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The Impact of Geomorphology and Human Disturbances on the Faunal Distributions in Tiquara and Angico Caves of Campo Formoso, Bahia, Brazil

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Abstract

Characterization of fauna is important for the understanding of communities and ecosystems, enabling the design of actions for conservation. In the present piece of work, we identified total 45 morphospecies belonging to the order Acarina, Pseudoscorpionida, Dictyoptera, Araneida, Amblypygi, Isopoda, Plecoptera, Amphipoda, Zygentoma, Spirostreptida, Coleoptera, Collembola, Diptera, Ensifera, Heteroptera, Hymenoptera, Lepidoptera and Psocoptera from two distinct types of caves of Campo Formoso, state of Bahia in Brazil. It was made to provide subsidies for conservation studies. The targeted caves were Tiquara Cave suffered for many years from saltpeter extraction and Angico Cave less visited cave having high tourist potential. Though the conservation status is much better in Angico cave, but we found comparatively more morphospecies in Tiquara cave.

Introduction

North-eastern Brazil is home of longest caves where climate is semi-arid receive mean annual rainfall around 490 mm, concentrated between the months of February and May, and having mean annual temperature around 26°C . Vegetation comprises a sparse, low arboreal

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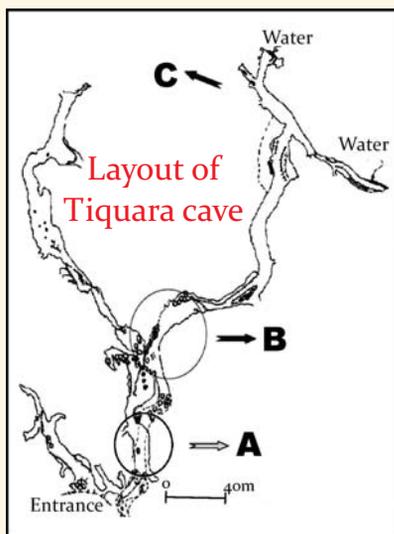
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Figure-1a: Tiquara Cave (credit, Auller 1996)

deciduous scrub land, known locally as *caatinga*, lies dormant and leafless over most of the year. Karst develops mostly in Proterozoic Una Group of carbonates. Both the targeted caves of the present study are located in the area Campo Formoso Karst. The entrance of Tiquara cave (40°32'15"S, 10°2703"W) is in the bottom of a subsidence sinkhole. The cave is 1010 meters long and comprises three main conduits which remain predominantly dry. Water is only lying in two small pools fed by a single conduit as its final discharge (Fig.-1a).

Due to the extraction of saltpeter by miners Tiquara cave remain effected for many years. Further, though it is nearer to the urbanization it receives indiscriminately large flow of tourists. Nevertheless, Angico Cave (10°2379'S, 40°29'989"W) is a limestone cave located in the geological formation of the Una Group and it is situated at around 26 kilometers far from urbanization. Here, next to the limestone outcrop it is surrounded by a typical fragment of dry vegetation common for karst regions. The cave has more than one entry with some detached rock and roof portions lying scattered inside. Most of the galleries have a high ceiling and at some places the cave roof is open to skylights that allow external light to enter directly inside the cave (Fig. 1b). This cave suffers less human disturbances, and is in a better state of preservation as compare to Tiquara Cave.

Since eighties of the previous century, various efforts have been made to survey the cave fauna of Brazil (Chaimowicz, 1984; 1986; Gnaspini & Trajano, 1994). In the recent years also remarkable discoveries on Brazilian cave fauna have been published, especially from the North-east caves (Trajano & Bichuette 2010; Bertani *et al.,* 2013; Prevorcnik *et al.*, 2012; Ázara & Ferreira, 2014). The occurrences of troglobites, high biodiversity and other peculiar ecological characteristics are some of the biological criteria accepted by the international community to determine the priority for protection of the underground passages (Trajano & Bichuette, 2010). However, the new Brazilian legislation for protection of caves is considered setback for the national speleological community. The creation of the Federal Decree No. 6,640 / 2008 , exchange the full protection of the natural cavities by the possibility of destruction of caves that does not fit on certain criteria (Figueiredo *et al.,* 2010).

