor knowledge about the systematics of the group (*e.g.*, Acari, Coleoptera) and 61 accidental (organisms typical of epigean environments). Nine (9) morphotypes were classified as dubious category (accidental or troglophile), since they belong to groups that have preference for subterranean habitats (some Formicidae, as Ponerinae and Formicinae and Eucnemidae coleopterans). Thirteen troglomorphic taxa showed troglomorphic traits (reduction or absence of

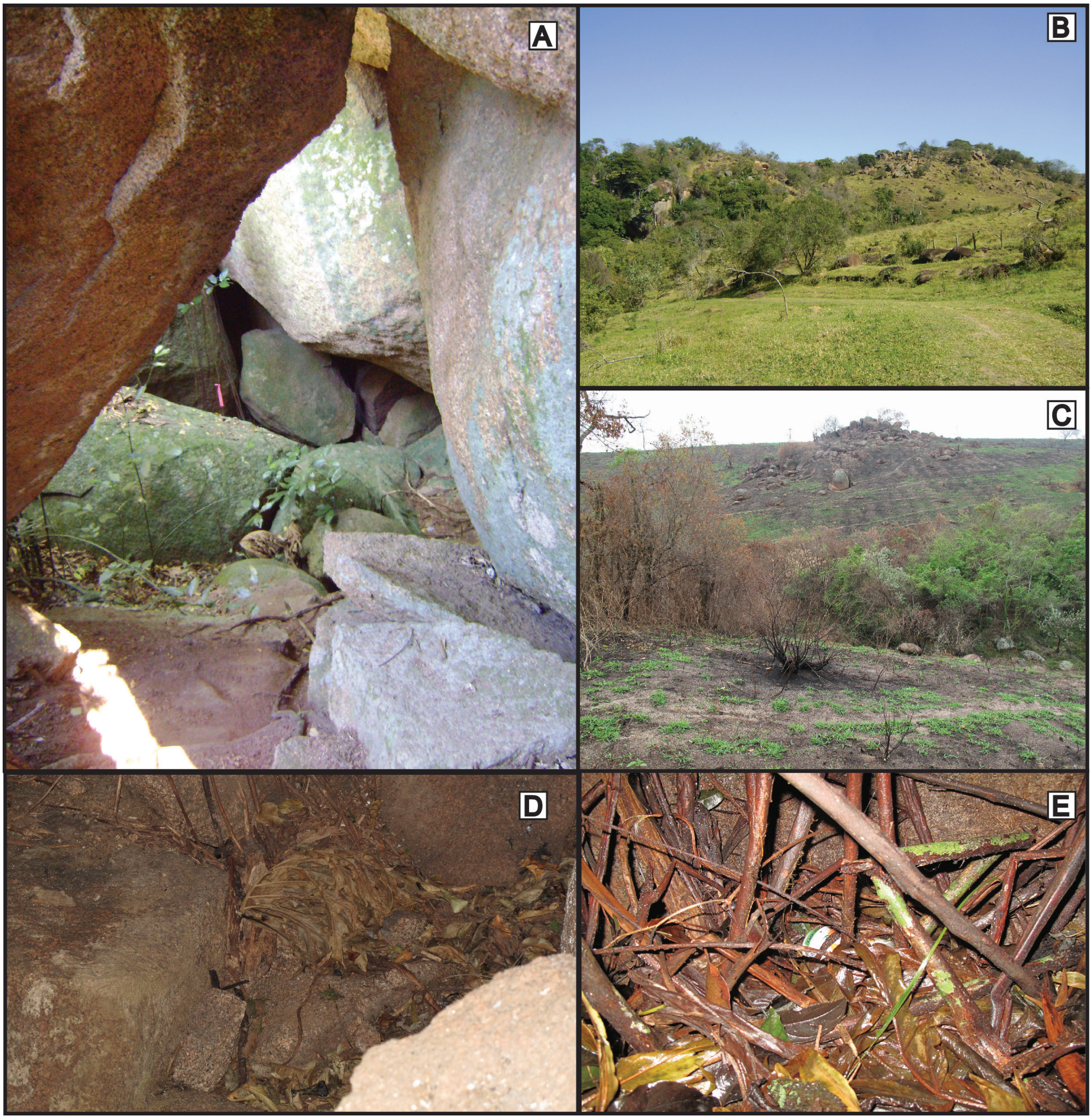

Figure 3. (A) Cave entrance of Riacho Subterrâneo granitic cave, Itu municipality, southeastern Brazil, (B) Cave surrounding vegetation, (C) Cave surroundings after a fire at 2010, (D) Organic matter patches among granitic blocks, (E) Organic matter with roots.

Source: A and B, Tamires Zepon; C, D and E, Maria Elina Bichuette.

eyes and melanic pigmentation), mainly components of soil fauna: *e.g.*, Geophilomorpha centipedes, Polydesmida millipedes, Symphyla and Collembola.

The total observed abundance was 472 individuals. Arachnida and Insecta (Figure 5) were the most abundant groups (Figure 6) totaling 221 and 180 individuals respectively (85% of relative abundance), considering the four sampling occasions. Arachnida was predominant in the first sampling occasion and Insecta in the third occasion (Figure 6).

