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Survey topographic, environmental and invertebrate's occurrence of Santa Clara Cave, Jundiaí-SP, Brazil

(Ocorrência de invertebrados, levantamento ambiental e topográfico da Caverna Santa Clara, Jundiaí-SP, Brasil)

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ABSTRACT

The *Santa Clara* cave, located in the biosphere reserve of *Japi* Mountain range, is a remnant of the Atlantic Forest consisting of secondary forests in yellow podzolic soil and characterized by quartzite rocks. Officially protected by CONDEPHAAT, it has some unidentified invertebrate animals. The objective was to perform the topographic survey, the identification of the invertebrate fauna and the relationships between the environmental characteristics of the cavity with the taxon occurrence, in a period of one year, for the knowledge of the specific biome, and preservation. The results obtained characterize a cave composed of five distinct halls, with the occurrence of invertebrates distributed in 5 classes, 10 families and 12 species in a total of 252 taxon observed. The internal environmental relations and the taxon occurrence in the halls demonstrated the similarities and variations of occurrence related to the external environment. It was concluded that the *Santa Clara* cave represents a habitat with a topographic situation favorable to maintenance of invertebrate species, with a distinct occurrence between the entrance and the indoor halls. The interrelation of invertebrates presented a delicate balance. The survey carried out served as a basis for a proposal to preserve the cave environment.

Key words: Espeleology; Preservation; Cave fauna; Topography; Climatology

RESUMO

A caverna de Santa Clara, localizada na reserva da biosfera da Serra do Japi, é um remanescente da Mata Atlântica composta por florestas secundárias em solo podzólico amarelo e caracterizada por rochas quartzíticas. Oficialmente protegida pelo CONDEPHAAT, possui alguns animais invertebrados não identificados. O objetivo foi realizar o levantamento topográfico, a identificação da fauna de invertebrados e as relações entre as características ambientais da cavidade com a ocorrência do táxon, no período de um ano, para o conhecimento do bioma específico e sua preservação. Os resultados obtidos caracterizam uma caverna composta por cinco salas distintas, com a ocorrência de invertebrados distribuídos em 5 classes, 10 famílias e 12 espécies em um total de 252 táxons observados. As relações ambientais internas e a ocorrência do táxon nos salões demonstraram as semelhanças e variações de ocorrência relacionadas ao ambiente externo. Concluiu-se que a caverna de Santa Clara representa um habitat com uma situação topográfica favorável à manutenção de espécies de invertebrados, com uma ocorrência distinta entre a entrada e os salões interiores. A inter-relação dos invertebrados apresentou

um delicado equilíbrio. A pesquisa realizada serviu de base para uma proposta de preservação da caverna Santa Clara.

Palavras-chave: Espeleologia, preservação, fauna caverna, topografia, climatologia

INTRODUCTION

The Brazilian constitution in its laws, establishes as property of the union all the natural underground cavities of the national territory (BRAZIL, 1988). In 1990 Federal Decree 99.556 / 1990 established that all Brazilian caves should be preserved, with the integrity of their ecosystems guaranteed (BRAZIL, 1990), and *CONAMA* Resolution 347/2004 established the concept of "relevant natural Geographic isolation (V)" (BRAZIL, 2004 & BRAZIL, 2009). For the legal framework, it is necessary to evaluate ecological, environmental, scenic, scientific, cultural or socioeconomic attributes at a local and regional scale due to the characteristics of size, morphology or landscape values; geological, geomorphological or mineralogical peculiarities; archaeological or paleontological vestiges; endemic, rare or endangered species; water resources; biological diversity; cultural and tourism factors.

Brazil has one of the most valuable and diversified caving sites in the world, with caves that stand out due to their extension, beauty or scientific importance (SANTOS *et al*., 2002), the few studies lead to the unknown potential and consequent destruction (LEÃO *et al*., 2003).

