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FIRST RECORD OF THE MACROINVERTEBRATE COMMUNITY OF LAKE ACOYOTONGO, MORELOS, MEXICO

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Abstract: Studies related to macroinvertebrates that have been carried out within the Lagunas de Zempoala National Park (PNLZ), Morelos, Mexico, have focused mainly on three of the four lakes that still have water resources available. With this, it can be considered that the information on the macroinvertebrate communities in this area continues to be relatively unknown. The present work is aimed at recording the biodiversity of macroinvertebrates that inhabit the coastal zone of Lake Acoyotongo of the PNLZ. Four collection campaigns were carried out, considering the rainy and dry seasons. A total of 7,822 organisms were obtained, distributed in three phyla, six taxonomic classes: Arachnida, Clitellata, Entognatha, Gastropoda, Insecta and Malacostraca; 14 orders and 26 families. The Insecta class presented six orders obtaining the greatest richness of species: Hemiptera with five families; Coleoptera, Diptera and Odonata with three families each; Ephemeroptera and Lepidoptera with one family each. The study defined the ecological state of the lake, since its members reflect how the community relates in the sense of the functionality of the system.

Keywords: Macroinvertebrates, Lake, Coastline, Insects, Morelos

INTRODUCTION

The Lagunas de Zempoala National Park (PNLZ) is a protected natural area, located in the States of Morelos and Mexico (Godínez-Ortega *et al*., 2017); One of the most outstanding characteristics of this region located within the state of Morelos is its hydrology. Originally seven lakes were registered within this ANP named as follows: Zempoala, Tonatiahua, Compila, Acoyotongo, Quila, Acomantla and Hueyapan and a small spring named La Joya de Atezcapan, which are part of the Balsas Basin (Bonilla-Barbosa and Novelo-Retana, 1995; Contreras-McBeath, 1995; cited in Godínez-Ortega et al., 2017). These freshwater ecosystems are home to a large number of both microscopic and macroscopic organisms, such as macroinvertebrates, and some of them are endemic to this place.

In freshwater ecosystems, macroinvertebrates have a role with great potential in the structure and functioning of a lake since, thanks to them, the aquatic system remains stable and balanced, participating in activities such as nutrient recycling and passage of energy flow to higher trophic levels (Gong *et al*., 2000; Quiróz-Castelán *et al*., 2012; Keke *et al*., 2017). The groups of these organisms show a great variety of adaptations, including differences in their life cycles, since some groups spend all or almost their entire life cycle submerged in water, which is because they are considered aquatic or semi-aquatic (Archangelsky *et al*., 2009; Springer *et al*., 2010).

The community structure of macroinvertebrates and aquatic vertebrates is used to monitor the health of aquatic environments (Nkwoji et al. 2010), and have been widely used as biological indicators, in river quality assessments, ecological risk assessments and to monitor water quality, because these organisms are affected by changes in the natural variables of rivers such as width, depth, type of substrate, water speed and by physical-chemical variables (Odume and Muller 2011; Keke *et al*. 2017), in addition, they are relatively sedentary, their life cycles are relatively long and therefore reflect alterations in the environment, being sensitive to different disturbance factors and are an important part of the trophic chain of aquatic ecosystems.

The community can be modified by responding quickly to environmental variations, demonstrating the ecological integrity of the system not only spatially, but also seasonally (Gutiérrez-Yurrita, 1999), considering that its diversities and abundances are dependent on changes in nutrient concentrations and productivity in the ecosystem, so a reduction in energy flows leads to the variation of populations. This resilience is of great importance for the stability of the entire system (Ricklets, 1979; cited in Hurtado *et al*., 2005), therefore, to understand the role that macroinvertebrate groups represent in these ecosystems, it is necessary to know how the community is structured, how the dynamics between populations work, their associations with other groups in the habitats, as well as the trophic groups (Gong *et al*., 2000; Keke *et al*., 2017).

In the PNLZ, hydrobiological studies have been carried out mainly in the Zempoala and Tonatiahua lakes, highlighting the microscopic and macroscopic biological characterizations; as well as fluctuations in the physical and chemical conditions of the water. Among the most recent investigations we find Díaz-Vargas *et al*. (2005) who report the groups of component organisms of the benthic fauna of Lake Zempoala. In Lake Tonatiahua, Brug-Aguilar (2005) characterized the macroinvertebrate community of the littoral zone and its relationship with some physicochemical parameters. García-Rodríguez *et al*., (2010), listed the phytoplankton and zoobenthos of Lake Zempoala. Trejo *et al*. (2014), carried out an investigation on the zooplanktonic fauna of Lake Zempoala, particularly the cladoceran *Daphnia laevis* (Birge, 1879). Finally, Barragán-Zaragoza (2016) updates the taxonomic list of the littoral zone fauna of the Zempoala and Tonatiahua lakes, providing new records for the State of Morelos.

