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Article

Identification of Fish Community in Lake La Alberca, Cienega de Chapala, Michoacán, México

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Abstract: Small, enclosed lake is in a tourist area called "Los Negritos", by the prominences a few steps from the lake on a perimeter of tens of meters with hot pools and mud bubbles. The lake originally belonged to Lake Chapala, so the group of fish present here derives from that. This is an endorheic vessel with at least one deep water inlet to the center, with a slight salinity (2.14 to 2.38 0/00), which is precisely greater at the point of upwelling and at a depth of approximately 36 m. This study to date has continued to collect and take data, also presents the characteristic of being an area of saline soils and halophilic vegetation. This body of water we consider is as relevant as that of Alchichica in Puebla. Its study is by monthly sampling with “chinchorro” and "chango" type trawl, recording morphological parameters, also environmental variables in the water, with a Data Sonde 4 brand Hydrolab. Knowing the structure and temporal dynamics of this fish community, along with the physical and chemical characterization of the water and implementation of Importance Value Index (IVI).

Keywords: ichthyological community; endorheic; Chapala

1. Introduction

Lake La Alberca is in Ciénega de Chapala, 15 km northeast of Cd. de Jiquilpan, Mich. The region is in the physiographic province of the Mexican Neovolcanic Axis. This lake is part of the geothermal area of Los Negritos; it is located at the intersection of two tectonic provinces: the Chapala graben and the northwestern limit of the so-called *Tarasca* Plateau. It is characterized by the presence of regional faults of east - west direction and by rocks of volcanic origin whose age varies from the Miocene to the quaternary.

The most conspicuous volcanic apparatuses correspond to monogenetic buildings of Plyocuarterial geological age, aligned in northwestern - southwestern direction the volcanic rocks are andesite and andesitic basalts.

The thermal manifestations are in the central eastern position of the Sahuayo valley, have temperatures between 30 and 82 0 C and include springs, fumaroles, and mud volcanoes. The waters are chlorinated - sodium type.

The oldest volcanic rocks, from the Miocene, could accommodate the likely geothermal deposit, since the intense fracturing to which they have been subjected may have led to the necessary permeability. The heat source could be constituted by a magmatic chamber located at great depth, with which the most recent volcanism is related [1].

Lake *La Alberca* was included in Lake Chapala until the Maltaraña dam was built between 1905 and 1910. It is here that the cartography reveals two clearly differentiated epochs in the lake outline: one before the construction of this board, the other after the drying of the area known as *Ciénega de Chapala*. The ship left a surface of 50,000 ha. uncovered of water in the Cienega. In the late 1930s, the dam was reinforced, and the pumping station was installed in La Palma, Mich., to drain the surplus from the swamp towards the lake, Figure 1 [2].

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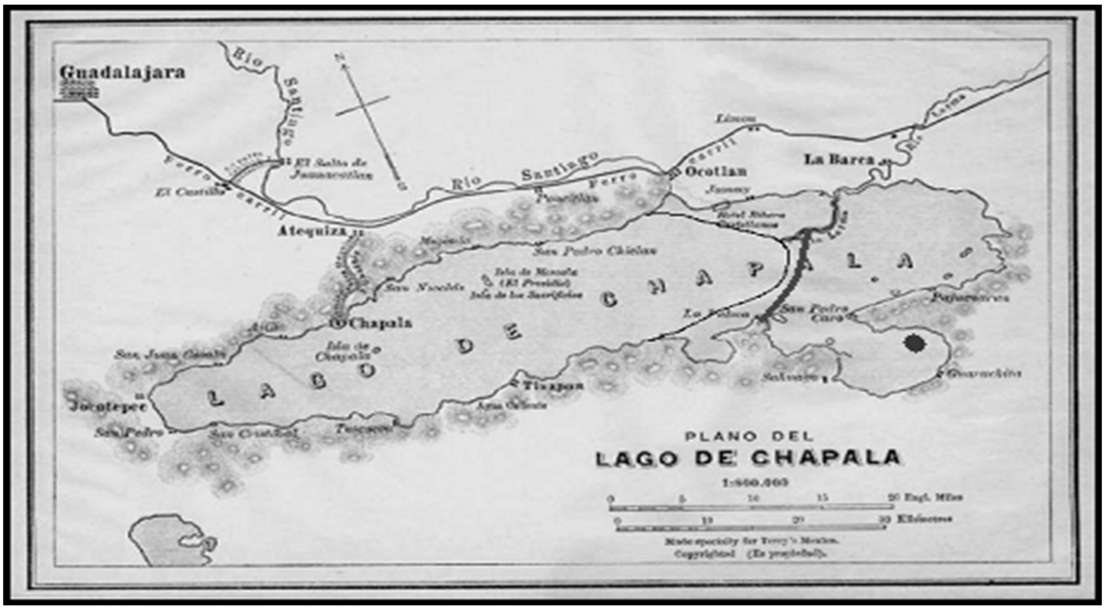