The distribution of organisms in the cave environment may be influenced by the availability of food resources (FERREIRA & MARTINS, 1988). The food substrates for the maintenance of the populations enter the caves by the waters derivations that pass through their interior, winds or due to the behavior of the species of the environment. Many organisms colonize the entrance of the caves, and the size of the caves, as well as their composition of galleries and halls determine the distribution of some groups of organisms (FERREIRA & POMPEU, 1997).

The preservation and conservation of caves, speleological sites and their respective areas of influence aim to maintain these ecological systems, sensitive and differentiated. In the caves, it is possible to develop scientific studies; Leisure options (recreational, sports and contemplation practices), use such as tourism, sport, and its associated benefits; To record information on geological processes, to efficiently preserve information on past life through

fossiliferous and archaeological sites, and to conserve habitats of endemic and / or threatened species of fauna and flora (*ICMBIO* / *CECAV*) (BRAZIL, 2010).

This study was conducted with the objective of characterizing the *Santa Clara* cave, in its composition of salons, climatological characteristics and survey of the invertebrates found in each room, establishing the relation of occurrence of taxa and similarity characteristics between the salons.

MATERIAL AND METHODS

The *Santa Clara* Cave is in the *Japi* forest, between the countries of *Jundiaí*, *Pirapora do Bom Jesus*, *Cajamar* and *Cabreúva*, latitude 23º 13 '28.70"S / longitude 46º 53 '34.80"W. UTM Coordinates: 23K Zone, East 306323, North 7430372, Altitude 807.00. Geographic location is shown in Figure 1, and the entrance to the cave in Figure 1.1.

Font: wikipedia/São Paulo

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Figure 1. Geographical location of the "*Serra do Japi*"

For those in the study ecosystem, specific materials were used for speleology, guaranteeing the integrity of the members and researchers. In the field and in situ work, protective materials were used, following the protocols for speleological incursion and conducting research.

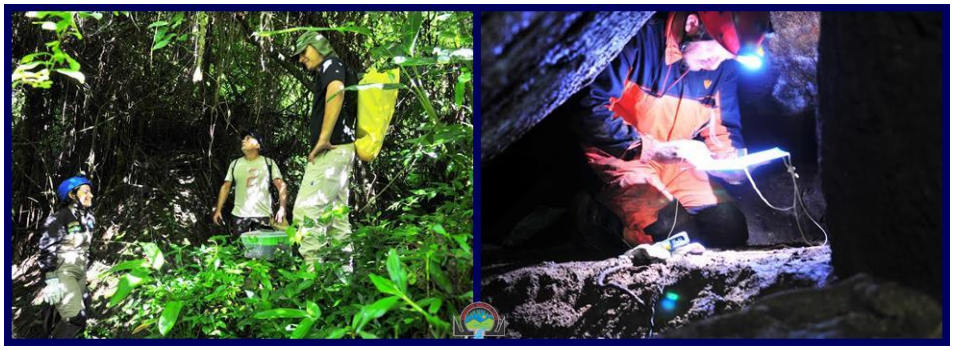


Figura 1.1: Cave entrance

The places of taxa occurrence, identified in the first incursion, were marked for monitoring the presence and possible changes in future visits. Taxon that could be identified at the site were not removed or collected to maintain the systemic population balance. Some taxa that could not be identified in the cave were collected.

For the capture of taxa, a collection methodology was used according to Ferreira (2004), covering the total area of the cave. Samples were collected manually, with the aid of tweezers, brushes, plastic bags and glasses (SOARES *et al*., 2013). For the observation, image capture was performed. The taxon that could not be identified at the site were captured and preserved in a 90% ethyl alcohol and 10% formaldehyde solution and sent for the laboratory of preventive veterinary medicine of the Federal University of Goiás, for later confirmation of the taxonomic identifications.

All procedures performed with the invertebrate animals were authorized by the *Chico Mendes* Institute for Biodiversity Conservation - *ICMBio*, N^{o}. 39736-1 (Authorization of scientific activities), issued based on Normative Instruction n.154 / 2007. Through authentication code n.15585444, authenticity verification in *Sisbio* / *ICMBio*.