Information on the physical and chemical state of the water quality in Lake Acoyotongo, as well as the macroinvertebrate community, is non-existent. Therefore, the present study aimed to record for the first time the biodiversity of macroinvertebrates presents in the rainy and dry seasons of the littoral zone of Lake Acoyotongo, and some physical and chemical parameters of the water of the aquatic system.

STUDY AREA

The Lagunas de Zempoala National Park covers an area of 4,790 hectares, including part of the municipalities of Huitzilac and Cuernavaca, in the state of Morelos and of Ocuilan in the state of Mexico. It is located at an approximate distance of 65 km south of Mexico City and 38 km northwest of the city of Cuernavaca (Figure 1) (Trujillo-Jiménez and Espinosa de los Monteros, 2006). The lakes that comprise the park are of volcanic origin (Godínez-Ortega *et al*., 2017).

Lake Acoyotongo is located between 19°03’43” North and 99°19’ West (Figure 2) (Trujillo-Jiménez and Espinosa de los Monteros, 2006) at 2,832 meters above sea level, with an area of 3.31 hectares and a volume of 42,969 m^3 in its flooding period (CONACyT-CONAGUA, 2012). Of the seven lakes that are recognized today, three are completely dry, and the other four present a regime of water level fluctuations (Godínez-Ortega *et al*., 2017), since the intense evaporation and infiltration of their water level, decreases considerably during the dry season. Due to its physical-chemical and productivity study, it is considered a mesotrophic environment (Granados-Ramírez *et al*., 2014).

MATERIALS AND METHODS

Four sampling periods were carried out from October 2016 to October 2017, considering both temporalities (rain and dry season). Samples were taken from three sites located in the coastal zone of Lake Acoyotongo (Figure 2), which were chosen according to accessibility, as well as the representativeness

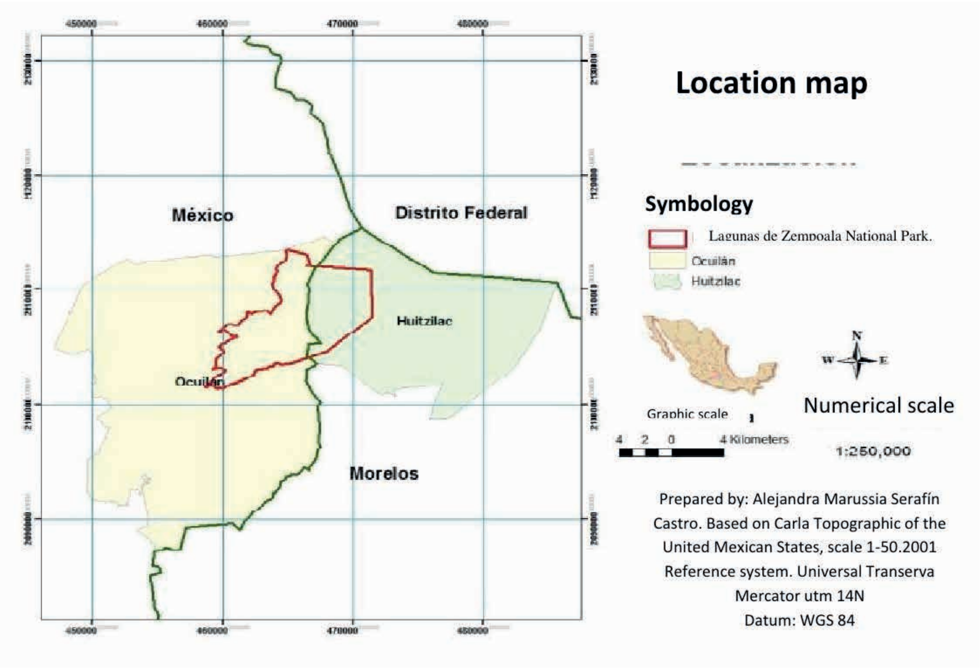

Figure 1. Location map of the (Taken from Serafín-Castro, 2014).

