

Cave macroinvertebrates used as bioindicators of water quality

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Abstract

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Caves are very fragile systems which are influenced by specific biogeographic and ecological patterns that maintain unique species of fauna, flora, and microbiota. One cave species, macroinvertebrates, represents a heterogeneous group of animal taxa which is in constant danger of extinction, principally due to anthropogenic activities. Macroinvertebrates have been widely used as bioindicators of the quality of biogeographic zones, ecosystems, and protected areas, as well as to determine protected species. The Boca del Río Cave is located in the biogeographic transition zone in Mexico's Neotropical region, and is home to a large enclave of different biotic elements. Twenty-nine organisms were collected and grouped into 19 families based on their morphological and physiological characteristics. The coefficient of taxonomic work (CTW) indicates that the taxonomic level *family* is the most consistent for all of the organisms collected. The *Coenagrionidae* family was the most abundant in the study. The BMWP, ASPT, and SCI biotic index scores indicate that the water in the Boca del Río Cave is slightly contaminated, while the Family Biotic Index (FBI) indicates poor water quality with very substantial organic

Resumen

Galindo-Pérez, E. J., Chávez-Sandoval, B. E., Espinoza-Graciano, E., Flores-Martínez, M. C., Villeda-Callejas, M. P., Bhalli, J. A., Tejocote-Pérez, M., & García-Franco, F. (septiembre-octubre, 2017). Macroinvertebrados de cuevas utilizados como bioindicadores de calidad del agua. *Tecnología y Ciencias del Agua*, 8(5), 5-17.

Las cuevas son sistemas frágiles, influenciados por patrones ecológicos y biogeográficos particulares, que mantienen la flora, fauna y microbiota de especies únicas. Entre los organismos de las cuevas, los macroinvertebrados representan un grupo muy heterogéneo, en constante riesgo de extinción, en particular por la acción de las actividades antropogénicas. Los macroinvertebrados han sido ampliamente utilizados como bioindicadores de calidad de zonas biogeográficas, ecosistemas y áreas protegidas, también para determinar especies protegidas. La Cueva Boca del Río se localiza en la región biogeográfica neotropical mexicana, enclavada en la zona de transición, importante enclave de diferentes elementos bióticos. Se colectaron 29 individuos, y con base en sus características morfológicas y fisiológicas se agruparon en 19 familias. El coeficiente de trabajo taxonómico (CTW) indica que el nivel taxonómico de familia es la más consistente para todos los organismos colectados. La familia *Coenagrionidae* fue la más abundante en el estudio. Los índices BMWP, ASPT y SCI indican que la calidad del agua en la cueva Boca del Río está ligeramente contaminada, mientras que el índice FBI considera una baja calidad del agua con contaminación orgánica muy sustancial. La diversidad de familias de macroinvertebrados confirman que la cueva Boca del Río es un importante refugio para la fauna en la zona de transición mexicana,

pollution. The diversity of macroinvertebrate families confirms that the Boca del Río Cave serves as an important refuge for fauna in the transition zone located in Mexico's Nearctic biogeographic region. This report represents the first study to use bioindicators to analyze the water quality of a cave system, and contributes to the inventories of macroinvertebrate cave fauna.

Keywords: Subterranean insects, water quality, biotic indices, transition zone, endemic lineages, troglobionts, stygobionts, bioindicators.

en la región biogeográfica Neártica. Este informe representa el primer estudio de la calidad del agua de un sistema de cuevas a través de bioindicadores y es una contribución a los listados de fauna cavernícola de macroinvertebrados.

Palabras clave: insectos de cuevas, calidad de agua, índices bióticos, zona de transición, linajes endémicos, troglobiontes, stygobiontes, bioindicadores.