Temperature data and relative humidity were obtained with the aid of Thermometer / Barometer Celestron, model treck guide MUD 48001, -x a + xºC +/- xºC; and a Itest Spit Thermometer, model TDP-4E. Range: -50°C to 300°C. Accuracy: ± 1°C (0-80°C) ± 5°C. GPS, Datum WGS84 was used to determine the geographic location.

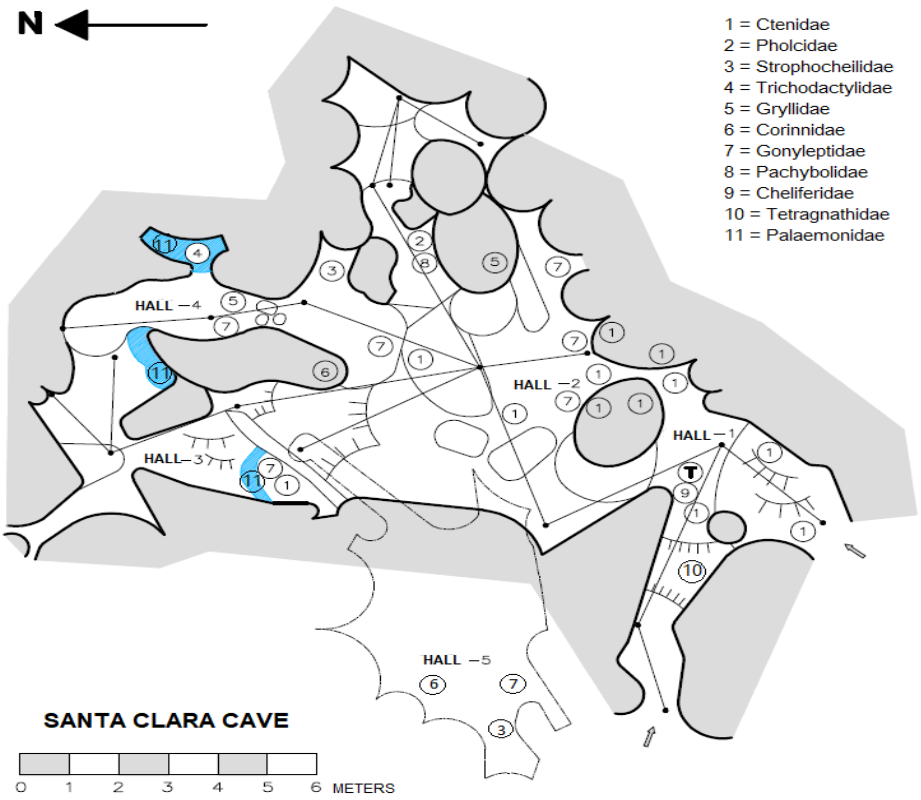
Twelve incursions were carried out in periods of one month for a year. The visitation periods have undergone changes due to the safety conditions and entrance in the caves, guaranteeing the integrity of the team and the obtaining of periodic data. Topographic survey of the caves was carried out with the determination of the component rooms and the taxa found in each room.

The R software (R, 2016) was used for the statistical analysis and evaluation of the results obtained. The environmental temperature data and relative humidity of the halls were evaluated by the statistical model of multivariate groupings analysis of qualitative dissimilarity measurements through the dendrogram by the UPGMA method, with the measure of Euclidean distance. The taxa and their distributions were evaluated through quantitative multivariate cluster analysis using the dendrogram by the UPGMA method with the Euclidean distance measure.

RESULTS AND DISCUSSION

The cave, located in a Private Preservation Area, presents good environmental preservation, since visits are restricted and prohibited. Anthropogenic impacts in the remnants of Atlantic Forest may be subject to accidental or criminal fire activities. At the last visit to collect data, in September 2014, there was a great burning in the region, with impact on the animals of the reserve, but no impact was detected inside the cave with respect to the environment and species inhabiting the cavity. Fernandes & Bichuette (2013) cited the negative impact caused by fires in the perimeters of cave environments, significantly affecting the animal populations established at the entrance of these biomes, which was not verified in the present study.