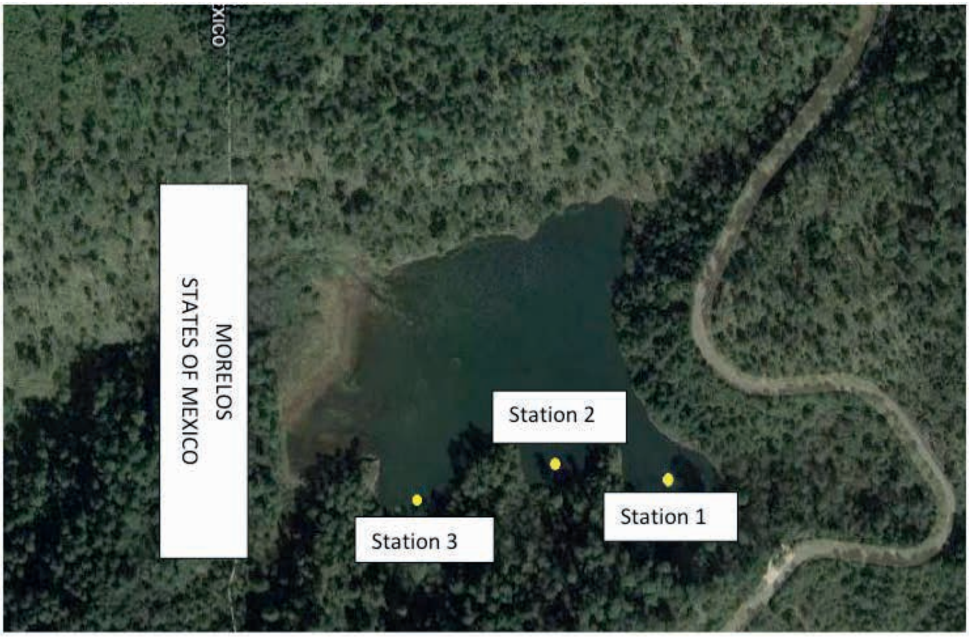

Figure 2. Geographic location of Lake Acoyotongo and location of the three study sites. (Taken from Google Earth Pro, 2023)

of the microclimates of the lake.

The data referring to the water samples were taken from CONACyT-CONAGUA (2012), and to evaluate each of the variables the following procedure was carried out. A HANNA HI991300 multiparameter was used to measure electrical conductivity, total dissolved solids, pH and a HANNA HI9146 oximeter to measure the values of water temperature and dissolved oxygen (DO); transparency and depth were measured in the area of the sample using a Secchi disk.

To carry out the collections of macroinvertebrates, approximately 50 meters of routes were made at each station on the littoral zone, with the help of type "D" and rectangular nets with a mesh size of 500 μm (Domínguez and Fernández, 2009). The collected macroinvertebrates were preserved in 70% alcohol and transported to the Invertebrate Laboratory of the Faculty of Biological Sciences for processing. The community structure of aquatic macroinvertebrates was recorded at the family level, using the literature of: Pennak (1978), McCafferty (1998), Merritt *et al*. (2008), Domínguez and Fernández (2009), Springer *et al*. (2010).

The Jaccard Similarity Index (Moreno, 2001) was applied to the data obtained. The trophic guilds of each group were obtained according to Merritt *et al*. (2008) and finally the Family Biotic Index (FBI) of Hilsenhoff (1988) was estimated.

RESULTS

The average values of the physical and chemical parameters of the study stations are reported by CONACYT-CONAGUA (2012) and indicate that Lake Acoyotongo is shallow (less than 0.5 m), with transparent waters, cold waters (8.7 to 11.7 °C), neutral to slightly alkaline (7.1 to 7.4 units); well oxygenated (7.4 to 8.8 mg L^{-1}) and registering high levels of conductivity in the three stations (between 105 and 126 μScm^{-1}). TDS values between 52.22 and 63.3 mg L^{-1} were observed and the total alkalinity values recorded were 60 mg $CaCO_3$ L^{-1}.

Regarding the collection campaigns in Lake Acoyotongo, they began in October 2016, the second in February 2017, the third in May, and the fourth in October of the same year, contemplating the rainy and dry periods. The collected material was deposited in the scientific collection of the Invertebrate Laboratory of the Faculty of Biological Sciences, of the Autonomous University of the State of Morelos.

In general, a total of 7,822 organisms were collected, distributed in three phyla, with six taxonomic classes: Arachnida, Clitellata, Entognatha, Gastropoda, Insecta and Malacostraca; 14 orders and 26 families (Table 1). The Insecta class presented nine orders, obtaining the largest number of families, the Hemiptera, with five; Coleoptera, Diptera and Odonata with three families each and Ephemeroptera and Lepidoptera with only one family.

The first collection was carried out in the rainy season; 447 organisms representing the following taxonomic classes were identified: Insecta, Malacostraca and Gastropoda, nine orders and 13 families. The groups with the highest abundances were the hemipterans of the family Corixidae with 52.57% and Veliidae with 26.85%; followed by the crustacean family Cambaridae with 5.15% (Figure 3).

In the dry season (February 2017), 1743 organisms were collected, belonging to nine orders and 14 families. The orders Hemiptera and Odonata recorded the largest number of families and the order Basommatophora (Phylum Mollusca) was collected for the first time with two families and the rest with one family each group. The most abundant families were: Hyalellidae and Chironomidae

Phylum	Subphylum	Class	Order	Family
Annelida		Clitellata	Haplotaxida	Tubificidae
Arthropoda		Arachnida	Trombidiformes	Hydrachnidia
		Entognatha	Collembola	Isotomidae
		Insecta	Coleoptera	Curculionidae
				Dytiscidae
				Hydrophilidae
			Diptera	Ceratopogonidae
				Chironomidae
				Tipulidae
			Ephemeroptera	Baetidae
			Hemiptera	Aphididae
				Veliidae
				Gerridae
				Corixidae
				Notonectidae
			Lepidoptera	Pyralidae
			Odonata	Aeshnidae
				Coenagrionidae
				Libellulidae
	Crustacean	Malacostraca	Amphipoda	Hyalellidae
			Decapoda	Cambaridae
			Isopoda	Asellidae
Mollusca		Gastropoda	Basommatophora	Ancylidae
				Physidae
				Planorbidae
			Mesogastropoda	Lymnaeidae