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Introduction

The freshwater ecosystems in both surface and groundwater are the main sources of freshwater in the world. However, surface water represents 1.2%; ground water, 30.1%; polar ice and glaciers 68.7%. Only a small fraction of existing fresh water, almost entirely stored in aquifers (United Nations Environment Programme (UNEP, 2008). Aquifers are highly efficient interfaces with surface water through allogeneic charges, internal runoff, diffuse infiltration, recharge perched basins, and some of these structures are associated with the formation of subterranean caves (Bertelli, Dos Santos, & Bichuette, 2013).

Caves serve as collection sites for rainwater, table conditions, act as natural laboratories of biological evolution, and maintain the fauna, flora and the microbiota of unique species (Griebler & Lueders, 2009; Taylor & Holsinger, 2011; Weigand, 2013). Cave systems also have acted as a refuge for many species providing special evolutionary conditions, including regressive evolution (Villacorta, Jaume, Oromí, & Juan, 2008; Jeffery, 2009; Juan, Guzik, Jaume, & Cooper, 2010).

Worldwide there are between 10,000 and 100,000 species of obligate subterranean terrestrial species (troglobionts) and aquatic species (stygobionts). A few fishes and salamanders

are included in this group but the vast majority are macroinvertebrates, especially arachnids, beetles, nematodes, mollusks, and crustaceans. These organisms have different morphological, physiological, and ethological characteristics, acquired during the historical events and adaptations to these dark and isolated environments. They are endangered, mainly by anthropogenic activities (Ubick, 2001; Culver & Sket, 2002; Tierney *et al.*, 2015).

Mexico has over 7 000 caves of various formations and sizes that are habitats for a great diversity of species like troglobions, troglóphiles, and troglóxenes contributing to biodiversity and endemism in the country, which are among the highest in the world. This is due to the physiographic, climatic, and ecological complexity of the country and a particular placement within the Nearctic and Neotropical biogeographic regions.

Therefore, the ecological conditions of both biogeographic regions overlap, resulting in the Mexican Transition Zone (MTZ), where there is a very high concentration of endemic species and biodiversity. The presence of high diversity and endemism is particularly remarkable in the region of the Pacific Southwest, considered as a Pleistocene refuge (Hoffmann, Palacios-Vargas, & Morales-Malacara 1986; Myers, Mittermeier, Mittermeier, Da Fonseca, & Ken, 2000; Hoffmann, López-Campos, & Vásquez-Rojas, 2004;

Llorente-Bousquets & Ocegueda, 2008; Morrone & Márquez, 2008; Morrone, 2015).

The presence or absence of certain species in ecosystems has proven to be a very effective tool for detecting the level of disturbance, especially because of the anthropogenic activities. Some species are very tolerant of environmental change and human pollution, while others are too sensitive to these changes (Clesceri, Greenberg, & Eaton, 1999; Mafla, 2005; Bustamante, Monsalve, & García, 2008; Tione, Bedano, & Blarasin, 2011; Riley, Gerba, & Elimelech, 2011). Because of this, they have been widely used as bioindicators to determine the disturbance of ecosystems, establish protected areas, define biogeographic regions, and especially to determine water quality. Thus, some of these species are listed as protected species (Hamilton-Smith, 2001; Morrone, 2009; Corona-López, Toledo, & Morrone, 2009; De Walt *et al.*, 2012).

Biological indicators identify at least 100 indices developed over the past ten years, of which about 60% are based on macroinvertebrates. Therefore, the suitable indices are calculated and standardized to assign values to water quality (Malard, Plenet, & Gibert, 1996; Mandaville, 2002; Mathuriau, Mercado, Lyons, & Rivera, 2012).

This report is a contribution to listings of the macroinvertebrate fauna of caves in the Neotropical Region of Mexico, and particularly to the Transition Zone. Also, represents the first study of water quality in a cave in Mexico using biotic indices.