Table 1. Sampling Occasions with detailed informations of Riacho Subterrâneo cave, Itu municipality, southeastern Brazil.

Month	Year	Season	Surrounding vegetation
October	2010	beginning of rainy	burnt/depleted
August	2012	dry	restoring
November	2012	rainy	restoring
March	2013	end of rainy	restored

Figure 4*.* Cave fauna recorded in Riacho Subterrâneo granitic cave, Itu municipality, southeastern Brazil. (A) *Isoctenus* sp. on rocky substrate, (B) *Enoploctenus cyclothorax* spider resting over granitic blocks, (C) Psocoptera individuals over a granitic block, (D) *Acutisoma hamatum* opilionid with eggs.

Source: A and B, Maria Elina Bichuette; C, Tamires Zepon; and D, Leonardo P. A. Resende.

The abundance differed significantly among sampling occasions (Kruskal-Wallis, $H=35.7$, $df = 3$, $p=8.661^{-8}$) and the Mann-Whitney pairwise comparisons indicated that there was significant difference between the first and the second samplings occasions ($p=2.523^{-6}$), the first and the fourth ($p=0.005654$), the second and the third ($p=1.076^{-7}$), the second and the fourth ($p=0.03886$) and the third and the fourth ($p=0.0008667$).

In according to the rarefaction curve, the sampling effort (four occasions) was not enough to access the total richness (Figure 7). The estimators for this study were: Jackknife 1 (322.75) and Chao 2 (621.81). Singletons and

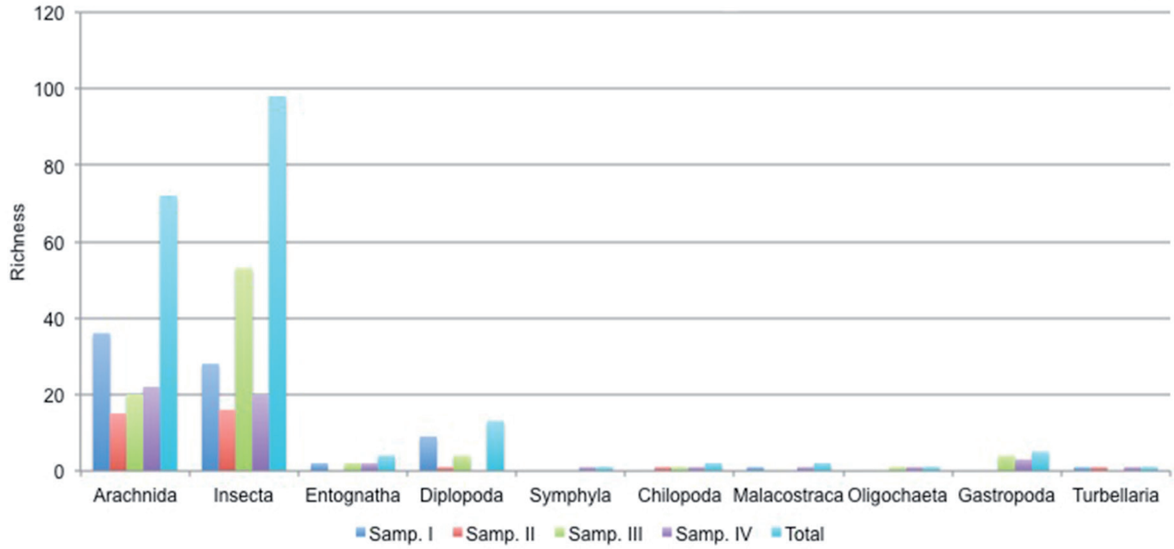

Figure 5. Richness per sampling of Riacho Subterrâneo cave, Itu municipality, southeastern Brazil. Samp. = Sampling occasions.