Table 1. Taxonomic identification list at family level, registered for Lake Acoyotongo of the PNLZ

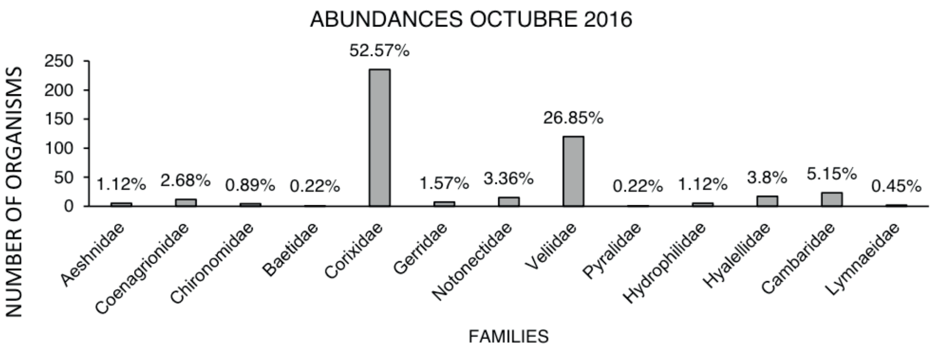

Figure 3. Richness and relative abundance of the families registered on October 2016

with 36.55% and 20.94% respectively; They were followed by the families Cambaridae (13.31%), Corixidae (9.98%) and Baetidae (6.48%) (Figure 4).

The May 2017 collection, which includes the period of greatest water stress in the region (dry season), a total of 4,384 individuals were recorded, which represented five classes: Insecta, Arachnida, Gastropoda, Malacostraca and Clitellata. In this month the greatest richness of species was obtained, with 13 orders and 23 families. In this period, the families Hyalellidae (50.18%), Chironomidae (24.68%) and Veliidae (6.89%) stand out for their abundance. The family Tubificidae (5.47%) and the family Aphididae (4.20%) were collected for the first time (Figure 5).

In the October 2017 collection (rainy season), a total of 1248 organisms were identified, belonging to six classes: Insecta, Arachnida, Entognatha, Gastropoda, Malacostraca and Clitellata. They represent 11 orders and 18 families. The order Hemiptera recorded the largest number of families; Basommatophora with three families; Coleoptera and Odonata with two; and with a family the rest of the orders. The best abundances were for the families Chironomidae (32.93%) and Corixidae (31.17%); and with a lower percentage the families Hyalellidae (10.90%), Veliidae (9.05%), Notonectidae (4.57%) and Cambaridae (3.04%). The rest with less than 1% (Figure 6).

For Lake Acoyotongo, in the dry season, five classes, 13 orders and 24 families with a total of 6,127 organisms are reported. For the Insecta class, 14 families were recognized, Gastropoda with four, Malacostraca with three and finally the classes Arachnida, Entognatha and Clitellata with one family. The families Ceratopogonidae and Tipulidae (Diptera), Physidae (Basommatophora), Dytiscidae (Coleoptera) and finally the isopod of the family Asellidae were observed for the only time.

A comparison of the similarity of the populations between the stations was made and it was observed that Station 1 (E1) and Station 3 (E3) shared 92.3% of the families during the month of February, despite the distance between them. High percentages were also recorded between stations E1 and E2 (84.6%); and between E2 and E3 (78.6%), so the distribution of the organisms was very similar in the rest of the collection period. The similarity was given by the dominance of a few families (Chironomidae, Hyalellidae, Veliiidae, Corixidae, Cambaridae and Tubificidae) and as reported by Barragán-Zaragoza (2016), these populations form groups with very similar abundances and distributions, thanks to the availability of the food, which is because they have successfully colonized the lakes of the Park.

Because in the same family there can be different types of feeding, and even the same species can change its food preference as it passes from its larval stage to adult, as mentioned by Pérez-Munguía *et al.* (2004), it is difficult to set taxonomic groups into a single trophic level; Therefore, in the present study, five functional food groups were determined (Table 2), of which predators showed the greatest dominance both in the rainy season (45%) and in the dry season (50%), with an average of 12 families present in Lake Acoyotongo, followed by the shredders in the rainy season (20%) and in the dry season (12.5%). In third place are the scrapers and collectors with 15% abundance during rains and 16.7% during dry periods. And with a single family in both seasons we find the collectors-filters.

