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Faunistic survey of sandstone caves from Altinópolis region, São Paulo State, Brazil

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ABSTRACT

The fauna of eight sandstone caves of the region of Altinópolis, (Serra Geral Arenitic Speleological province, São Paulo State, Southeastern Brazil) was surveyed. Our results improve the previous faunistic knowledge of the region, recording 15 new occurrences for Brazilian caves and 26 for Brazilian sandstone caves. The fauna is characterized by a large number of detritivores/omnivores such as crickets and cockroaches, and several predators like spiders and heteropterans in bat guano.

Keywords: cave fauna, sandstone caves.

INTRODUCTION

The number of faunistic studies in caves has increased recently in Brazil, mainly in caves of the State of São Paulo, which corresponds to the best known fauna of Brazil. Other regions of the country (viz., Pará, Goiás, Mato Grosso do Sul, and Bahia), started to be better known during the 90's (Pinto-da-Rocha, 1995). These efforts resulted in Brazil having the richest cave fauna (concerning number of taxa) of South America, although this knowledge (considering number of taxa) is still not comparable to countries of North America, like Mexico and United States (Pinto-da-Rocha, 1995). For instance, the number of troglobites recorded for Brazilian caves is still low (Gnaspini & Trajano, 1994) if compared to other countries; one single cave from Venezuela had about sixty coleopteran taxa (Trajano & Gnaspini, 1991). Besides, the best

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known fauna of Brazilian caves is that of limestone caves, both because they are the most numerous and generally also include the largest cavities (*cf.* Pinto-da-Rocha, 1995). Faunistic studies in cavities formed in other kinds of rocks, such as granite and sandstone, are scarce. Generally, it would be expected a faunistic composition of the non-limestone caves similar to that of limestone caves of the same region, because geographic distribution seems to be more important than the constituent rock (Uéno, 1977, Gnaspini & Trajano, 1994), although differences related to cave development may also influence the composition of the fauna, especially differences concerning the presence of troglobitic taxa.

Six out of twelve Brazilian speleological provinces are arenitic: Furnas, Itararé, Serra Geral, Altamira-Itaituba, Alto Urubu, and Espinhaço (Karmann & Sanchez, 1979; Trajano & Sánchez, 1994). The largest known arenitic caves are located in the Altamira-Itaituba (Pará State) and Serra Geral (São Paulo and Paraná States) provinces, which includes the caves from Altinópolis. The main faunistic studies including arenitic caves were those from Trajano (1987), also listing caves from Altinópolis, Gnaspini & Trajano (1994), which dealt with other caves from the Serra Geral Province (other than those of the Altinópolis region), and Trajano & Moreira (1991), which focused on caves from Pará State. The caves of Altamira-Itaituba and Serra Geral may be characterized by high atmospheric temperatures (including inside the caves) and high concentration of bats (Trajano, 1987; Trajano & Moreira, 1991).

The aim of this study is to characterize the arenitic cave fauna of Altinópolis, in which a series of large caves are present. This study improves the faunistic knowledge of the region, carried out 15 years ago by Trajano (1987), based on fragmentary samples.

Study Area

Altinópolis is a county in the northern region of the State of São Paulo (approximately 21°2.7'S 47°22.8'W), located in the High Paraná River Basin Domain (Radambrasil, 1983). The region represents the Northernmost part of the Botucatu formation, composed by reddish sandstone, with thin to medium grains, dating from the Jurassic (about 180 million years) (Petri & Fulfaro, 1983). Altinópolis region is geographically composed by a tenuous relief in which the highest elevations reach ca. 800 m. The region presents a tropical weather, with mean temperature about 36°C during summer (the rainy season) and 8°C during winter. The annual rain fall is about 1250 mm (Nimer, 1989).