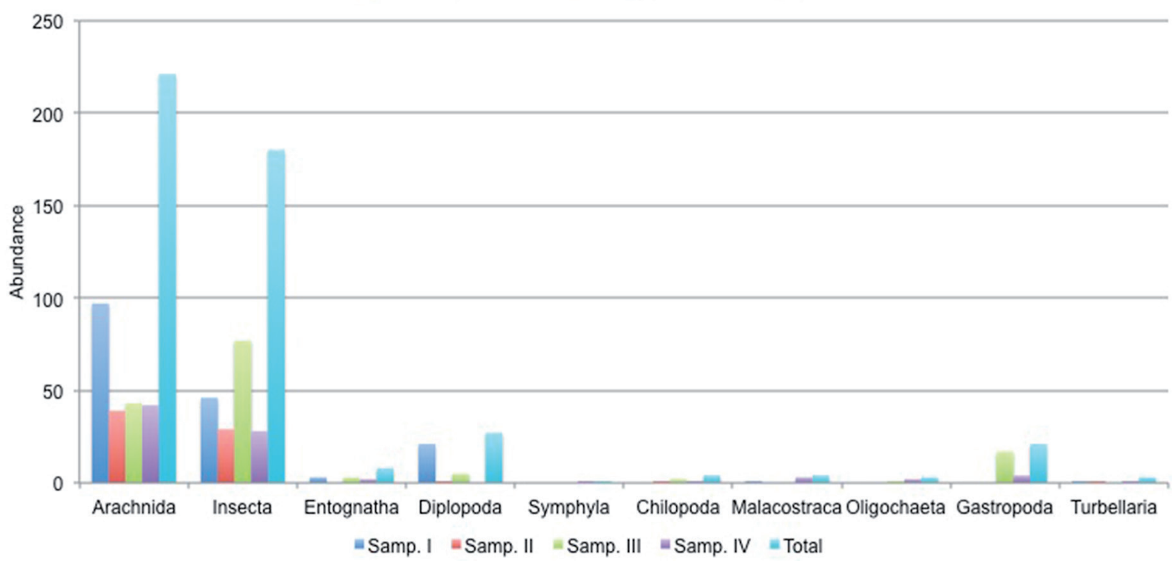

Figure 6. Total abundance per sampling of Riacho Subterrâneo cave, Itu municipality, southeastern Brazil. Samp. = Sampling occasions.

doubletons means are also showed in Figure 7, and represent the occurrence of only one (single) or two (double) individuals in all samplings.

The substrates with higher richness values were rocky (RO), followed by rocky and litter (RLI), rocky, unconsolidated and litter (RULI) and unconsolidated (UN); meanwhile substrates formed by litter (LI) showed lower richness values (Figure 8A). Similar results were observed for abundance: rocky substrates were the most abundant (RO), followed by rocky and litter (RLI) and unconsolidated (UN); meanwhile litter substrates (LI) showed the lowest abundance values (Figure 8B).

The Kruskal-Wallis test (H= 41.6, df=6, p= 0.0002201) and the Mann-Whitney pairwise comparisons showed a significant difference on fauna richness among the substrates (see Table 2). Besides, according to NPMANOVA analysis there is a significant difference on fauna composition among the substrates (p= 0.019) and the post-hoc tests show that rocky substrate (RO) was the most distinct in relation to the other substrates: RO *versus* LI (p=0.0301),

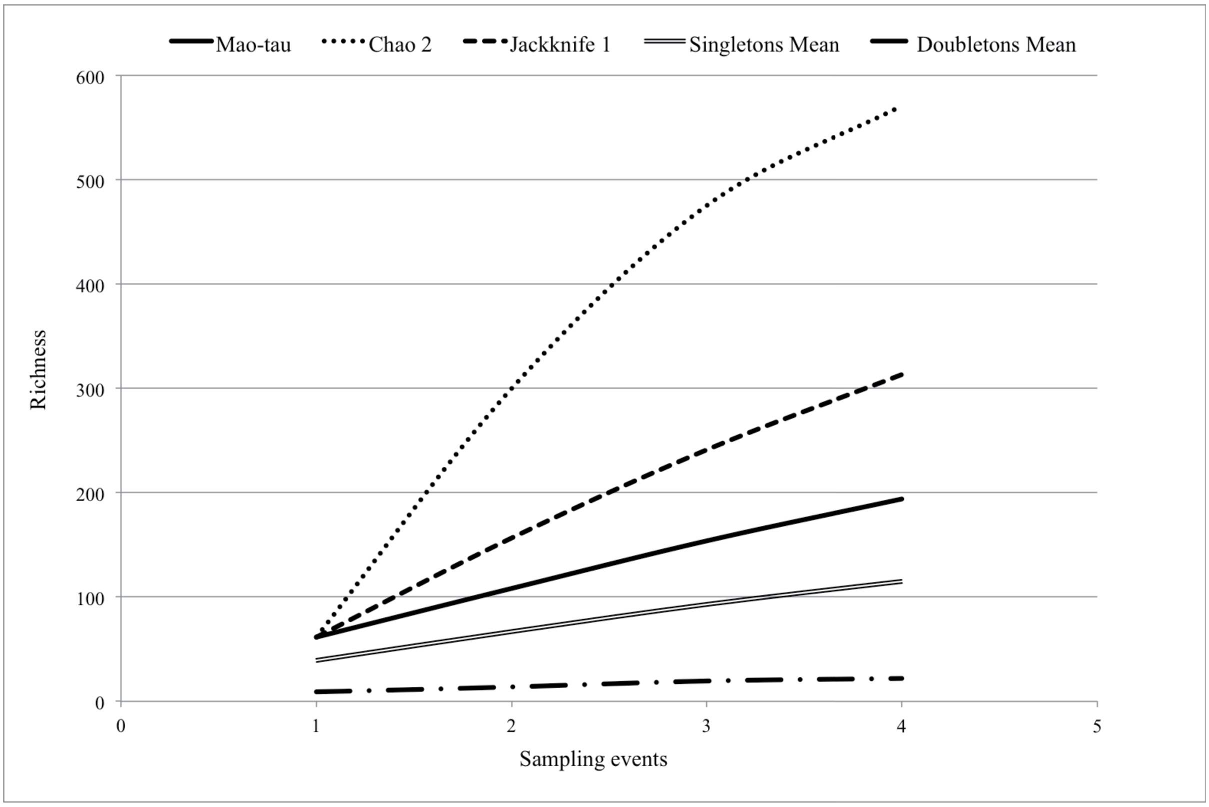

Figure 7. Mao-tau sample-based rarefaction curve, Jackknife 1 and Chao 2 estimators curves for data from Riacho Subterrâneo cave, Itu municipality, southeastern Brazil.