Figure 1. Map of Lake Chapala at the beginning of the 20th century, showing the board of Maltaraña in a thick line and the thin line indicating the level of the lake in the year 2003. The black point indicates the place that occupied within the lake the current lake *La Alberca.* The area to the right of the board is the Cienega.

In Lake Chapala there coexist eight species of the genus Chirostoma of which five of them are called *charales*: *Chirostoma arge* Jordan & Zinder 1899 (now *C. contrerasi* Barbour 2002), *C. consocium* Jordan & Hubbs 1919, *C. chapalae* Jordan & Snyder 1899, *C. jordani* Woolman 1894 and *C. labarcae* Meek 1902 and three of the white fish *C. lucius* Boulenger 1900, *C. promelas* Jordan & Snyder 1899 and *C. sphyraena* Boulenger 1900 [4,5].

Lake *La Alberca* has never been the subject of a systematic study to see what the situation of the community of fish is that live there. Of this place only a work was found by Díaz-Pardo and Godínez-Rodríguez in 1991, where in a spot sampling, they found a Siamese embryo of *Chapalichthys encaustus*, during the identification of organisms from here.

In 1993, these authors carried out a study in the basin of the Lerma River, which reveals the changes in the composition of the fish communities that have been happening in all that area, as well as the tolerance of the species to the prevailing environmental conditions. In the same way they mention that the ictiofauna of the basin has been affected by the ecological alterations associated with the activities of this region.

Aguilera-Taylor 2003 [5], in his analysis of the reproductive biology of *Chirostoma jordani, C. consocium and C. labarcae,* in Lake Chapala, found that these three species of *charales* reproduce throughout the year. However, its peak breeding season is from mid-January to mid-June. For the case of *C. consocium*, the reproductive maximum occurs in the month of March, being a second peak of lower intensity between September and October. *C. labarcae* shows its reproductive peak between May and June. Of the three species *C. jordani* is the one that maintains a more constant reproductive activity, being its maximum reproductive from March to mid-May.

It was hypothesized that Lake *La Alberca* must have had the same species of native fish that existed in Lake Chapala, since it was included in it when its extension covered the entire area today called *Ciénega de Chapala* (Figure 1).

2. Materials and Methods

To know the shape, dimension, and bathymetric profile of Lake *La Alberca* a topographic and bathymetric survey was carried out, using a Total Spectra™ Station, with a Land Development interpolation, a total of 775 points were recorded and a digital elevation model was generated. Later the respective map of this body of water was elaborated, with a scale of 1:1500, where the isobatas of one meter are marked. Monthly sampling was carried out from November 2001 to October 2002 and seasonal autumn, winter, spring and summer, during the years 2007 and 2008 (Buelna-Osben, H.) [6], sampling was carried out on a quarterly basis during 2016 (Hernández, P) [7] and, during July 2018 and June 2019 (Cabezas, M) [8].