Most of the caves are located in the area that belongs to "Votorantim Celulose e Papel" (VCP) (Águas Virtuosas and Fradinhos farms), a paper and cellulose plant which develops silviculture in that area, cultivating mainly eucalyptus. The county area is also occupied by plantations of sugar cane, and some smaller areas with different plantations (soybean and orange). The native forest was hardly wasted, being presently represented only by patches of secondary vegetation often concentrated around cave entrances and springs.

The sandstone caves of the region are often associated with shallow (ca. 0.3 m deep) and narrow (1-2 m wide) streamlets, which usually arise from the caves. Most caves are horizontally developed, only one is somewhat vertically developed although its horizontal extension is larger. A total of nine caves was sampled, five in the VCP region (Olho de Cabra, Fradinhos, Cinco Bocas, Prata, and Águas Virtuosas caves) and the other four in the same county (Itambé, Sertãozinho de Cima, Sertãozinho de Baixo, and Duas Bocas caves). A brief description of each cave is given below, the code SP-### refers to the number given for the cave in the national catalogue from Sociedade Brasileira de Espeleologia (1990). Description of caves includes data from Trajano (1987), Sociedade Brasileira de Espeleologia (1990, when available), and personal observations.

Olho de Cabra cave (SP-178, 21°07'25"S 47°24'47"W, altitude = 640 m, extension = 721 m): it is one of the largest sandstone caves of Brazil, and the largest of the region. There are two main galleries, one upstream and other downstream, and two entrances. The main entrance is lateral, allowing sunlight illumination to reach ca. 20 m from the entrance, and the second entrance is ca. 200 m downstream at the end of a narrow gallery (ca. 3 m wide). The galleries are about 15 m (main entrance) to 0.5 m (a labyrinthic gallery upstream) high. Environmental conditions inside the cave are rather constant throughout the year. A considerable number of bats is distributed all over its extension.

Fradinhos cave (SP-183, 21°07'06"S 47°25'38"W, altitude = 610 m, extension = 208 m): it includes a pair of parallel tunnels at different levels, one below the other. The inferior tunnel is larger, corresponding to a short open stream gallery in which sunlight is present, with two large (ca. 5 m) entrances. The height throughout the cave is 5-10 m. The superior tunnel is a dark and dry

gallery about 1.5-2 m height, with colonies of different species of bats (see results), with two entrances.

Cinco Bocas cave: (SP-184, 21°07'37"S 47°24'25"W, altitude = 655 m, extension = 218 m): this cave has five entrances, which allow enough sunlight to come in, therefore having no true aphotic zone. A streamlet is present in most of its extension.

Prata cave (not catalogued): it is a long and large cave with a stream, most of its extension is aphotic, and true cave abiotic conditions are seen. This cave resembles Olho de Cabra in extension, and many bat colonies are seen along the cave. The cave branches off upstream, ending in a long (estimated in more than 50 m) and narrow stream gallery, about 1-2 m wide and 0.5-1.0 m high, following a shallow streamlet, and housing many hematophagous bats. The cave is located in most preserved vegetation patch of the studied area.

Águas Virtuosas cave (not catalogued): the only known entrance to this cave is a hole of about 40 m deep and ca. 20 m in diameter. Inside the cave there are two sloped (about 30-45°) galleries, one of them dividing into two other galleries. Rock erosion formed the ground, constituted by a thick and soft layer of sand. There is no river, stream, lake, or any perennial water formation in this cave. Bat colonies seem to be reduced. Many bones of mammals, snakes, and other animals can be found in the collapsed sandy roof under the opening of the cave, where there is a tenuous vegetation.

Itambé cave (SP-179, 21°04'05"S 47°26"14"W, altitude = 650 m, extension = 355 m): this cave has a religious altar near the entrance and is the most visited cave of the region. There is a large entrance and a main gallery with a streamlet and some lateral connections.

Sertãozinho de Cima cave (SP-180, 21°03'54"S 47°26"00"W, altitude = 660 m, extension = 92 m): there are two galleries inside, the larger dry and the smaller with a stream.