Material and methods

Localization of Boca del Río Cave

The State of Guerrero is located within the biogeographic Neotropical Region, which spans the Caribbean, Central and South America (figure 1, top). The municipality Chilpancingo de Los Bravos is located in the Central region of Guerrero State, and is the seat of the capital of the state that bears the same name Chilpancingo

de Los Bravos (INEGI, 2010). Boca del Río Cave Apetlanca is located in the town of Acahuizotla, in the south of the State capital Chilpancingo de Los Bravos, at coordinates 17° 22' 60" N; 99° 27' 0" W (DMS). This cave has a length of 2576 meters and a depth of 137 meters (figure 1).

Sampling method

Two periods of sampling were conducted in the cave Ahuizotla, from 21 to 25 February and from 11 to 14 November 2011. Three sampling sites were established: Station 1, entrance; Station 2, first steep (drop off) to 150 meters distance from the entrance; Station 3, second steep (drop off) to 320 meters from the entrance (figure 1).

The aquatic arthropods were collected randomly with a metal landing net, the insects were taken with entomological tweezers and brushes (Barbour, Gerritsen, Snyder, & Stribling, 1999). Water temperature was 19 °C with pH ranging between 6 and 6.5 and the maximum depth in the pools was 2.5 m.

Taxonomic characterization

The macroinvertebrates were preserved in 70% alcohol, these are result of except crustacean adults that were fixed in 40% formalin, and the entire collection was transferred to the laboratory, to be identified using morphological keys (Usinger, 1956; Needham, 1981; Borror, Triplehorn, & Johnson, 1989; Westfall & May, 2006; Hanson, Springe, & Alonso, 2010; Miller & Montano, 2014).

The following indices were applied, to quantify the status of the water quality of the studied system.

The coefficient of taxonomic work (CTW)

The index enables the assessment of taxonomic collections indicating the adequate taxonomic level.

Equation (1) determines the value of CTW:

$$CTW = Dt / T \quad (1)$$

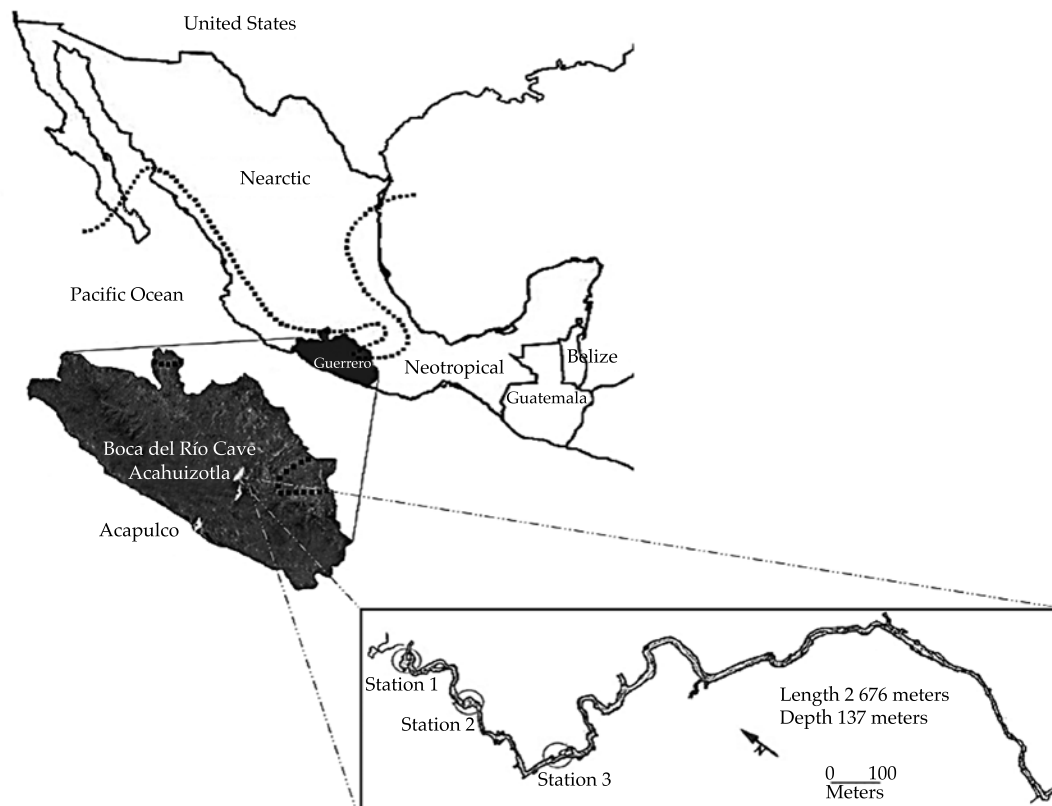


Figure 1. Location of Boca del Río Cave. Top, a map of Mexico, dotted line indicates confluence between biogeographical regions Nearctic and Neotropical. Down, Boca del Río Cave in the State of Guerrero. Below, in rectangle, topographic map of Boca del Río Cave circles represents sampling stations (image modified from Engler, 1982).

Dt = number of characterized families (families with the specific name).

T = a total number of families (any family).

When the CTW value is close to one this indicates appropriate taxonomic knowledge of the taxon, when it is close to zero this denotes inadequate taxonomic knowledge, because most of the collected organisms are only considered morpho-groups (Navarrete-Heredia, 2006; Naranjo-López & Navarrete-Heredia, 2011).

The biological monitoring working party for Colombia (BMWP/Col)

BMWP/Col originally adapted by Armitage, Moss, Wright and Furse (1983), and Alba and Sánchez (1988), and later developed for families

of macroinvertebrates of the Neotropical Region in Colombia by Roldan (1999), Zamora (2007) and Vergara (2009). It is based on the level of tolerance of macroinvertebrates to pollution, using the family level as an appropriate taxon. The absence of macroinvertebrate families that are intolerant to pollution is considered as a strong indicator of environmental biological alteration, accord to the chart of values and colors of level of water quality BMWP/Col (table 1).

The family biotic index for El Salvador (FBI/SV2010)

This is an index adapted from original index FBI developed by Hilsenhoff (1988) for macroinvertebrates of the Neotropical Region of the El Salvador (Sermeño *et al.*, 2010).

This provides an average of tolerance values for all families within the sample and allows water quality rating according to the chart for water quality to El Salvador (FBI/SV2010) (table 1).

Average score per taxon (ASPT/Col) index

This index reflects the quality of the environment for each site using an increase in the gradient of anthropogenic impact on aquatic ecosystems described in fresh waters of the Neotropical Region in Colombia (Arango *et al.*, 2008).

The score total for index ASPT corresponds to the level of water quality in chart of values ASPT/Col (table 1).

Sequential Comparison Index (SCI)

This index is employed for a simple stream quality method, which is relative on estimates of differences in biological diversity by color, size, and shape. This is called the diversity index (ID). The preserved collection of fauna from a sampling station is randomized by gently shaking the collection jar. Thus, the total number

of different pairs identified (“total runs”) is divided by the total number of organisms collected. This calculated number (ID) is multiplied by the number of different taxa (different kinds of organisms) to give the Diversity Index Total (DI_T) or final SCI index (Cairns & Dickson, 1971).

The DI_T value is interpreted in the chart of water quality corresponding to SCI, adapted of the original values of Cairns and Dickson (1971) by Saldaña *et al.* (2001) in streams in the Neotropical Region Mexico.

Clean rivers with high diversity and a balanced density generally have high index values (> 12) whereas polluted water bodies with a poor community structure generally have low index values (< 8). Intermediate values of 8 to 12 are the indication of moderately polluted waters (Saldaña *et al.*, 2001), as shown in table 1.

Results

Organisms collected and taxonomic characterization

A total of 29 aquatic macroinvertebrates were collected and, using taxonomic keys, were

Table 1. Cartography of the water quality for the indices, BMWP, ASPT, FBI and SCI.