DISCUSSION

The values of the physical-chemical parameters recorded in Lake Acoyotongo during the study carried out were within the

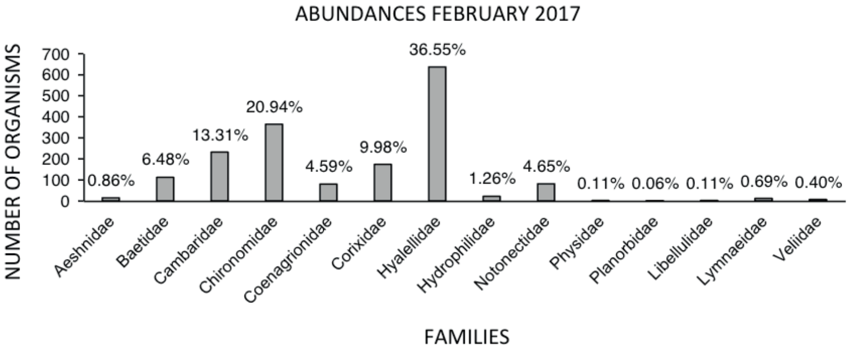

Figure 4. Richness and relative abundance during February 2017

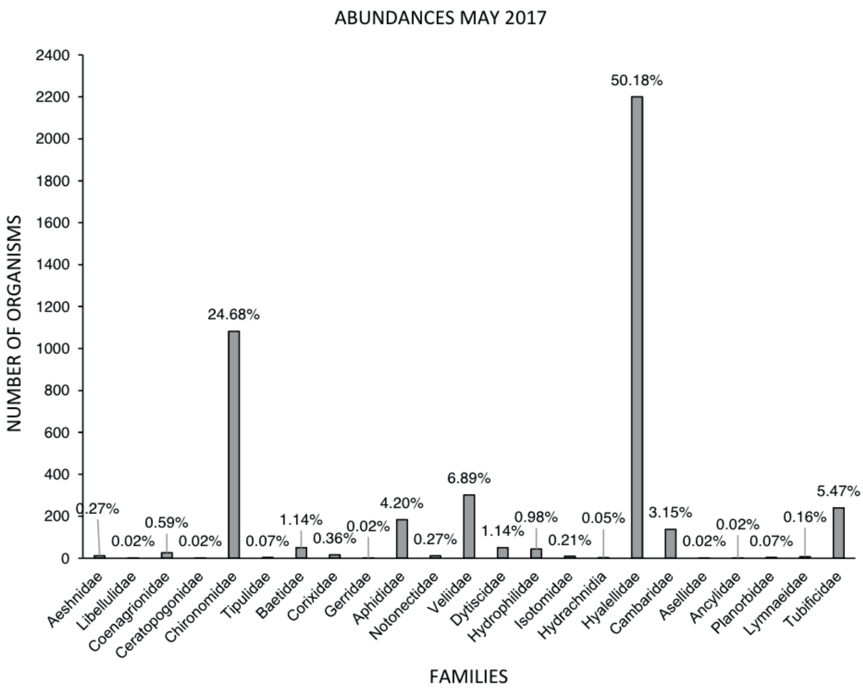

Figure 5. Richness and relative abundance during May 2017

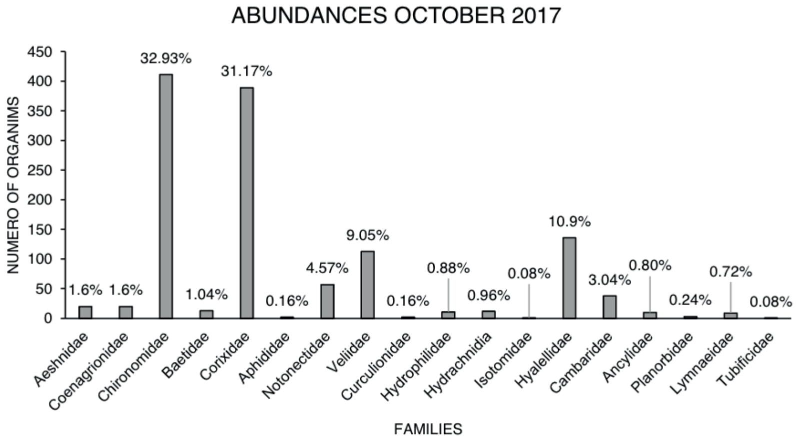

Figure 6. Richness and relative abundance during October 2017

PREDATOR	COLLECTOR	SCRAPER	CRUSHER	COLLECTOR / FILTER
Aeshnidae (In)				
Coenagrionidae (In)	Baetidae (In)	Physidae (G)	Curculionidae (In)	
Corixidae (In)				
Gerridae (In)				
Hydrophilidae (In)	Isotomidae (E)	Planorbidae (G)	Tipulidae (In)	
Hydrachnidia (Ar)				Chironomidae (In)
Notonectidae (In)			Cambaridae (D)	
Aphididae (In)	Tubificidae (C)	Lymnaeidae (G)		
Veliidae (In)			Pyralidae (In)	
Libellulidae (In)				
Dytiscidae (In)	Asellidae (Is)	Ancylidae (G)	Hyalellidae (A)	
Ceratopogonidae (In)				

Table 2. Trophic guilds to which the families of aquatic macroinvertebrates found in Lake Acoyotongo belong. G=Gasteropoda, C=Clitellata, A=Amphipoda, Is=Isopoda, D=Decapoda, Ar=Arachnida, E=Entognatha and In=Insecta.