Sertãozinho de Baixo cave (SP-181, 21°03'44"S 47°25"28"W, altitude = 655 m, extension = 316 m): the entrance leads to a stream gallery that ends in a superior gallery, dry.

Duas Bocas cave (not catalogued): cave with two large entrances that allow indirect incidence of light in its larger gallery, and a narrow, streamlet tunnel.

MATERIAL AND METHODS

Preliminary samples were performed at caves SP-179, SP-180, SP-181, and Duas Bocas cave in November/1998. The samples have been intensively performed in the five caves located at the VCP region, in several expeditions from February to June/1999. Caves were visited by 2-6 collectors for about four hours each. Animals were manually collected in their environments (ground surface, ground layer, walls, blocks, sediment patches, streams, organic accumulation patches). Bats were sampled with mist nets in two caves, Olho de Cabra and Fradinhos, as well as fish traps were used in Olho de Cabra and Cinco Bocas. Sediment samples were taken and processed in the Berlese-Tullgren funnel in the laboratory. Signs of animals like feces and footprints were also noted. The materials were preserved in 70% ethanol. All materials were sorted and identified in the laboratory. The specimens were sent to experts for identification, and they were incorporated to their collection. Specimens of taxa in which there is no expert are with the authors.

Faunistic composition

A list of taxa is given for each cave of the region in Table 1. The list includes relative abundance of the taxa (e.g., common or abundant) as well as ecological conditions (e.g. if it was found in guano, near the entrance) whenever judged necessary. A total of 83 taxa were observed, including 15 new records for Brazilian caves and 26 new records for Brazilian sandstone caves.

Biospeleological remarks

This study is the most complete faunistic survey of the Serra Geral speleological Province, in which 41 taxa listed herein were not recorded by Trajano (1987).

Trajano (1987) remarked that the formation of subterraneous cavities would be more likely in limestone regions and, consequently, these regions would provide a higher number of shelters in relation to sandstone regions. On the other hand, the relative low number of cavities in sandstone rocks would cause a high density of bats in the cave habitat. In fact, Brazilian sandstone caves seem to be shelter of numerous bat colonies. The high number of bats generates large deposits of guano which support a complex faunal community (cf. e.g., Trajano & Moreira, 1991). These ecological conditions are similar between the Arenitic Speleological Provinces of Altamira-Itaituba and Serra Geral. Consequently, cave

TABLE 1. Species (morphotypes) observed in the nine sandstone caves of Altinópolis region. Legend: OC, Olho de Cabra cave; It, Itambé cave; SC, Sertãozinho de Cima cave; SB, Sertãozinho de Baixo cave; Fr, Fradinhos cave; CB, Cinco Bocas cave; Pr, Prata cave; AV, Águas Virtuosas cave; DB, Duas Bocas cave; 1, first occurrence of the taxon in Brazilian caves; 2, first occurrence of the taxon in sandstone caves; X, presence of the taxon; A, abundant; C, common; *, first occurrence of the taxon.

Taxa	New Occurrences	Caves								
		OC	It	SC	SB	Fr	CB	Pr	AV	DB
Arthropoda										
Arachnida										
Araneae										
Sicariidae										
Loxosceles adelaida	2	A				A	A	A		
Theridiosomatidae										
cf. *Baalzebub* sp.								X		
Theridiidae										
Theridion hispidum							X			
cf. *Dipoena* sp.							C			
Uloboridae										
Miagrammopes sp.	1					X				
Pholcidae		C*								
Trechaleidae							C			
Araneidae										
Alpaida sp.	2	X				A		X		
Scytodidae				X						
Ctenidae				X*						
Isoctenus sp.	2	A					A			
Pholcidae				X*				X		
Opiliones										
Gonyleptidae										
Mitobatinae										
Discocyrtoides cf. *nigricans*							X			
Goniosomatinae										
Goniosoma sp.							X			
Pseudoscorpiones										
Chernetidae										
Spelaeochernes eleonorae		C*				C*	C*	C		
Acari		X				X	X			
Crustacea										
Isopoda		X				X*				
Diplopoda										
Polydesmida										
Pyrgodesmidae	2				X					
Spirobolida										
?Trigoniulidae	1	X				X	X			
Insecta										
Collembola										
Isotomidae										
Isotoma sp.							X			
Proisotoma sp.	1						X			
Cyphoderidae										
Cyphoderus sp.	2						X			X
Brachystomellidae										
Brachystomella sp.	2									X
Entomobryidae										
Lepidocyrtus sp.	2	X					X			
Heteromurus sp.	2					X				
Hypogastruridae										
Xenylla sp.	1					X				
Paronellidae										
Salina sp.	1	X				X	X		X	
Sminthuridae										
Sphyrotheca sp.	1	X	X		X		X	X	X	X