RO *versus* RLI (p=0.0242), RO *versus* ULI (p=0.0303), RO *versus* RULI (p=0.0263) (Table 3).

Discussion

Some of the taxonomic groups recorded in the Riacho Subterrâneo cave were also recorded in other studies focusing granitic caves (Gnaspini and Trajano, 1994; Bernardi *et al.,* 2012) and are common in Brazilian caves of other lithologies (Pinto-da-Rocha, 1995; Trajano and Bichuette, 2010). The high number of accidental records in all sampling occasions (61), such as Chrysomelidae and Lampyridae coleopterans; Braconidae, Ichneumonidae and Formicidae hymenopterans; Pulmonata gastropods; Bothriuridae scorpions, is related to the granitic cave morphology, which has many contacts with the surface and many routes for access of epigean fauna. In this case, the cave can act as a refuge in the dry season or after any unexpected disturbance in the surface environment (as fire or deforestation). The number of troglophilic species was also high (82) and this result is a pattern of many Brazilian caves (see Trajano and Bichuette, 2010). The troglophilic taxa are similar to that observed for Brazilian cave fauna in general, considering high (*e.g.*, order or family) or low (*e.g.*, genus or species) taxonomic levels (*e.g.*, *Endecous* sp. and *Eidmanacris alboannulatus* Piza 1960 orthopterans; Staphylinidae coleopterans; Drosophilidae, Mycetophilidae and Tipulidae dipterans; Ctenidae, Pholcidae, Sicariidae, Theridiidae and Theridiosomatidae spiders). For the trogloxene category, the three records follow the pattern observed for caves from Rainforest of state of São Paulo, with records of Goniosomatinae opilionids (*Acutisoma hamatum* (Roewer 1928) and *Mitogoniella* sp.) and the ctenid spider *Enoploctenus cyclothorax* (Bertkau 1880). These results emphasize the importance of the cave for maintenance of populations of troglophilic and trogloxene populations, besides the refuge for epigean fauna (Appendix 1). Despite many records of troglomorphic groups (13) it was not possible to affirm their troglobitic status without a wider epigean surveys since these taxa live in microhabitats ecologically similar (*e.g.*, deep soil) to the subterranean habitats and are typical edaphic fauna (Trajano and Bichuette, 2010).

Arachnids and insects were the most representative (in richness and abundance), as observed in studies conducted in caves from different Brazilian regions (Trajano and Bichuette, 2010). The occurrence of six species of Opiliones in a single cave (Gonyleptidae family) is similar to ob-

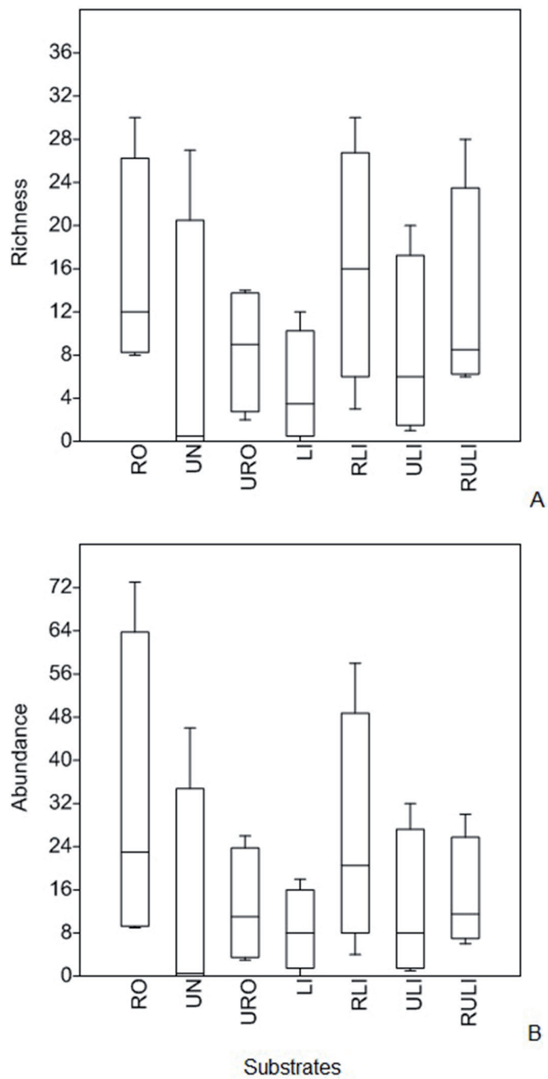

Figure 8. Box-plots with medians, maximum and minimum values of richness (A) and abundance (B) for the different substrates observed at Riacho Subterrâneo cave, Itu municipality, southeastern Brazil. LI = litter; RO = rocky; RLI = rocky and litter; ULI = unconsolidated and litter; UN = unconsolidated; URO = unconsolidated and rocky; RULI = rocky, unconsolidated and litter.