Topographic survey data indicated the presence of five distinct halls, with specific environment and structured populations, presented in Figure 2



. **Figure 2.** The cave, halls and occurrence of species

Temperature and relative humidity inside the cave in the halls changed during the year, showing that the first hall located near the opening of the cave suffered more variation, due to the influence of the variations of the exterior of the cave, the other halls presented a standard similar, although each has different temperatures due to the distance of the entrance, shown in Figures 3 and 4.

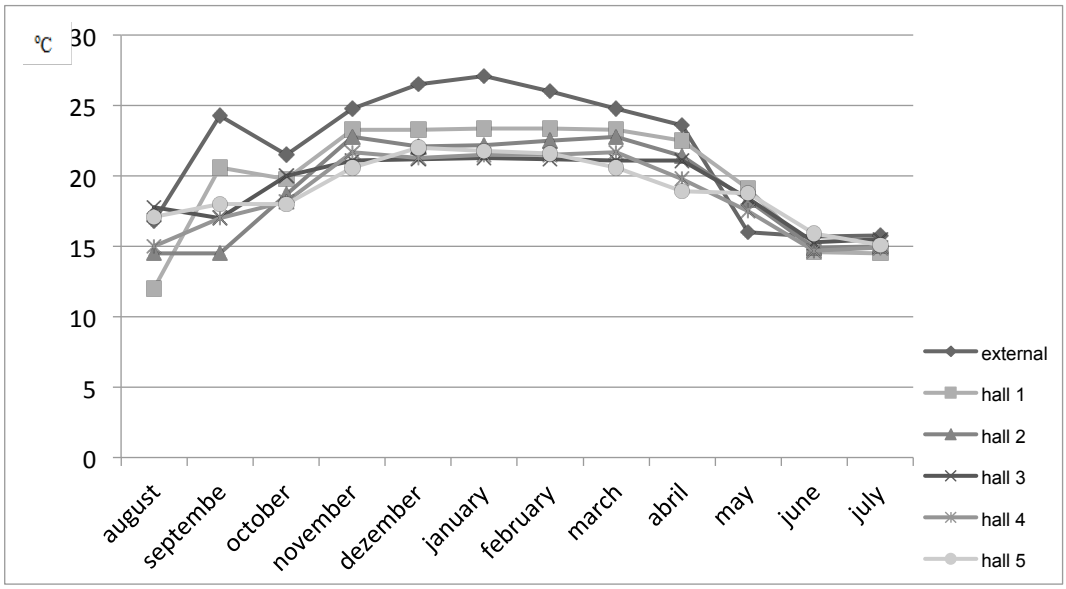


Figure 3. Temperature variation in cave halls

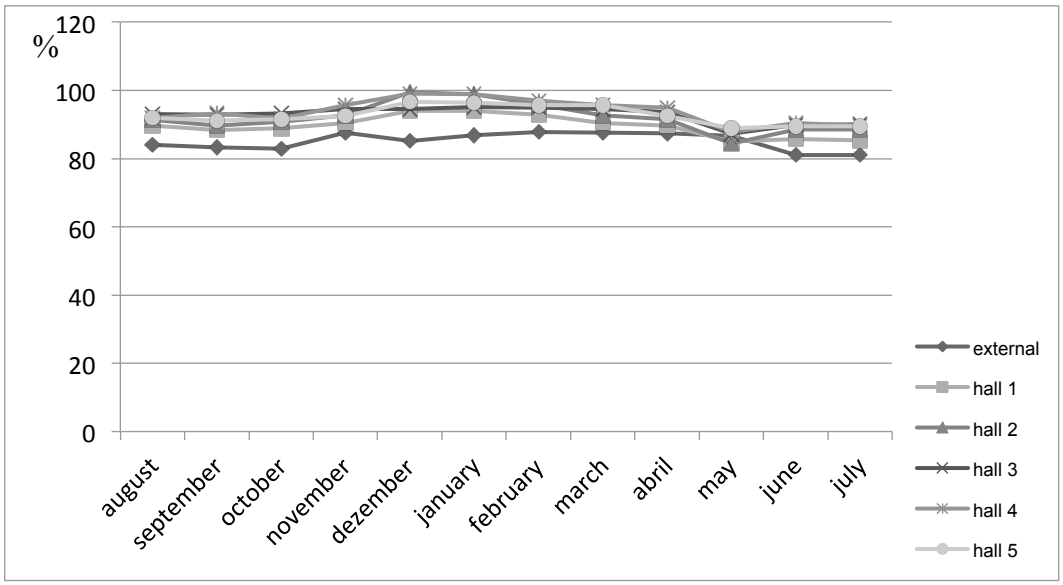


Figure 4. Relative humidity variation in cave halls

Souza-Silva (2008) found that humidity and temperature interfere with the occurrence and distribution of taxa in caves and are also related to variations in richness and abundance.