Contunuação

Taxa	New Occurrences	Caves OC	It	SC	SB	Fr	CB	Pr	AV	DB
Dicyrtomidae										
Ptenothrix marmorata		X								
Neelidae										
Neelus (Megalothorax) incertus		X								
Ephemeroptera					X					
Odonata										
Libellulidae										X
Blattaria		X*								
Blattellidae (ninfa)	2	X	X		X	C	X	X		X
Isoptera										
Termitidae										
Nasutitermitinae										
Velocitermes sp.	1						X			
Ensifera										
Phalangopsidae										
Endecous sp.		X	X		X	X	X	X		X
Psocoptera										
Psyllipsocidae	2	X	X				X			
Heteroptera										
Veliidae				X*						
Reduviidae										
Zelurus sp. (nymph)	2	X	X	X	X		X			
Homoptera										
Cicadellidae	2		X				X			
Trichoptera				X						
Odontoceridae	2		X							
Hydropsychidae							X	X		
Hydroptilidae	2					X	X	X		X
Coleoptera			X							
Carabidae	2				X		X			
Curculionidae							X			
Nitidulidae	2	X								
Staphylinidae						X*				
Gyrinidae	2					X				
Cholevidae										
Dissochaetus sp.	2	X								
Lepidoptera										
Tineidae	X*				A*	X*	X	X		
Diptera										
Mycetophilidae (larvae)	2	X								
Ceratopogonidae					X*	X*				
Chironomidae			C*		C*					
Phaenopsectra sp.	1							X		
Psychodidae (larvae and adults)			X*		X*	X*	X*			X
Tipulidae										
Polymera sp.							X			
Keroplatidae										
Neoditomyia sp.		X	X	X	X	X	X	X		
Sciaridae						X				
Phoridae		X*					X*	X		
Drosophilidae		X*	X*		X					
Sphaeroceridae	2	X								
Anthomyiidae	1	X					X	X		
Sepsidae	1	X								
Hymenoptera										
Formicidae			X*			X	X*			
Evaniidae	1	X				X		X		X
Cynipidae	2							X		

Contunuação

Taxa	New Occurrences	Caves								
		OC	It	SC	SB	Fr	CB	Pr	AV	DB
Proctotrupidae	1	X					X			
Chordata										
Teleostomi										
Siluriformes										
Trichomycteridae										
Trichomycterus sp.	2							X		
Characiformes										
Characidae										
Astyanax sp.	2						X			
Squamata										
Serpentes										
Boidae										
Eunectes murinus (not collected)	1					X				
Viperidae										
Bothrops sp. (skull)	1								X	
Aves										
Gruiformes										
Cariamidae										
Cariama cristata (skull)	1								X	
Mammalia										
Rodentia										
Agoutidae										
Agouti paca (footprints)		C				A*		A		
Chiroptera										
Phyllostomidae										
Desmodus rotundus		A	X	X*	X	A	A	A	A	A
Glossophaga soricina	2	X				X		X		
Carollia sp.		X*				X*				
Xenarthra										
Myrmecophagidae										
Tamandua tetradactyla (feces)		X*								
(skull)									X	
Carnivora										
Felidae (feces)		X*								
Mustelidae	2								X	
Procyonidae										
Procyon cancrivorous (footprints)	2					X				