In the present piece of work, our aim was to compare the composition, distribution and similarity among the communities of cave arthropods abiding in two distinct types of caves exist in the municipal district of Campo Formoso,
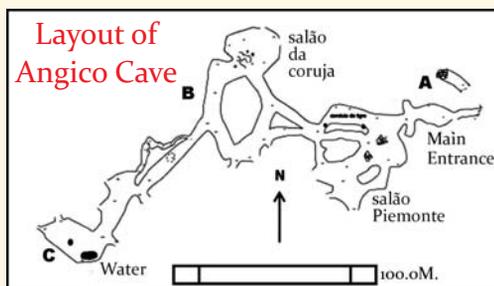

Figure-1b: Angico Cave

state of Bahia in Brazil. The possible reasons for faunal distribution with respect to various geophysical factors have been tried to understand.

Materials and Methods:

In the present study, a wide variety of techniques were employed for field collections. Careful visual searches were done with aspirators and brushes. With a variety of attractants, we used Pitfall traps baits. Aquatic fauna were collected by visual searching and drift net sets. The sampling period was January - July 2005 and tabulation was done during annual caving expeditions, 2008 to 2014 .

The collections and observations in both the caves were made with respect to three distinct zones (habitats). The Entrance zone (A), the intermediate zone (B) and the flooded Zone (C). During the collections, the approached size of each morphospecies population was observed and tabulated as follows: small size, less than 20 individuals; Medium size, 20 to 50 individuals; Large size, more than 50 individuals. For statistical analysis we used the index of abundance (Ia), obtained from the percentage of individuals of a given taxon to the total of individuals collected from all taxa found in the cave. Rating on Ia was made as per the following forms: abundant, 50% >Ia> 25%; frequent, 25% >Ia> 9%; rare, 9% >Ia> 2%; very rareIa< 2% (Bichuette & Santos, 1998).

Results and Discussion:

During survey we tabulated total 45 morphospecies belonging to the order Acarina, Pseudoscorpionida, Dictyoptera, Araneida, Amblypygi, Isopoda, Plecoptera, Amphipoda, Zygentoma, Spirostreptida, Coleoptera, Collembola, Diptera, Ensifera, Heteroptera, Hymenoptera, Lepidoptera and Psocoptera. In Tiquara Cave, 24 taxa were designated up to the family level while for Angico Cave, 19 taxa were designated so. Both the caves possessing the largest number of the species from the class Insecta followed by class Arachnida. In Tiquara Cave we tabulated 63% insects and 31% arachnids whereas in Angico Cave the percentage was 67 % and 31 % respectively (Fig. 2 a,b).

Figure 3. Arthropods percentage distribution in Tiquara Cave and Angico Cave.

Our results on morphospecies revealed that *Endecous* crickets (Phalangopsidae) and brown spiders *Loxoceles* are the most abundantly found species with numbers above 100 individuals. In both the caves, the above species were found in almost all the habitats and that the zone "A" of Tiquara Cave reported the largest population of brown spiders and both morphospecies showed little variation in population sizsize during the sampling period. The abundance index shows
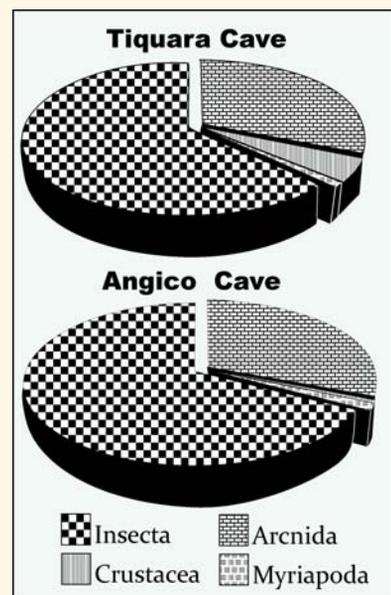
Fugure-3: Troglobites of Tiquara cave, a) *Coarazuphium sp.* (Coleoptera); b) - *Coletinia sp.* (Silverfish);
c) -*Spelaeogammarus sp.* (Crustacea)

Endecous sp. with relative abundance of 25 % at Tiquara Cave and 13% at Angico Cave whereas the brown spiders showed rates of 13 % in both the Tiquara as in Angico Cave.

Interestingly, from our collection all the three troglobitic arthropods were only found in the Tiquara Cave which were beetle (Carbidae: *Coarazuphium* sp.); silverfish (Nicoletiidae: *Coletinia* sp.); and the amphipod (Artesiidae: *Spelaeogammarus trajanoi*) (Fig.-4 a,b,c respectively). However, the abundance index of *Coarazuphium* sp. and *Coletinia* sp. are revealed very rare.