The *Santa Clara* cave temperature interfered in the taxon occurred, presented later with the occurrence of taxon in the halls.

Figure 5 analyzes of the quantitative dissimilarity measurements obtained by the dendrogram by the UPGMA method, constructed from the Euclidean distance of the temperatures.

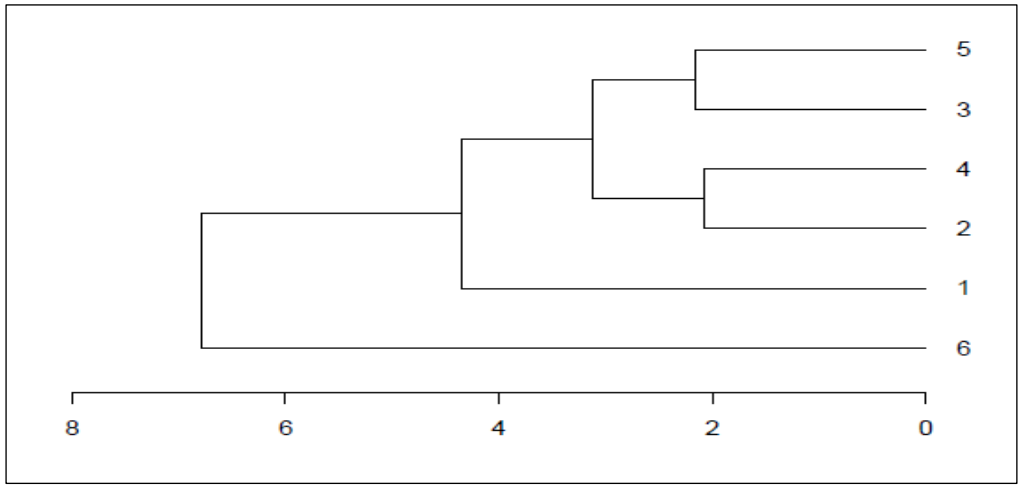


Figure 5. Dendrogram (UPGMA method), from the Euclidean distance of external temperature (n°.6) measurements and 5 halls of *Santa Clara* Cave.

The results showed the relationships between the halls, with the greatest similarity between halls 3 and 5, 2 and 4, different from hall 1 and the external environment.

Figure 6 analyzes the quantitative dissimilarity measurements obtained by the dendrogram by the UPGMA method, constructed from the Euclidean distance of the relative humidity.