communities of both regions are composed mainly by guano-feeding arthropods, scavengers and their predators (cf. Trajano & Moreira, 1991). In Altinópolis, these groups are represented by Collembola, Lepidoptera (Tineidae) and larvae of Diptera, (Psychodidae and Mycetophilidae) among the guano-feeding arthropods; crickets (mainly the genus *Endecous*) and cockroaches (Blattelidae) among the scavenges; and Coleoptera, Pseudoscorpiones (Chernetidae), spiders (Sicariidae), heteropterans (Reduvidae) and other mites among the predators.

There are no troglobites in the cave fauna of the region. The only animals with "regressive" morphological features are the eyeless cyphoderid collembolans (Duas Bocas Cave), and the Brachystomellidae with reduced eyes (although still present). However, these features may be also related to the soil habitat of the animals, not necessarily to the cave habitat. The absence of troglomorfism in the caves of Serra Geral may be related to the Geological events of those caves. Altamira-Itaituba, a region with many troglobitic taxa recorded (Trajano & Moreira, 1991), belongs to the Maecuru formation, a Carboniferous marine deposit that, according to Petri & Fulfaro (1983), were already exposed and has been resisting to erosion since Paleozoic times. This old history allows maintenance of cave habitat over long periods. On the contrary, in Altinópolis (Serra Geral Province), collapse of caves is a common event. This accelerated dynamism, causing instability of the cave habitats of the region, could constrain the evolution of troglobitic fauna in the region.

Our faunistic checklist presents a considerable number of taxa not recorded for Brazilian arenitic caves and even Brazilian caves as a whole. This result may be related with (1) the absence of faunistic surveys and/or (2) specific ecological features of the area. Considering the ecological features of Altinópolis, the native forest of the region has been hardly wasted. Presently, only patches of secondary vegetation around cave entrances are often observed. This condition possibly constrains the fauna to areas close to the caves and, occasionally, even invading the cavities. However, it is likely that any massive sample effort in the neotropical region will provide an increase of previously undetected biodiversity.

Itambé is the most visited cave by tourists, and its fauna is rather depauperate. Other (non-touristic) caves are better preserved, especially those located inside the region of VCP, for which visitation is restricted. This fact shall be regarded as an important policy for conservation purposes, especially because touristic interest in the region is increasing.

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RESUMO

A fauna de oito cavernas areníticas da região de Altinópolis (província espeleológica arenítica da Serra Geral, Estado de São Paulo, Sudeste do Brasil) foi amostrada. Nossos resultados aumentaram o conhecimento faunístico prévio da região, com o registro de 15 novas ocorrências para cavernas brasileiras e 26 para cavernas brasileiras em arenito. A fauna é caracterizada por um grande número de detritívoros/carnívoros tais como grilos e baratas, diversos predadores tais como aranhas e heterópteros no guano de morcego.

PALAVRAS-CHAVE: Fauna cavernícola, cavernas areníticas.

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(2) ***Abstract:*** All papers should have an abstract in English and another in Portuguese, regardless of the original language. The abstract is of great importance as it may be reproduced elsewhere. It should be in a form intelligible if published alone and should summarize the main facts, ideas, and conclusions of the article. Telegraphic abstracts are strongly discouraged. Include all new taxonomic names for referencing purposes. Abbreviations should be avoided. It should not include references. Abstracts should not exceed 350 words.

(3) ***Body of Text:*** The main body of the text should include the following sections: Introduction, Materials and Methods, Results, Discussion, and Acknowledgments at end. Primary headings in the text should be in capital letters and centered; the following text should begin on the next line, indented. Secondary headings should be in capital and lowercase letters and flush left; the following text should begin on the next line, indented. Tertiary headings should be in capital and lower case letters, in italics and indented; the following text should be on the same line and separated from the heading by a hyphen.

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