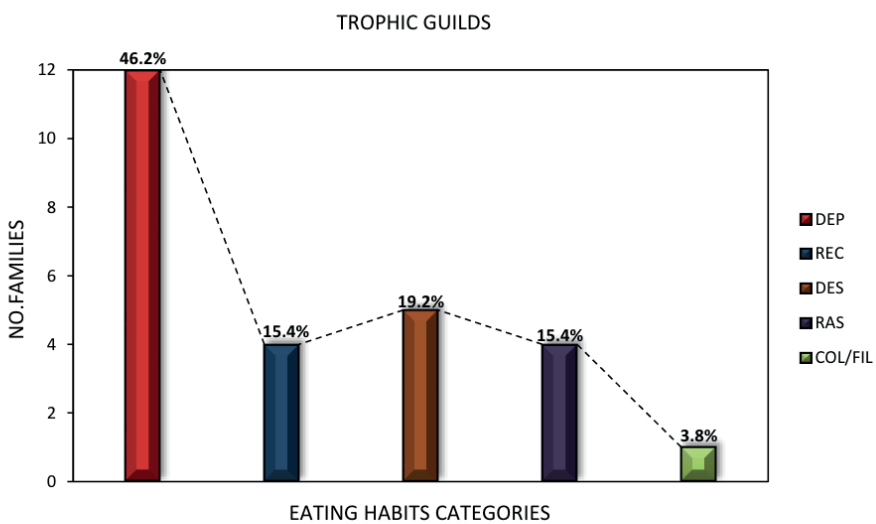

Figure 9. Proportion of families that make up trophic groups in annual cycle. DEP= Predator; REC=Collector; DES=Shredder; RAS=Scraper; COL/FIL=Collector/Filter

range for optimal growth and survival of aquatic life of organisms in cold-temperate zones. The average water temperature was significantly lower in the lake, although temperatures are influenced by the time of year, decreasing in the cold months (November to February) and increasing during the dry months (March to June). Similar behavior is reported for Lake Zempoala by Trejo-Albarrán *et al*. (2014), although with higher values. According to Roldán and Ramírez (2008), the higher temperature in the dry season could be attributed to the heating of the water surface by solar radiation. Furthermore, as is known, water temperature is a variable that determines the growth, metabolism and life cycle of benthic macroinvertebrates and all aquatic fauna, and can also affect the flow of energy in aquatic ecosystems.

Respect to dissolved oxygen, the DO was higher in the wet season than in the dry season in the lake. The seasonal patterns of dissolved oxygen and its spatial variation are similar to the findings by Trejo-Albarrán *et al*. (2014).

Most natural waters have a pH between 4.0 and 9.0 (Lind, 1985; Roldán and Ramírez, 2008) and lake water has a neutral pH within this range. The lower pH value during the rainy season could be attributed to precipitation, as well as water runoff increasing the organic matter content in lakes, which can cause a decrease in the pH of aquatic systems (Roldán and Ramírez, 2008).

The level of total dissolved solids fluctuated in the lake and was different during the two sampling periods carried out. Although grazing activities occur around the lakes throughout the year, the increase in TDS during the rainy season is more likely due to the increase in livestock manure, human feces, fertilizers and pesticides that are carried by runoff towards the lakes.

Therefore, the physical-chemical characteristics of an aquatic system are those that largely determine the fauna it can support, as well as its distribution (Wetzel, 2001; Roldán and Ramírez, 2008). The macroinvertebrates observed in the study coincided with the findings reported for the Zempoala and Tonatiahua lakes of the PNLZ.

This may mean that the macroinvertebrates recorded in the lake prefer more neutral to slightly alkaline waters, less turbid waters, possibly due to the lack of predators and low temperatures, which causes the metabolic rate to be low so as not to use much energy within the aquatic system.

Brug-Aguilar (2005) records 29 families for Lake Tonatiahua during the dry season, sharing 19 families reported in this research; Therefore, the contribution that Lake Acoyotongo shows are the families: Tipulidae, Pyralidae, Isotomidae, Lymnaeidae, and Asellidae. For Lake Zempoala, Barragán-Zaragoza (2016) identified 23 families and for Lake Tonatiahua 21 families, highlighting that 24 families of that total were located in the three lakes. The variation in species richness and abundance can be explained due to changes in the values of physical and chemical factors, as well as the availability of food, events that are generated during the months with greater water stress (Díaz-Vargas 2000; Hurtado *et al*., 2005 and Granados-Ramírez *et al*., 2017).