served in other studies for limestone caves in Minas Gerais state (five species, four Gonyleptidae) (Resende and Bichuette, 2016) and in Goiás state (eight species, three Gonyleptidae) (Bichuette *et al*., 2015). It is noteworthy that in these studies it was necessary at least four sampling occasions to reach that richness of opilionids and other species records, which indicates that the number of samplings is directed related to the diversity. Gallão and Bichuette (2015) show that even after six sampling occasions, species were added in their samplings, which highlights the inefficiency of Brazilian laws that demand only two sampling occasions (Trajano, 2010; Gallão and Bichuette, 2015). Besides, the high richness of opilionids in Riacho Subterrâneo cave likely is related to vegetation surrounding, which is remaining of Atlantic Rainforest.

Gnaspini and Trajano (1994) estimated a richness range of 16 to 28 and ca. of seven troglomorphic and possible troglobitic species in four granitic caves inserted in Atlantic Rainforest physiognomy. Souza-Silva *et al.* (2011) sampled 33 magmatic caves also inserted in Atlantic Rainforest, but in different latitudes; the authors recorded richness from 5 until 81 and ca. 11 troglomorphic organisms. Bernardi *et al.* (2012) recorded a richness of 52 in a single granitic cave from state of Minas Gerais (Atlantic Rainforest), most of them troglophilic and no one troglomorphic. In our study 199 species were recorded (with 13 troglomorphic), increasing the richness for Brazilian caves in igneous rock and shows its importance as a refuge to not-obligatory cave fauna.

All these works did not make replicas in the samples and overlooks the hidden diversity in subterranean environments. It is mandatory a robust sampling effort with standardized replicas to describe the taxonomic diversity and understand the community functioning (Trajano, 2013; Gallão and Bichuette, 2015). This affirmation is corroborated by estimators values observed at Figure 7, allied to the intermediary values of singletons and doubletons, which represent the occurrence of only one (single) or two (double) individuals in all samplings. Gallão and Bichuette (2015) and Bichuette *et al.* (2015), studying sandstone and limestone caves, respectively, stressed this question and proposed the necessity of replicas on subterranean studies

Table 2. P values of Mann-Whitney test comparing the richness of invertebrates and substrate categories in the Riacho Subterrâneo cave, Itu municipality, southeastern Brazil. Significant p values are highlighted in gray. RO = rocky; UN = unconsolidated; URO = unconsolidated and rocky; LI = litter; RLI = rocky and litter; ULI = unconsolidated and litter; RULI = rocky, unconsolidated and litter.

	RO	UN	URO	LI	RLI	ULI	RULI
RO	0	**0,005538**	**0,01818**	**4,15E-05**	0,3126	**0,0125**	0,9083
UN	-	0	0,6731	0,1629	**0,0001737**	0,7771	**0,007795**
URO	-	-	0	0,07001	**0,0008074**	0,89	**0,02458**
LI	-	-	-	0	**4,56E-07**	0,09389	**6,62E-05**
RLI	-	-	-	-	0	**0,0004945**	0,2605
ULI	-	-	-	-	-	0	**0,01712**
RULI	-	-	-	-	-	-	0

Table 3. P values of post-hoc tests of NPMANOVA (Bray-Curtis distance; 9999 permutations) comparing the composition of invertebrates and substrate categories in the Riacho Subterrâneo cave, Itu municipality, southeastern Brazil. Significant p values are highlighted in gray. RO = rocky; UN = unconsolidated; URO = unconsolidated and rocky; LI = litter; RLI = rocky and litter; ULI = unconsolidated and litter; RULI = rocky, unconsolidated and litter.

	RO	UN	URO	LI	RLI	ULI	RULI
RO	0	0.0659	0.1121	**0.0301**	**0.0242**	**0.0303**	**0.0263**
UN	-	0	0.3322	1	0.5325	0.2031	0.2658
URO	-	-	0	0.7417	0.9129	0.1153	0.8583
LI	-	-	-	0	0.4872	0.1452	0.7082
RLI	-	-	-	-	0	0.1116	0.7735
ULI	-	-	-	-	-	0	0.2866
RULI	-	-	-	-	-	-	0

to discuss any distribution and diversity pattern, since they are related to intrinsic temporal variations (Trajano, 2013).

The spatial and temporal distribution of cave fauna is influenced by several factors which presents variation in their occurrence, such as patches of vegetable organic matter, guano, concentration of prey (Trajano, 2013), allied to the desiccation of surface habitats in climatic marked regions (in this case, cave habitats operate as seasonal shelters). The seasonality must influences the communities, as observed for the cave fauna of Riacho Subterrâneo cave, where several groups showed higher richness and abundance in the beginning of wet seasons when floods carry organic matter, the trophic basis of detritivores. The lowest richness values observed in the dry season are probably related to the availability of trophic resources, less abundant in this season. Our results are opposite to those observed by Simões (2013) in a single cave from Goiás state (Angélica cave, six replicas): the highest richness and abundance were recorded in the dry seasons and the lowest in the end of rainy season, possibly due the floods influence, carrying and washing the fauna, which reinforce that the cave morphology represents another factor regulating the distribution of the fauna.