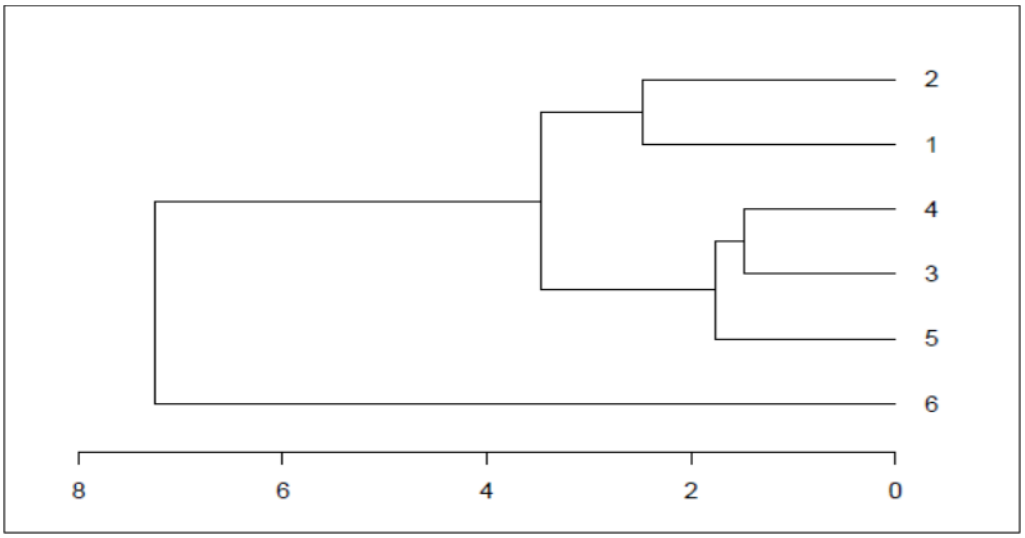


Figure 6. Dendrogram (UPGMA method), from the Euclidean distance of relative humidity measurements of the 5 component halls of *Santa Clara* Cave and external environment (6)

Euclidean distance analysis of relative humidity showed that halls 3 and 4 were more similar, different from halls 1 and 2 that also presented similarities in the values of humidity. Hall 5 presented greater similarity to halls 3 and 4,

and did not present significant difference between all the other rooms. The external environment presented the biggest difference, and on the Euclidean scale, more distinct than the other salons.

The analytical values of quantitative dissimilarity measurements obtained through the dendrogram by the UPGMA method from the Euclidean distance of the atmospheric pressures are presented in Figure 7.

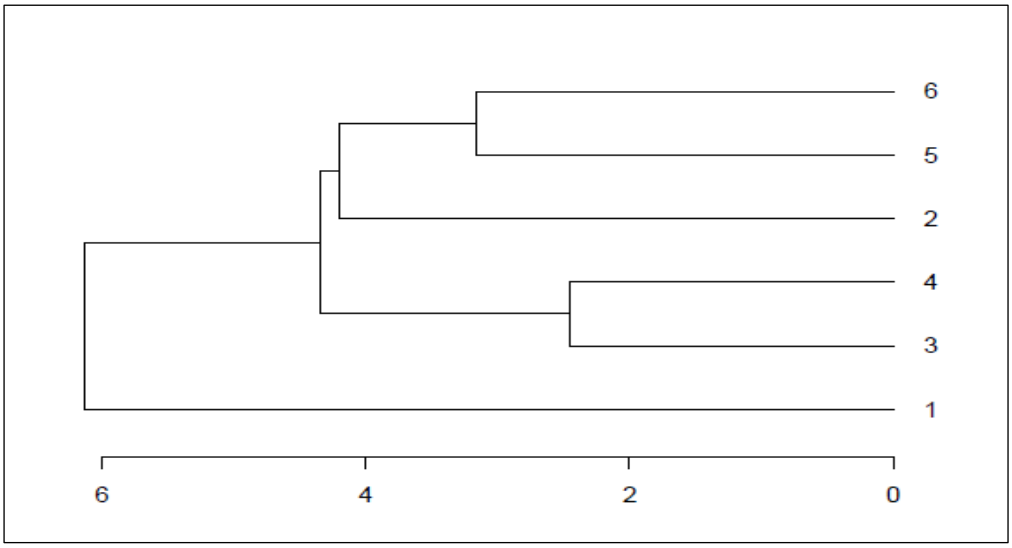


Figure 7. Dendrogram (UPGMA method), from the Euclidean distance of atmospheric pressure measurements of the 5 component halls of *Santa Clara* Cave and external environment (6).