BMWP/Col (Roldan, 2003)		ASPT/Col (Arango <i>et al.</i> , 2008)		FBI/SV2010 (Sermeño <i>et al.</i> , 2010)			SCI (Saldaña <i>et al.</i> , 2001)	
Index value	Water quality	Index value	Water quality	Index value	Water quality	Organic contamination	Index value	Organic Pollution
≥ 121	I. Dark blue = very good	> 9-10	Dark blue = very clean	0.00-3.75	1. Dark blue = excellent	Unlikely	> 12	Good quality
101-120	II. Clear blue = good	> 8-9	Clear blue = unpolluted	3.76-4.25	2. Clear blue = very good	Slight likely		
61-100	III- Green = acceptable	> 6.5-8	Green slightly = polluted	4.26-5.00	3. Sky blue = good	Some likely	< 8	Contaminated
36-60	IV. Yellow = doubtful	> 3- 4.5	Yellow = moderately polluted	5.01-5.75	4. Green = fair	Quite substantial is likely		
16-35	V. Orange = critical	> 4.5-6.5	Orange = heavily polluted	5.76-6.50	5. Yellow = fairly poor	Substantial is likely		
∞	VI. Red = very critical	1-3	Red = strongly polluted	6.51-7.25	6. Orange = poor	Very Substantial likely	< 8	Contaminated
				7.26-10.00	7. Red = very poor	Very substantial likely		

assigned to 11 families, seven genera, and four species.

The highest density and diversity were found at Station 3, with 21 macroinvertebrates belonging to seven different families. Six organisms corresponding to two families, and only two macroinvertebrates of two different families were found at Station 1.

The family *Coenagrionidae* was the largest, with 10 individuals collected (table 2).

The coefficient of taxonomic work CTW

Coefficient of taxonomic work calculated for species shows a value of 0.36, which represents a low fidelity value in the identification of species, with *Argia cuprea* being the most abundant species, with ten specimens.

However, the CTW indicator for the families show a value of 1.0, *Coenagrionidae* was the most being the most abundant family.

Biologically monitoring working party (BMWP)

Based on the chart BMW/Col of assigned values of the level of tolerance of macroinvertebrates to water pollution, each family of macroinvertebrates collected from Boca del Río Cave was assigned a respective value (table 3).

The sum of assigned values for all families collected in the Cave Boca del Río is 81. According to the chart of values of level of water quality BMWP/Col (table 1), the score of 81 corresponds to a level of water quality type III, with quality acceptable, and cartography of green color.

Table 2. Sampling and taxonomic characterization of macroinvertebrates found in Boca del Río Cave, in three sampling sites (station 1, 2 and 3).

Common name	Identified family	Identified genus	Identified species	Organisms collected from sites		Identified life stages
Diving beetles	<i>Dytiscidae</i>	Not identified	Not identified	1	Station 1	1 Aquatic adults
Freshwater crabs	<i>Pseudothelphusidea</i>	<i>Pseudothelphusa</i>	Not identified	1	Station 1	1 Aquatic adults
Spread-winged damselflies	<i>Lestidae</i>	<i>Archilestes</i>	<i>Archilestes grandis</i>	4	Station 2	2 Aquatic naiad 2 Terrestrial adults
Water scavenger beetles	<i>Hydrophilidae</i>	Not identified	Not identified	2	Station 2	2 Aquatic adults
Damselflies	<i>Coenagrionidae</i>	<i>Argia</i>	<i>Argia cuprea</i>	10	Station 3	2 Aquatic naiad 8 Terrestrial adults
Broad-winged Damselflies	<i>Colopterygidae</i>	<i>Heterina</i>	<i>Heterina occisa</i>	2	Station 3	1 Aquatic naiad 1 Terrestrial naiad
Mayflies	<i>Heptageniidae</i>	<i>Stenonema</i>	<i>Stenonematra</i>	1	Station 3	1 Aquatic larva
Dobsonflies	<i>Corydalidae</i>	Not identified	Not identified	1	Station 3	1 Aquatic larva
Creeping water bugs	<i>Naucoridae</i>	<i>Cyphocricos</i>	Not identified	2	Station 3	2 Aquatic nymphs
Broad shouldered Riffle bugs	<i>Veliidae</i>	<i>Ragovelia</i>	Not identified	2	Station 3	2 Aquatic adults
Water striders	<i>Gerridae</i>	Not identified	Not identified	3	Station 3	3 Aquatic adults
Total	11	7	4	29	3	6