Unpredictable events must be discussed herein: the occurrence of fires in 2010 certainly influence the high richness values observed in the first sampling (cave acting as shelter), which again, reinforces the necessity of replicas to detect if the fauna distribution is a pattern (influenced by seasonality for example) or if could be a stochastic process related to an unpredictable event.

Specificity for microhabitats and singularity of fauna show the importance of habitat and the necessity of conservation. In this case, we observed a high specificity for the cave fauna of Riacho Subterrâneo cave (measured by richness and abundance), with an unexpected preference by those showing more rocky components and not those with higher concentration of organic matter. We proposed at least four possible explanations for that: (i) igneous rocks are extremely rough with several crevices, forming humid microhabitats (with mousses in places close to the entrance) for the fauna; (ii) we observed several roots of *Philodendron* sp. (Figures 2 and 3) close to the sampled rocky substrates, representing a resource for the fauna nearby; (iii) the fact that granitic caves possess several routes (and contacts to the surface), the floods carry food amounts, but also could wash the fauna, at least in rainy season; (iv) the cave morphology, with several rounded blocks hampers the samples in the lowest level of the cave, where the organic matter accumulates, causing a biases in the samples. Again, only the application of replicas in the sampling can reduce these biases.

Riacho Subterrâneo cave is the largest granitic cave in the Southern Hemisphere and shows a high richness (199) with an importance as refuge for epigean fauna. These particularities highlight the importance of this cave. There are few granitic caves recorded in Brazil (ca. 216), and certainly most of them are under threat since this kind of rock has a large-scale exploitation. Therefore, this study can contribute to establish comparable parameters for other repeatable studies, mainly those for environmental purposes. Indeed, the replicas showed that some aspects can influence the fauna distribution, as seasonality, which provides parameters that must be applied for cave faunistic studies in general. Finally, besides its role as refuge, it is clear that cave morphology must also be considered as a strong influence for ecology (communities) of cave organisms.

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Appendix

Appendix 1. List of cave fauna of Riacho Subterrâneo cave, Itu municipality, southeastern Brazil. AC, accidental; TF, troglophile; TM, troglomorphic taxa; TX, trogloxene;?, undefined category.

Class	Order	Sub Order	Infra Order	Family	Sub Family	Morfotype / Genus / Species / Status
Turbellaria	Tricladida			Geoplanidae		Geoplanidae sp. 1 (TF)
Oligochaeta	Haplotaxida					Haplotaxida sp. 1 (?)
Gastropoda	Pulmonata					Pulmonata sp. 1 (AC)
						Pulmonata sp. 2 (AC)
						Pulmonata sp. 3 (AC)
						Pulmonata sp. 4 (AC)
						Pulmonata sp. 5 (AC)
Malacostraca	Isopoda			Dubionicidae		*Dubioniscus marmoratus* Lemus de Castro, 1970 (TF)
				Philosciidae		Philosciidae sp. 1 (TF)
Symphyla						Symphyla sp. 1[TM] (TF)
Chilopoda	Geophilomorpha					Geophilomorpha sp. 1[TM] (TF)
	Scolopendromorpha					Scolopendromorpha sp. 1 (TF)
Diplopoda	Polydesmida					Polydesmida sp. 1[TM] (TF)
						Polydesmida sp. 2[TM] (TF)
				Chelodesmidae		Chelodesmidae sp. 1[TM] (TF)
						Chelodesmidae sp. 2[TM] (TF)
				Paradoxosomatidae		Paradoxosomatidae sp. 1[TM] (TF)
				Chelodesmidae		*Henrisaussurea* sp. 1[TM] (TF)
				Chelodesmidae		Gen. 1 sp. 1[TM] (TF)
				Chelodesmidae		*Brasilodesmus* sp. 1[TM] (TF)
	Spirobolida			Rhinocricidae		Rhinocricidae sp. 1 (AC)
						Rhinocricidae sp. 2 (AC)
	Spirostreptida					Spirostreptida sp. 1 (TF)
				Pseudonannolenidae		Pseudonannolenidae sp. 1 (TF)
						Pseudonannolene sp. (TF)
Entognatha	Collembola					Collembola sp. 1 (TF)
						Collembola sp. 2 (TF)
		Entomobryomorpha				Entomobryomorpha sp. 1[TM] (TF)
				Entomobryidae		Entomobryidae sp. 1[TM] (TF)
Insecta	Archaeognatha			Meinertellidae		Meinertellidae sp. 1 (TF)
	Blattaria			Blattelidae		Blattelidae sp. 1 (TF)
	Coleoptera					Coleoptera sp. 1 (?)

Appendix 1. Continuation.