During the rainy season, six classes, 13 orders and 20 families were recorded in Lake Acoyotongo, accounting for 1,695 specimens in total. For the Insecta class, 12 families were identified in this period; Gastropoda with three, Malacostraca with two and finally the classes Arachnida, Entognatha and Clitellata with one family. The families Pyralidae of the class Lepidoptera and Curculionidae of the class Coleoptera are recorded for the only time.

Barragán-Zaragoza (2016) reports for this same time in Lake Zempoala 15 families and 10 genera of macroinvertebrates, of which the most abundant were *Cambarellus zempoalensis* (Family Cambaridae) and *Hyalella azteca* (Family Hyalellidae). For Lake Tonatiahua, in this same period, the greatest richness was recorded with 31 families and 27 genera, highlighting the order Sarcoptiformes and the families Corixidae, Cambaridae and Hyalellidae as the most abundant. For Lake Acoyotongo in this period, the families: Chironomidae, Corixidae, Hyalellidae, Veliidae, Notonectidae and Cambaridae were also collected, although with low abundances.

Very different results were obtained in the crater lakes of the Santiago Valley, Guanajuato, where coryxids, beetles and odonate larvae are reported as the main components of the littoral zone (Alcocer *et al*., 2002), which prefer a lentic environment as speeds slow and well-developed riparian vegetation with Diptera (Jeong-Ki and Dong-Soo. 2020). In the lakes of Montebello, Chiapas, the families Chironomidae, Hyalellidae, Coenagrionidae and Scirtidae are recorded as the most dominant (Guadarrama-Hernández *et al*., 2015; Orozco-Martínez, 2016). The high mountain lakes, El Sol and La Luna del Nevado de Toluca (Oseguera *et al*., 2016), recognize only eight species of macroinvertebrates, mainly oligochaetes, chironomids and bivalves standing out for their abundance.

Lake Acoyotongo during the study period showed characteristics similar to those that have been observed in the lakes of the PNLZ and little similarity with other lentic aquatic ecosystems in the south-west region of the state, where the variation and abundance of some taxa was has been associated with periods of high mineralization and organic input, which generates a change in the physical-chemical dynamics (Alonso and Camargo, 2005; Onah *et al*., 2022). Other influencing factors are temperature, photoperiod and food quality (De March, 1977; Pilgrim and Burt, 1993; Wellborn, 1994; Onah *et al*., 2022). The presence of the Chironomidae family has been associated with environments with a high amount of organic matter, mainly in clay-silty substrates (Díaz-Vargas, 2000; Barragán-Zaragoza, 2016; Granados-Ramírez *et al*., 2017), has led to the disappearance of taxa sensitive to pollution and the proliferation of resistant taxa. The proliferation of Tubificidae, Diptera and Chironomidae is explained by the precarious environmental conditions of the stations, which favored their development as cited by Agblonon *et al*., (2022).

The increase in the volume and runoff of sediment into the ecosystem causes a series of changes to occur in the macroinvertebrate community, such as migration, the culmination of biological cycles, natural mortality, changes in productivity and modification in trophic structures, including temperature and dissolved oxygen oscillations (Díaz-Vargas, 2000; Barragán-Zaragoza, 2016; Granados-Ramírez *et al*., 2017; Giam *et al*., 2017; Mzungu *et al*., 2023). Moreover, the introduction of exotic species, as happened with the stocking of rainbow trout (*Oncorhyncus mykiss Walbaum*, 1792) in the Zempoala and Tonatiahua lakes of the PNLZ (Viana, 1991), affects the dynamics of the populations, since can decimate native species (*Girardinichthys multiradiatus*, commonly known as mexcalpique, small, viviparous fish, endemic to the Lerma River basin, considered of special interest, due to its confined distribution and abundance) take them to the extinction, as well as degrade the environment (Trujillo-Jiménez and Espinosa de los Monteros, 2006).

The results obtained in both seasons (dry season and rains) are very similar to those recorded for the Zempoala and Tonatiahua lakes; For example, Brug-Aguilar (2005) and Barragán-Zaragoza (2016) record the species *Hyalella azteca* (Hyalellidae), *Cambarellus* *zempoalensis* (Cambaridae) and *Trichocorixa* sp. (Corixidae), and mites of the order Sarcoptiformes as the dominant and most abundant; Likewise, the Asellidae family is recorded with the genus *Asellus* sp. Rocha *et al*. (2009), mention that isopod species in Mexican territory have been little studied; being that 49 species have been described so far, so there is a very wide field of study for these organisms. Granados-Ramírez *et al*. (2017), report the presence of the genus *Asellus* sp. in Zempoala and Tonatiahua, which was located in Lake Acoyotongo in the dry season; citing a niche expansion for this family and genus in the three lakes of the PNLZ.