Table 3. Assignment chart for index values BMWP/Colombia to aquatic macroinvertebrates

Families of macroinvertebrates collected in Boca del Río Cave	Assigned value BMWP/Col (Roldan, 2003)
<i>Heptageniidae</i>	10
<i>Coenagrionidae</i>	7
<i>Lestidae</i>	8
<i>Calopterygidae</i>	7
<i>Dytiscidae</i>	9
<i>Veliidae</i>	8
<i>Gerridae</i>	8
<i>Pseudothelphusidae</i>	8
<i>Naucoridae</i>	7
<i>Corydalidae</i>	6
<i>Hydrophilidae</i>	3
Total score	81

Sequential Comparison Index (SCI)

Results obtained from the sample of 29 macroinvertebrates identified on Cave Boca del Río are shown in table 4.

According to the SCI scores from the water quality (table 1), the obtained value of 11.81 represents the water quality as moderately contaminated.

Average score per taxon (ASPT)

The index value ASPT is obtained by dividing the total score BMWP (81 points, table 3) by the total density of families (11 families) (table 2).

The ASPT value obtained for the aquifer Boca del Río Cave is 7.36, that corresponds to the chart of water quality, corresponding to water quality type III class, slightly contaminated (table 1).

Family Biotic Index (FBI)

For Boca del Río Cave, this index is estimated for each sampling station, considering the number of families presents in each sampled station, the number of organisms for each family, and the total number of organisms at each station.

This index is calculated by assigning tolerance values of zero to 10 to each family. Values close to zero are assigned to the families with a higher tolerance to contamination, whereas values close to ten are assigned to the families with greater tolerance to pollution (table 5).

In the first place, it multiplies the total number of specimens of each family by its assigned value IBF/SV2010 for each family, and then the total number of individuals collected divides this value. Finally, the values obtained from all families are then added together to

Table 4. Obtained values of SCI index to families collected in Boca del Río Cave.

Total number of specimens	Number of runs	Diversity index (ID)	Number different taxa	Diversity Index Total (ID_T) ISC
29	27	0.074	11	11.81

Table 5. Assignment chart for index values FBI/Salvador to aquatic macroinvertebrates.

Families of macroinvertebrates collected in Boca del Río Cave	Assigned value FBI/SV2010 (Sermeño et al., 2010)
<i>Heptageniidae</i>	3
<i>Coenagrionidae</i>	9
<i>Lestidae</i>	6
<i>Calopterygidae</i>	7
<i>Dytiscidae</i>	7
<i>Veliidae</i>	5
<i>Gerridae</i>	6
<i>Pseudothelphusidae</i>	6
<i>Naucoridae</i>	6
<i>Corydalidae</i>	7
<i>Hydrophilidae</i>	7
Total score	69

obtain the value of the index FBI/SV-2010 (table 6).

The obtained value FBI/SV2010 for Boca del Río Cave were of 7.07, which is interpreted in the chart cartography of the water quality for the indices FBI/SV2010 (table 1), as a decrease in water quality poor with very substantial organic pollution probable.

Discussion and conclusions

Density of identified organisms into de cave systems was low, 29 organisms macroinvertebrates,

due to the restriction of nutrients that are mainly exogenous; however, the eleven families identified has given us a very clear idea of high diversity, of these organisms in this cavernous ecosystem.