Class	Order	Sub Order	Infra Order	Family	Sub Family	Morfotype / Genus / Species / Status
				Cerambycidae		Cerambycidae sp. 1 (AC)
				Ceratocanthidae		Ceratocanthidae sp. 1 (AC)
				Ciidae		Ciidae sp. 1 (AC)
				Curculionidae		Curculionidae sp. 1 (AC)
						Curculionidae sp. 2 (AC)
						Curculionidae sp. 3 (AC)
						Curculionidae sp. 4 (AC)
				Chrysomelidae		Chrysomelidae sp. 1 (AC)
						Chrysomelidae sp. 2 (AC)
				Eucnemidae		Eucnemidae sp. 1 (AC/TF)
						Eucnemidae sp. 2 (AC/TF)
				Glaphyridae		Glaphyridae sp. 1 (AC)
				Lampyridae		Lampyridae sp. 1 (AC)
				Leiodidae		Leiodidae sp. 1 (TF)
				Meloidae		Meloidae sp. 1 (AC)
				Phalacridae		Phalacridae sp. 1 (AC)
				Scydmaenidae		Scydmaenidae sp. 1 (TF)
					Scydimaeninae	Scydmaeninae sp. 1 (TF)
				Scolytidae	Scolytinae	Scolytinae sp. 1 (AC)
				Staphylinidae		Staphylinidae sp. 1 (TF)
						Staphylinidae sp. 2 (TF)
						Staphylinidae sp. 3 (TF)
					Aleocharinae	Aleocharinae sp. 1 (TF)
					Pselaphinae	Pselaphinae sp. 1 (TF)
						Pselaphinae sp. 2 (TF)
				Tenebrionidae		Tenebrionidae sp. 1 (TF)
						Tenebrionidae sp. 2 (TF)
	Diptera			Bibionidae		Bibionidae sp. 1 (AC)
				Cecidomyiidae		Cecidomyiidae sp. 1 (?)
						Cecidomyiidae sp. 2 (?)
				Ceratopogonidae		Ceratopogonidae sp. 1 (?)
				Chironomidae		Chironomidae sp. 1 (TF)
						Chironomidae sp. 2 (TF)
						Chironomidae sp. 3 (TF)
						Chironomidae sp. 4 (TF)
						Chironomidae sp. 5 (TF)
				Drosophilidae		Drosophilidae sp. 1 (TF)
				Mycetophilidae		Mycetophilidae sp. 1 (TF)
				Sciaridae		Sciaridae sp. 1 (TF)
						Sciaridae sp. 2 (TF)
				Simulidae		Simulidae sp. 1 (TF)
				Tipulidae		Tipulidae sp. 1 (AC)
						Tipulidae sp. 2 (AC)
	Hemiptera					Hemiptera sp. 1 (?)
		Heteroptera				Heteroptera sp. 1 (?)
				Aradidae		Aradidae sp. 1 (AC)
				Nabidae		Nabidae sp. 1 (AC)
						Rhopalidae sp. 1 (AC)
				Thyreochoridae		Thyreochoridae sp. 1 (AC)
		Aucheno-rhyncha		Cercopidae		Cercopidae sp. 1 (AC)
				Cicadellidae		Cicadellidae sp. 1 (AC)

Appendix 1. Continuation.

Class	Order	Sub Order	Infra Order	Family	Sub Family	Morfotype / Genus / Species / Status
				Cixiidae		Cixiidae sp. 1 (TF)
	Hymenoptera	Apocrita		Ampulicidae		Ampulicidae sp. 1 (AC)
				Brachonidae		Brachonidae sp. 1 (AC)
				Ichneumonidae		Ichneumonidae sp. 1 (AC)
				Formicidae	Fomicinae	*Camponotus* sp. 1 (AC)
						Camponotus sp. 2 (AC)
					Ponerinae	*Hypoponera* sp. 1 (AC/TF)
						Hypoponera sp. 2 (AC/TF)
						Hypoponera sp. 3 (AC/TF)
						Hypoponera sp. 4 (AC/TF)
						Hypoponera sp. 5 (AC/TF)
					Ponerinae	*Odontomachus* sp. 1 (AC/TF)
						Odontomachus sp. 2 (AC/TF)
					Myrmicinae	Myrmicinae sp. 1 (AC)
						Myrmicinae sp. 2 (AC)
						Myrmicinae sp. 3 (AC)
						Myrmicinae sp. 4 (AC)
						Myrmicinae sp. 5 (AC)
						Myrmicinae sp. 6 (AC)
						Myrmicinae sp. 7 (AC)
						Atta sp. 1 (AC)
						Atta sp. 2 (AC)
						Cephalotes sp. 1 (AC)
						Crematogaster sp. 1 (AC)
						Solenopsis sp. 1 (AC)
						Solenopsis sp. 2 (AC)
					Dolichoderinae	*Linepithema* sp. 1 (AC)
						Linepithema sp. 2 (AC)
	Lepidoptera					Lepidoptera sp. 1 (?)
	Orthoptera	Ensifera		Phalangopsidae		*Endecous* sp. (TF)
						Eidmanacris alboannulatus Piza, 1960 (TF)
		Celifera		Tetrigidae		Tetrigidae sp. 1 (AC)
	Psocoptera					Psocoptera sp. 1 (?)
		Psocomorpha				Psocomorpha sp. 1 (?)
				Psocidae		*Cerastipsocus* sp. (TF)
				Pseudocaeciliidae		Pseudocaeciliidae sp. 1 (?)
				Peripsocidae		*Peripsocus* sp. 1 (TF)
				Elipsocidae		Nepiomorpha sp. 1 (?)
				Ectopsocidae		Ectopsocidae sp. 1 (?)
				Lepidopsocidae		*Echmepteryx* sp. (TF)
	Trichoptera			Leptoceridae		Leptoceridae sp. 1 (TF)
				Philopotamidae		Philopotamidae sp. 1 (TF)
						Philopotamidae sp. 2 (TF)
						Philopotamidae sp. 3 (TF)
Arachnida	Araneae	Opisthothelae	Araneomorphae			Araneomorphae sp. 1 (?)
						Araneomorphae sp. 2 (?)
				Araneidae		Araneidae sp. 1 (TF)
						Araneidae sp. 2 (TF)