The value of the Family Biotic Index (FBI) obtained for Lake Acoyotongo was 3.197, corresponding to the category of excellent water quality with little probability of organic contamination (Hilsenhoff, 1988). This value was favored by the presence of families such as Tipulidae, Baetidae, Pyralidae, Libellulidae, Coenagrionidae and Asellidae (Merritt *et al*., 2008). The mayfly order has also been recorded in the literature as a taxa with little or no tolerance to organic contamination and occurs in low abundances (Keke *et al*., 2017; Agblonon *et al*., 2022); However, the Baetidae family has been recorded as having wide ranges of tolerance to temperature and pollution (Springer *et al*., 2010; Orozco-Martínez, 2016). In the Dytiscidae family there are species indicative of clean and well-oxygenated waters, others typical of eutrophic environments and with slight contamination by organic matter (Millán, 2004; Pacheco-Chaires, 2010).

Organic pollution is considered one of the most influential components that modify biotic and abiotic conditions causing variations in energy flow in lakes (Alonso and Camargo, 2005; Orozco-Martínez, 2016). According to Hoback and Stanley (2001), Tomanova *et al*. (2006) and Rivera *et al*. (2013), suggest that the presence and high abundance of hyalelids, corixids and chironomids indicate an alteration in the system mainly due to a contribution of organic matter. It has been observed that, as the speed becomes slower and the composition of the substrate becomes finer, the family Baetidae decreases, but the abundance of Oligochaeta and Chironomidae is greater, as occurs in this study and which has also been reported by Jeong-Ki and Dong-Soo, (2020).

Physidae, Ceratopogonidae, Cambaridae and Hydrophilidae are other families that seem to have good tolerance to a certain degree of mineralization and organic contribution to waters (Barbour *et al*., 1999; Millán, 2004; Olomukoro and Dirisu, 2014).

In general terms, the macroinvertebrate community in Lake Acoyotongo is made up of predatory organisms (46.2%), mostly insects and mites; crumbers (19.2%) such as crustaceans and certain insects; collectors and scrapers (15.4%) generally gastropods and some insects, isopods, springtails and annelids; and collector-filters (3.8%) such as diptera. No spatial variations of the functional groups were observed during the study period (Figure 9).

Brug-Aguilar (2005) reported six trophic functional groups for Lake Tonatiahua, with the predator group being the dominant ones with 49%; the collector-collector in second place, followed by the scrapers, the shredders and finally the collectors-filters. Granados-Ramírez *et al*. (2017) made a comparison between the trophic trade unions of Lakes Zempoala and Tonatiahua and between seasons, recognizing six and seven functional groups respectively. The results for Lake Acoyotongo are similar to those recorded in the other two lakes of the PNLZ, where the predominant organisms were predators.

Orozco-Martínez (2016) records different results when recognizing six trophic groups in the lakes of Montebello, making a comparison of these between turbid lakes and transparent lakes; recording the collectors as the dominant ones in all the lakes studied and in second place the predators.

The predominance of predator groups in the PNLZ lakes seems to be related to the dry season, a period in which the number of prey increases, with the Aeshnidae and Coenagrionidae families increasing their presence; Corixidae and Veliidae, Hydrophilidae, Dytiscidae and Ceratopogonidae, among others. Also during the dry season, collectors increased their populations such as the families Baetidae, Isotomidae, Tubificidae and Asellidae; periods in which an increase in algae and microinvertebrates was observed, which served as food for these groups (Rivera *et al*., 2013). Scrapers also benefited from this season; however, families such as Physidae, Lymnaeidae, Ancylidae and Planorbidae are related to the growth of aquatic plants, which limit the passage of sunlight, preventing the development of the periphyton which is used by these organisms (Alonso and Camargo, 2005, in Rivera-Usme *et al*., 2013).

The shredders were mainly represented by the families Hyalellidae and Cambaridae. Tomanova *et al*., (2006), Mejía-Ortíz *et al*., (2003) and Rivera *et al*., (2013) point out that these families and the chironomids have a preference for the *littoral* zone that accumulates silt-clay sediments and maintains macrophyte plants generating greater food resources. Tomanova *et al*. (2006) and Peralta *et al*. (2007), in their studies found that most of the reported taxa can occupy at least two trophic levels or more. This flexibility (generalist consumers) allows species to maintain greater stability in the face of naturally occurring environmental changes (Hart and Robinson, 1990), and also allows them to increase their reproductive and survival abilities (Townsend and Hildrew, 1994). as well as reduce intra- and interspecific competition by taking advantage of the variability of the resource and available niches (Woodward and Hildrew, 2002).

CONCLUSION

We can point out that the macroinvertebrate community of Lake Acoyotongo has been very useful in providing information about the ecological integrity of the PNLZ lakes. The Insecta class turned out to be the dominant one, and within this the order Hemiptera recorded the greatest species richness with five families. The most abundant families during the annual cycle were Hyalellidae, Chironomidae, Corixidae, Veliidae and Tubificidae. The highest species richness occurred between stations 1 and 2 because they showed similar environmental characteristics; In this study, five functional food groups were determined, of which predators showed the greatest dominance both in the rainy season and dry season. This is the first report of the macroinvertebrate community for Lake Acoyotongo, and the taxonomic list of the littoral zone of the lakes is updated, providing new records for the state of Morelos.

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