The results of halls 3 and 4 presented a greater similarity compared to hall 2, and the latter had greater similarity with halls 5 and 6 (external). The external environment presents greater difference between the different salons.

In one-year period the occurrence of the taxa in the cave were identified, preserving the integrity of the balance of the community of invertebrates, according to the protocol of minimum impact established. The species identified are shown in Table 1.

Table 1: Identification of the taxa found, monthly in the year period.

Class / Family	Species (Scientific name)	aug	sep	oct	nov	dez	jan	feb	mar	apr	may	jun	jul	aug	sep
Arachnida															
Cheliferidae	*Cheliferidae* sp.	1													1
Corinnidae	*Corrinanitens* sp.						2	1				5			
Ctenidae	*Enoploctenus* sp.		3			1						1	2	3	8
Ctenidae	*Isoctenus* sp.	4													
Ctenidae	*Phoneutria* sp.						1								
Gonyleptidae	*Acrogonyleptes* sp.	8	8	15	4	5	4	3	2	5	8	15	17	15	21
Pholcidae	*Mesabolivar* sp.			2											
Tetragnathidae	*Tetragnatha* sp.		2				1								
Diplopoda															
Pachybolidae	*Centrobolus annulatus*	7			4	5			3	3					2
Gastropoda															
Strophocheilidae	*Megalobulimus* sp.	1			1							3	2		1
Insecta															
Grylidae	*Endecous* sp.	3		3		1						5	5	4	4
Malacostraca															
Trichodactylidae	*Trichodactylus petropolitanus*									4					2
Palaemonidae	*Macrobrachium carcinus*	2		5		3			1	1	3		2	2	2

A total of 252 invertebrates were collected, distributed in 5 classes, 11 families and 13 species. The identified taxa did not abundance significant changes of individuals during the year period, showing that the populations are in equilibrium possibly related to the climatic characteristics and the low and constant availability of food substrate. The variation of some species was verified between the halls during the year.

In the first hall was found a greater amount of trogloxenes and troglophile taxa, alive or dead residues of these animals. In the lodges located further to the inside cave, the occurrence decreased with the occurrence of troglobium populations.

Figure 8, shows the dendrogram of the Euclidean distances of the measurements of occurrence of taxa in halls 1,2,3,4 and 5.