To characterize the physical and chemical water of the lake a multiparameter sensor Data Sonde 4 brand Hydrolab was used, the data were saved in a Surveyor 4™ of the same brand for multiple registration of parameters, to be transferred to the office where the data bank was created for further analysis. The data recorded are Date, Time, Altitude, Latitude, Longitude, Depth, Turbidity, Temperature, % Dissolved Oxygen Saturation, Dissolved Oxygen, Conductivity, Salinity, Total Dissolved Solids, Hydrogen Potential (pH), Ammonium ion (NH4+), Total ammonia and Nitrates. All of them were taken on the surface of the body of water and on the bottom.

To know the structure, dynamics of the community of the species present, fish samples were taken in three sampling stations that were in this body of water, namely, North, Center, and South. The North is shallow and muddy, the Center is the deepest area of the lake, and the South is medium depth, sandy bottom. Fish from the North and South stations were sampled with a 20 m. long beach *chinchorro* by 3.5 m wide and a 0.5 cm mesh light, the trawl was 20 meters long, the Center station was sampled for 5 minutes, with a *chango* type trawl *chinchorro* shrimper, with a mesh light of 1 cm and a rope of 4 meters.

The fish were fixed with 4% formalin, buffered with sodium borate. The fishes collected were identified according to the criteria of Barbour 1973; they were also counted and weighed.

The Importance Value Index (IVI) was used to quantify the importance of the species and their probable influence on the site, as well as to determine which ones are dominant in this body of water. Its application aims to integrate the attributes of the community and give a more complete perspective of the community structure.

This index is the result of the combination of four measures, which are relative abundance (RA), relative biomass (BR), relative dominance (DR) and relative frequency (FR) all expressed in percentage:

$$IVI=AR+BR+DR+FR$$

being therefore the highest value of 400.

These attributes that were used in the above formula, were obtained as follows:

Abundance is the number of individuals per unit of area or volume, according to the expression:

$$\mathbf{Aa_i = \frac{a_i}{A}}$$

where: Aai is the abundance of individuals per m^2 of a species; ai is the number of individuals of a species and A is the sampled area.

Relative abundance: is the value that corresponds to the percentage of the number of individuals of a species in a season according to the total number of individuals of all species in all seasons:

$$ARi = \frac{Aaij \quad 100}{if=1\ nj=1\ Aaij}$$

where: ARi is relative abundance; aij is the number of individuals of species i in season j.

Biomass is the weight of organisms per unit area or volume according to the expression:

$$\mathbf{B_i = \frac{W_i}{\quad}}$$

$$A$$

where: Bi is the absolute biomass of individuals per m^2 of a species; W_i is the weight of individuals of a species and A is the sampled area.

Relative biomass: is the value corresponding to the percentage of biomass of a species in a station according to the total sum of biomass of all species in all stations:

$$BR_i = \frac{B_{ij} * 100}{\sum^{s}_{i=1} \sum^{n}_{j=1} B_{ij}}$$

where: BR_i is the relative biomass; B_{ij} is the biomass of species i in season j.

The frequency, is the number of times that a species is present in the total of seasons:

$$F_i = \frac{n_i}{n_T}$$

where F_i is the frequency; nor is the number of stations where the species i is present and n_T is the total number of stations.

Relative frequency: is the percentage of the frequency of a species to the sum of the frequencies of all species:

$$DP_{ij} = \frac{Aa_{ij} * 100}{\sum^{s}_{i=1} Aa_{ij}}$$

where: DP_{ij} is partial dominance; Aa_{ij} is the number of individuals of the species i in season j.

Relative dominance is equal to the reporting in percentage of the partial dominance of a species according to the sum of the Partial Dominance of all species in all seasons.

$$DR_i = \frac{DP_{ij} * 100}{\sum^{s}_{i=1} \sum^{n}_{j=1} DP_{ij}}$$

where: DR_i is the relative dominance; DP_{ij} is the partial dominance of the species i in season j, [9].