Appendix 1. Continuation.

Class	Order	Sub Order	Infra Order	Family	Sub Family	Morfotype / Genus / Species / Status
				Amaurobiidae		*Ciniflella* sp. (AC)
				Amphinectidae		*Metaltella* sp. (AC)
				Anapidae		Anapidae sp. 1 (?)
				Caponiidae		Caponiidae sp. 1 (?)
				Corinnidae		Corinnidae sp. 1 (?)
						Corinna aff. *nitens* (?)
						Corinna sp. 1 (?)
				Ctenidae		Ctenidae sp. 1 (TF)
						Ctenidae sp. 2 (TF)
						Ctenidae sp. 3 (TF)
						Enoploctenus cyclothorax (Bertkau, 1880) (TX)
						Isoctenus sp. (TF)
				Gnaphosidae		Gnaphosidae sp. 1 (AC)
				Lycosidae		Lycosidae sp. 1 (AC)
				Nesticidae		Nesticidae sp. 1 (TF)
				Ochyroceratidae		Ochyroceratidae sp. 1 (TF)
						Ochyroceratidae sp. 2 (TF)
				Oonopidae		*Scaphiella* sp. 1 (?)
				Pholcidae		*Leptopholcus* sp. 1 (TF)
						Mesabolivar sp. 1 (TF)
						Pholcidae sp. 1 (TF)
						Pholcidae sp. 2 (TF)
				Pisauridae		Pisauridae sp. 1 (TF)
				Salticidae		Salticidae sp. 1 (AC)
						Salticidae sp. 2 (AC)
				Scytodidae		Scytodidae sp. 1 (TF)
				Sicariidae		*Loxosceles gaucho* (Moenkhaus, 1898) (TF)
						Loxosceles sp. 1 (TF)
				Tetragnathidae		*Azilia histrio* Simon, 1895 (AC)
						Chrysometa sp. 1 (AC)
				Theridiidae		*Argyrodes* sp. 1 (TF)
						Theridiidae sp. 1 (?)
						Theridiidae sp. 2 (?)
						Theridion sp. 1 (TF)
						Thymoites sp. 1 (TF)
						Thymoites sp. 2 (TF)
				Theridiosomatidae		Theridiosomatidae sp. 1 (TF)
				Uloboridae		*Uloborus* sp. 1 (TF)
			Mygalomorphae			Mygalomorphae sp. 1 (AC)
	"Acari"					Acari sp. 1 (?)
						Acari sp. 2 (?)
						Acari sp. 3 (?)
						Acari sp. 4 (?)
						Acari sp. 5 (?)
	Ixodida					Ixodida sp. 1 (?)
						Ixodida sp. 2 (?)
	Mesostigmata			Macrochelidae		Macrochelidae sp. 1 (?)

Appendix 1. Continuation.

Class	Order	Sub Order	Infra Order	Family	Sub Family	Morfotype / Genus / Species / Status
						Macrochelidae sp. 2 (?)
				Ologamasidae		Ologamasidae sp. 1 (?)
	Oribatida					Oribatida sp. 1 (?)
						Oribatida sp. 2 (?)
						Oribatida sp. 3 (?)
						Oribatida sp. 4 (?)
						Oribatida sp. 5 (?)
	Trombidiformes			Anystidae		Anystidae sp. 1 (?)
				Bdellidae		*Spinbdella* sp. 1 (?)
				Labidostomatidae		Labidostomatidae sp. 1 (?)
				Microtrombidiidae		Microtrombidiidae sp. 1 (?)
				Trombidiidae		Trombidiidae sp. 1 (?)
	Opiliones	Laniatores		Gonyleptidae		*Acutisoma hamatum* (Roewer, 1928) (TX)
						Longiperna sp. 1 (TF)
						Mitogoniella sp. 1 (TX)
						Mitobatinae sp. 1 (TF)
						Promitobates viridigranulatus Soares & Soares, 1946 (?)
				Tricommatidae		Tricommatidae sp. 1 (TF)
	Scorpiones			Bothriuridae		*Thestylus aurantiurus* Yamaguti & Pinto-da-Rocha, 2003 (AC)
	Pseudoscorpi-ones			Chthoniidae		Chthoniidae sp. 1TM (TF)
				Olpiidae		Olpiidae sp. 1 (TF)