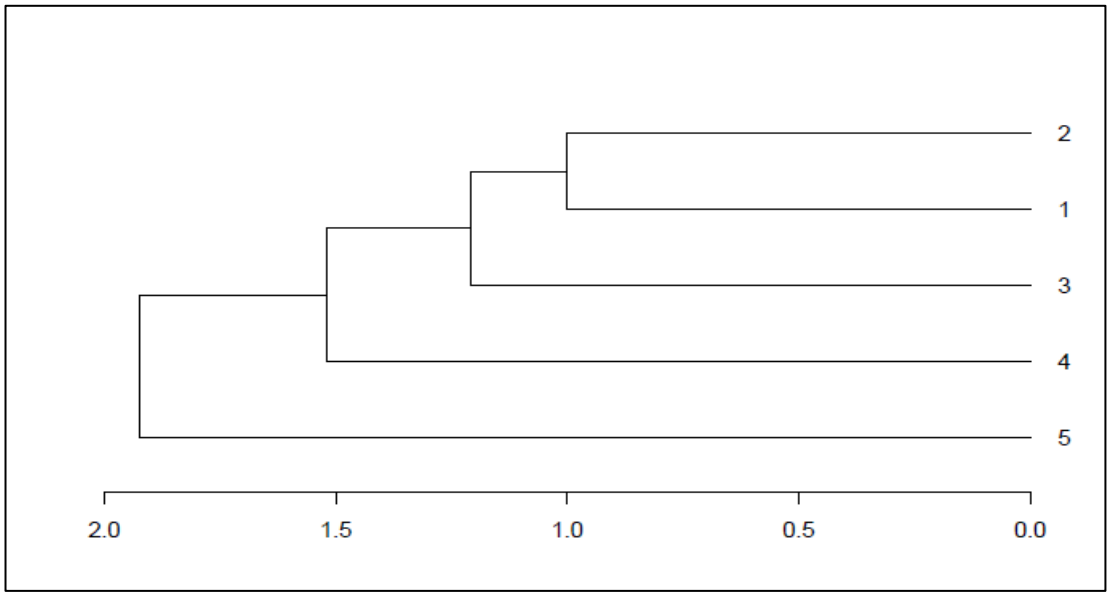


Figure 8. Dendrogram (UPGMA method), from the Euclidean distance of occurrence measurements of taxon of the 5 component halls of the *Santa Clara* Cave.

The survey of taxa occurrence showed that the cave has a balance in its population, based on the verification of population stability possibly related to temperature and humidity.

The highest amount of taxon of the same species found was of opilions (*Acrogonyleptes* sp). This species is commonly found in caves. A decline in population was observed in the months between November and May, with the subsequent re-establishment of the population. Some taxa in months were not identified, if in unobserved months, they were hidden in specific niches with the impossibility of visualization or capture. The fluctuation of the taxa must be considered in the dynamics of each population and in the data, that were obtained by sampling, with a previously fixed evaluation area and the widest possible within each hall, considered throughout the experiment. Due to the size of the cave, it would be impossible to evaluate all the individuals of each species, due to the unfeasibility of the collection, as well as to the impact that such sampling methodology could have.

The highest number of taxa were Arachnida class with 61.91% of them. Of the other species most verified, they are to *Centrobolus annulatus* with 9.53% and *Endecous* sp with 9.92%. These taxa are often found in geological cavities (TRAJANO & BICHUETTE, 2010). In the water resource, a large quantity of crustaceans was also collected in the interior of the cave, with two distinct

species: *Trichodactylus petropolitanus* with 2.4% and *Macrobrachium carcinus* with 8.33% showing the permanent watercourse.

The survey of invertebrates distributed in halls 1 to 5 showed that the number 02 showed the highest number of taxa: Pachybolidae and Gryllidae the most abundant. Hall number 01 presented the second largest number of taxa, and of these invertebrates, the largest number was arachnids (Ctenidae, Pholcidae, Corinnidae), opilions (Gonyleptidae) and millipedes (Pachybolidae). The temperature and average relative humidity suffered the biggest changes comparative to the other rooms. Halls number 03 and 04 presented the third largest number of taxa and the averages of temperature and relative humidity were the most stable, close to those observed in hall 02.

The other taxon families presented similar occurrence by all the hall. The variations of occurrence in the year periods are related to the presence of the taxon in the areas, but in all halls, at least at one moment of observation were detected. Ferreira *et al*. (2010) verified the association between relative humidity and species richness inside caves, since the low humidity is related to the low availability of resources, significantly affecting this richness, but the high humidity helps to accelerate the decomposition processes of the organic material Within the caves, favoring the faster flow of energy and the maintenance of the various taxa. Despite the variations observed in the experiment, the values of relative humidity remained high, always above 80% RH, favoring the establishment of the taxa verified in the *Santa Clara* Cave. The lower amount of taxon in the innermost halls is possibly not related to relative humidity but to the availability of food substrate.

CONCLUSION

The *Santa Clara* cave represents a habitat with environmental stability and a topographic situation that favors the maintenance of common invertebrate species in this ecosystem. Of 252 specimens of invertebrates collected, through taxonomic studies, were distributed in 5 classes, 11 families and 13 species. In the water resource were collected *Trichodactylus petropolitanus* (2.4%) and *Macrobrachium carcinus* (8.33%), demonstrating that the cave has water throughout the year. The invertebrate's interrelation presented a delicate balance. The relative humidity is related to the food substrate decomposition, which provided higher taxa amounts in the halls with greater substrate availability, closer to the entrance of the cave. The survey carried out in a period of one year served as a knowledge base and

will be to establish policies to preserve the studied cave environment.

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