3. Results

Lake *La Alberca* has a total area of 322,542 square meters, a perimeter of 2,973.53 meters, a volume of 1,125, 519 cubic meters and a maximum depth of 36 meters. In its maximum longitudinal section (North-South) it has 786.55 meters and in the maximum transverse (east-west) it has 577.42 meters. A map of the lake was made on a scale of 1:1500 (Figure 2).

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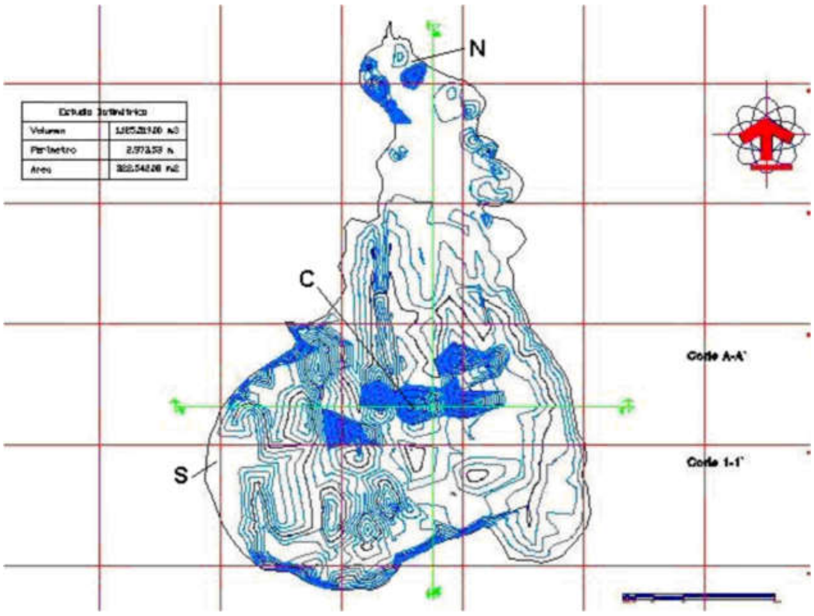

Figure 2. Map of Lake *La Alberca*, Mpio. de Villamar, Mich. The lines mark the isobatas of one meter and sampling stations (**N**orth, **C**enter, **S**outh). (Arch. F. Villalpando-Barragán)

The species of the family Atherinopsidae (four of *charal* and one of pez blanco =individuals of the largest sizes of the same species) found in this body of water are: *C. consocium, C. jordani, C. chapalae, C. contrerasi* and *C. lucius* (Figures 3 to 7).

Figure 3. Chirostoma jordani.

Figure 4. Chirostoma contrerasi.

Figure 5. Chirostoma chapalae.

Figure 6. Chirostoma consocium.

Figure 7. Chirostoma lucius.

Native species were also found: *Chapalichthys encaustus* Jordan and Snyder (1900), *Goodea atripinnis* Jordan and Snyder (1900), *Xenotichthys melanosoma* Fitzsimons, *Zoogoneticus quitzeoensis* Bean (1899) and *Alloophorus robustus* Bean (1892) of the family Goodeidae and *Poeciliopsis infans* Woolman (1894) of the family Poeciliidae and introduced species: *Tilapia rendalli* Steindachner (1864) of the family Cichlidae, and *Lepomis macrochirus* Rafinesque (1819) of the family Chicentradae.

3.1. Water quality.

Figure 8 shows the temperatures that occurred during the months of November 2001 to October 2002, in Lake La Alberca, the lowest being those for the month of January and among them the bottom of the Central station, which was 18.6^0 C. The highest were those of the month of May and of them the highest was the surface temperature of the South station with 28.89^0 C.