Each family of identified macroinvertebrates in Boca del Río Cave has shown to be particularly tolerant to pollution (Hilsenhoff, 1988; Mandaville, 2002). *Coenagrionidae*, *Lestidae*, *Veliidae*, and *Gerridae* are associated with the natural sources of water but have tolerance to water highly polluted (Patrick & Palavage, 1994).

Table 6. Assignment chart for index values FBI/Salvador to aquatic macroinvertebrates.

Familie of macroinvertebrates	Abundance	Score	Abd * Sce	(Abd* Ptj)/total
<i>Heptageniidae</i>	1	3	3	0.10
<i>Coenagrionidae</i>	10	9	90	3.10
<i>Lestidae</i>	4	6	24	0.83
<i>Calopterygidae</i>	2	7	14	0.48
<i>Dytiscidae</i>	1	7	7	0.24
<i>Veliidae</i>	2	5	10	0.34
<i>Gerridae</i>	3	6	18	0.62
<i>Pseudothelphusidae</i>	1	6	6	0.21
<i>Naucoridae</i>	2	6	12	0.41
<i>Corydalidae</i>	1	7	7	0.24
<i>Hydrophilidae</i>	2	7	14	0.48
Total	29	45	1 796	7.07

Dytiscidae, *Hydrophilidae*, *Colopterigidae*, *Naucoridae*, and *Pseudothelphusoidea* are families of macroinvertebrates characterized by a tolerance of water moderately contaminated (Alvarez & Villalobos, 1997).

The families *Heptageniidae* and *Corydalidae* are relatively intolerant to pollution change and are sensitive indicators of organic pollution (Borror *et al.*, 1989; Boonsoong & Braasch, 2013).

Ten of these families of macroinvertebrates have a very wide distribution, in both Neotropical and Nearctic regions (Cumberlidge, Alvarez, & Villalobos, 2014).

The specific value, for index BMW/Col, assigned to each family of macroinvertebrate, determined by the quality of the water in which was found the macroinvertebrates of the neotropical region of Colombia. Values close to 10 are assigned to families of macroinvertebrates intolerant to water pollution, and values close to zero are for the tolerant families to waters with some degree of contamination.

The sum of all BMW values, assigned to all the macroinvertebrates families present in a sampling, represents the final value to infer the water quality from the chart index BMW/Col. The score of 81 corresponds to a level of water quality Type III, with quality acceptable, and cartography of green color.

The CSI index value obtained (11.81) represents the water quality as moderately contaminated, is based on the biological diversity of the families, explains the presence of the great diversity of macroinvertebrates in Boca del Río Cave. This confirms the results obtained by the index of BMW/Col, in which it is proposed that Boca del Río Cave as an environment of refuge for the different families of macroinvertebrates of the Neotropical and Nearctic region but in particular of the Transition Zone.

In the same way, that the indices BMW/Col, SCI, and the values of the index ASPT represent a level of water quality that is slightly pollute. Allowing a high variability of families in this environment.

A higher ASPT value (~10) is indicative of very clean environments that can maintain high

scoring taxa while sites with low ASPT values (~0) do not support several taxa with high scores (Armitage *et al.*, 1983). The ASPT value obtained for the aquifer Boca del Río Cave is 7.36; it represent water quality slightly contaminated.

Unlike the rate described (BMW/Col, SCI y ASPT) that indicates water quality acceptable for Boca del Río Cave, while the index of the FBI/SV2010 the water quality decreases to poor with very substantial pollution probable.

This study represents the first investigation of water quality for a cave in Mexico, especially with macroinvertebrates. There are several studies on caves but the water quality was never considered as an indicator of the health of these ecosystems, mainly due to its hidden nature and inaccessibility.

Although the methods for measuring water quality using macroinvertebrates, originally were designed for surface water ecosystems, in this study we have been able to show an overview of the state of the water quality of Boca del Río Cave, by utilizing the presence of 11 families of macroinvertebrates with different densities of organisms.