The Angico Cave represented a greater number of individuals as compared to Tiquara Cave. Irreversible impacts on the biota in cave environments can be caused by huge human disturbances, which are much higher than its carrying capacity (Scaleante, 2003). According to Ferreira & Horta (2001) changes that modify the cave system can deplete the overall population of many organisms which may also result in local extinction of many taxa.

Further, the size of species' populations in a given cave is closely related to the amount of available various energy resources (Bahia & Ferreira, 2005) and the Angico Cave have higher import opportunities due to the occurrence of various skylights (no roof) inside the cave and a greater amount bat guano deposition as compared to Tiquara Cave. The presence of skylights and cracks in the cave ceiling facilitate the accumulations of plant material and animal droppings that accidentally fall into the cave (Ferreira & Horta, 2001). The bat diversity found in Tiquara cave is smaller than the Angico Cave, which could be only due to the destruction of native forests once exist around it. However, the Angico Cave is surrounded by a dense relatively native forest.

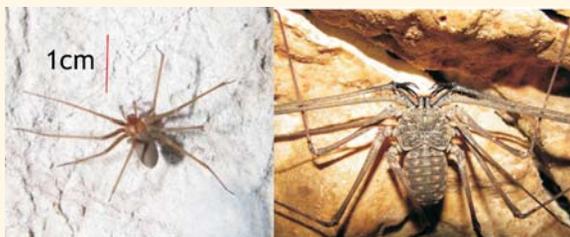Except for troglobites abiding in Tiquara Cave, the fauna found tabulated by us during the survey is consistent with what is found in other other parts of Brazilian caves (Trajano & Bichuette, 2010; Bichuette & Santos, 1998; Ferreira & Martins, 1999). The Coleoptera showed the highest diversity of morphospecies among insects, which represents by four families; Tenebrionidae, Scarabaeidae , Curculionidae and the beetle family Carabidae. The species recorded in

Figure- 5: - Morphospecies from Angico cave; a) *Loxoceles* sp. (Brown spider); b)- *Trichodamon* sp. (Amblipigy).

the present study are in agreement with relevant studies on the point that the beetles are the main representatives of the class insecta found in caves of Brazil (Rheims & Pellegatti-Franco, 2003; , 2003). According to Ferreira & Martins (1999), this high diversity of families is certainly due to the great diversity of potential settlers of epigeo environment.

Surprisingly we failed to f ind any representatives of Leiodidae and Dermestidae families as reported by Ferreira and Martins (1999), the most dominated families occupying the Brazilian caves. Further, among the most common Arachnida found in the caves of Brazil , we failed to notice only the opiliones.

Conclusively, all the tabulated troglobites of Tiquara Cave were found only in the 'C' sector, nearer to the flooded area. The sector although neither with the high food resources nor remain protected from human disturbances, but it is the area of the cave which remain wetter throughout the year.

The distribution of arthropods in the studied caves was as follows: in Tiquara Cave the largest number of morphospecies (sixteen) was found in the "A" sector i.e., the entrance zone, whereas in the Angico cave, the greatest number of morphospecies (featuring 23 morphospecies) was found to be in the intermediate zone (sector B). The rich diversity is always normal for the entrance zone as it works as an ecotone (transition area between the epigeo environment and hypogean) having in this area a community formed by epigean and hipogeos bodies, and a high rate of migration between the adjacent environment favors a great diversity in the transition area (Prous *et al*., 2004).

The sector "B" zone of Angico cave lies between a large skylight and the largest colony of cave roosting bats. The skylight favors entry of many organisms that fall accidentally and can survive because the conditions are close to the external environment. In addition, food sources are also rich around it. The resource type, as well as how it penetrates the system directly influences the distribution and diversity of cave fauna (Ferreira & Martins, 1999; Bahia & Ferreira, 2005). This is the only reason why we recorded the highest numbers of species from this particular zone.

The presence of a small population of amphipods (Class Crustacea), in the flooded part of Tiquara Cave was also noteworthy. Troglomorphic amphipods are not uncommon in Bahia, Boigidiellidae family representatives have been found in the caves of Iraquara (Camargo, 2004) and Artesiidae family in the caves of Campo Formoso (Auler 2001). Observations made during expeditions to Tiquara cave revealed marked variation in population size of amphipods which could be explained due to their seasonal reproduction phenomenon. Population studies in laboratory conditions for the species revealed a clear seasonal variation (Prato , 2006). Species of Prato (2006) on population density from the Northern Hemisphere (Italy) coincide with those observed here the maximum density achieved in the spring and summer seasons and minimum in autumn and winter.

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