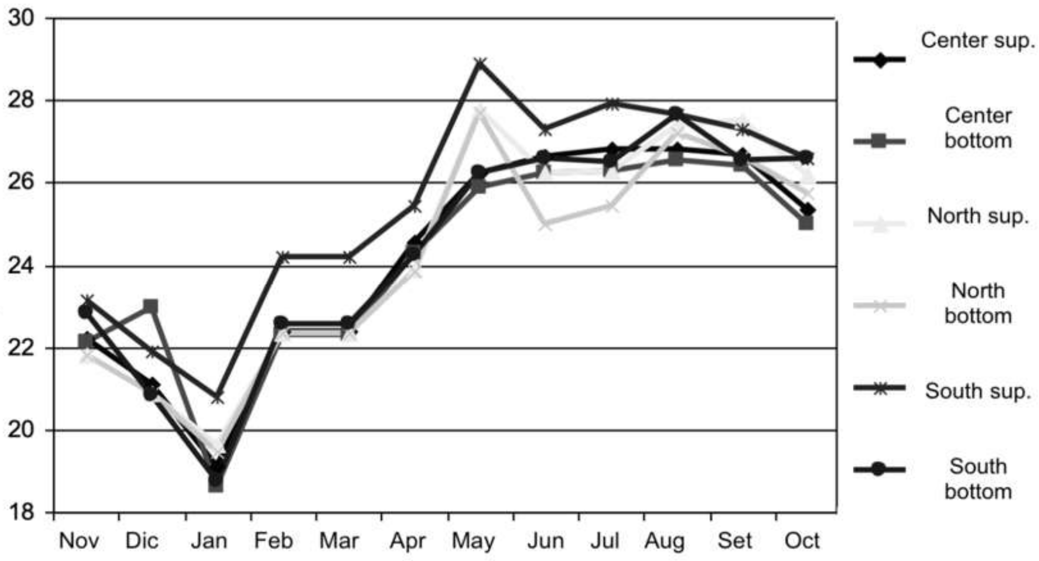

Figure 8. Water temperature, in degrees Celsius, surface and bottom, in Lake *La Alberca*, during the months of November 2001 to October 2002.

Figure 9 shows dissolved oxygen concentrations, which occurred during the same sampling period. Being the highest those corresponding to the month of January, and of them the largest was that of the bottom of the North station with 7.48 mg / liter. On the contrary the lowest were those of the month of September, and the lowest of them was that of the bottom of the North station with 1.92 mg / liter, due to the high temperatures, to the increase of the turbidity for being season of rains and that in this season there are days of high cloudiness.