The three indices, BMW/Col, ASPT/Col, and SCI, indicated that the water quality is slightly contaminated, which explains the high variety of macroinvertebrates families, from very intolerant (*Heptageniidae* and *Corydalidae*) to those tolerant is water highly contaminated community (*Coenagrionidae*, *Lestidae*, *Veliidae* and *Gerridae*), with predominance of the group *Gerridae* with 19 organisms, representing 65.5% of the sampled in the Cave Boca del Río.

These data indicate that water in Boca del Río Cave has sufficient quality to support macroinvertebrate populations. Additionally, the diversity of families and their respective densities of organisms are relatively high for the cave systems, as these systems are oligotrophic with limited sources of energy by not having primary productivity within the system

The analysis of the water quality to region Rio Balsas, very near Boca del Río Cave, which was made by the National Council of the Water of Mexico (Conagua, for its acronym in Spanish)

using both physicochemical and macroinvertebrate methods, have shown very similar results.

In the majority of the studied sites, water has good quality or has very slight contamination using both methods, physicochemical and microinvertebrates (Conagua, 2010).

The physicochemical analysis of the water quality of the aquifer Papagayo, to which is associated the Boca del Río Cave, resulted in water of good quality, with permissible limits for human consumption (Conagua, 2013).

Water quality determined by the use of physicochemical parameters and with macroinvertebrates provide results consistent and comparable, as well as between groundwater and surface water.

On the other hand, the results of the index FBI/SV2010 showed that the level of contamination is high for all three sites, but mainly for Station 3. At this station, there is the greatest variety of families (63.63%) and the highest density of organisms (72.41%), which is probably explained by the presence of greater organic contamination in the station number 3 (that can withstand these densities of organisms). Therefore, with the depth of the cave, 320 meters at the Station 3, the conditions are changing, but still enough good conditions quality for the presence of families with different tolerances to pollution. The high density of organisms at this station (21 organisms) was the result of the decrease of quality water and the presence of the particularly tolerant families.

Boca del Río Cave represents an important biogeographic enclave, as it is located within the Mexican Transition Zone of the region of endemism of the Sierra Madre del Sur, which is adjacent to the Basin of the Balsas, one of the main centers of greatest diversity in Mexico (Morrone, 2015).

The identification of 11 families of macroinvertebrates from 29 organisms troglobites, collected in three sampling stations within, showed that no family was located in two different stations, apparently each family is very specific to an ecological niche. This may imply

the existence of a complex structure between families, and the existence of a large number of micro-niches, with high potential to generate biodiversity and endemism in this ecosystem. These identified macroinvertebrates identified, with other communities of cave fauna, like bats and invertebrates, microorganisms, etc., interact with soil and walls, all associated with very fragile trophic networks. Therefore, Boca del Río Cave is an important refuge for the maintenance and generation of a variety of species.

Macroinvertebrates are an important tool, not only to monitor the quality of the water, but also for recognizing the state of these ecosystems. So it is important to study the macroinvertebrates of caves as a natural evolutionary group, because due to its high capacity of adaptation to caves, because they show very defined biogeographic patterns.

The proposal of this work is to generate the motivation to continue with the identification of species, and to differentiate the endemic groups, make sampling more extensive and intensive sampling in the entire cave and to identify possible gradients in the presence of families and species, and to associate them with niche-specificity.

It is recommended to carry out additional studies on water quality with other parameters biological and physicochemical should be carried out on this topic, to obtain more precise data. This would allow for the development of an index specific for caves and the biogeographic regions of Mexico.

For all of the above, it is urgent to consider sustainable management of this resource in the Cave Boca del Río. This is important because it is associated to with the major source of water supply for adjacent locations and the aquifer Papagayo and to make a sustainable use of the basin for the conservation of biological diversity. Since there are organisms that have had very complex evolutionary processes, they are highly specialized and have very short tolerance limits to the environmental and anthropogenic disturbances.

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