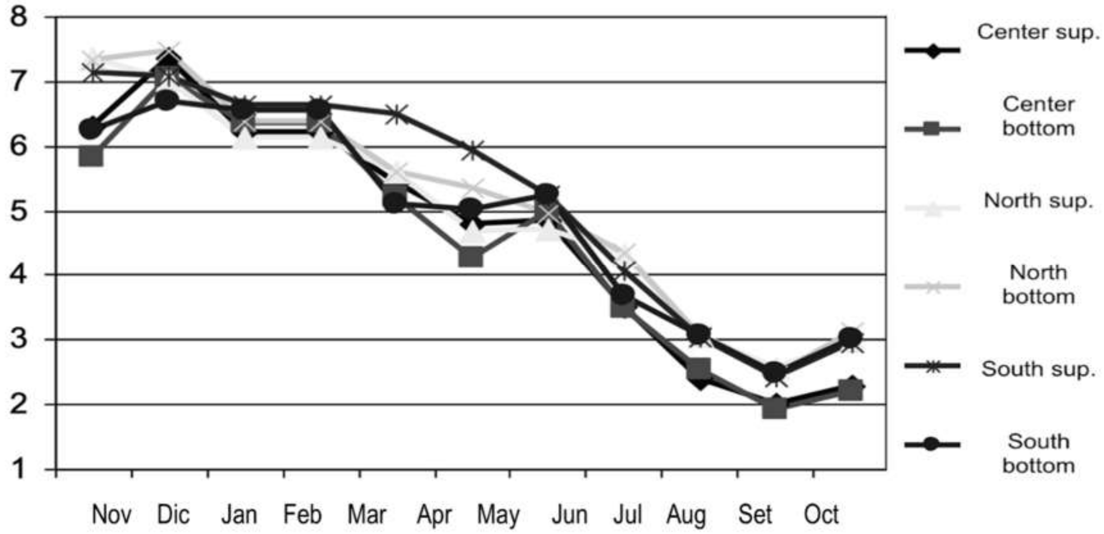

Figure 9. Dissolved oxygen in the lake *La Alberca* in milligrams per liter, surface, and bottom, during the months of December 2001 to October 2002.

Regarding turbidity, the lowest measurements were found in the month of June, being the lowest of them found on the surface of the Central station with 29.0 Nephelometric Turbidity Units (NTU) and the highest in the month of August, being the largest of them found on the surface of the North station with 98.7 NTU; from December to April the turbidity shows a clear increase and in May and June there is a decrease in both bottom and surface water at the three sampling stations, and it is from this moment that the turbidity increases due to the effect of the trawls due to the rains (Figure 10).

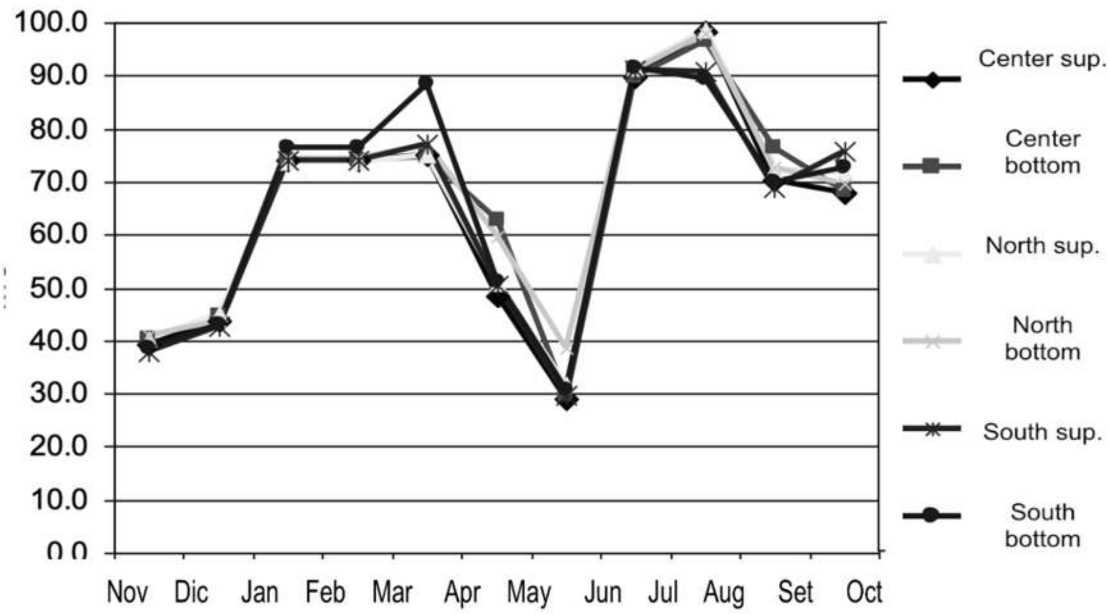

Figure 10. Turbidity in Nephelometric Turbidity Units (NTU), surface and bottom, in Lake *La Alberca*, during the months of December 2001 October 2002.

The lowest salinities were found in the month of September and October; the lowest of them were in the North station in September both at the bottom and on the surface and in all of the month of October with 2.11 g/l, In contrast, the highest salinities were present in the month of May in the surface of the North and South stations with 2.38 g /liter, because it was the season with the greatest evaporation since the cloud cover was lower and the temperatures were higher (Figure 11).

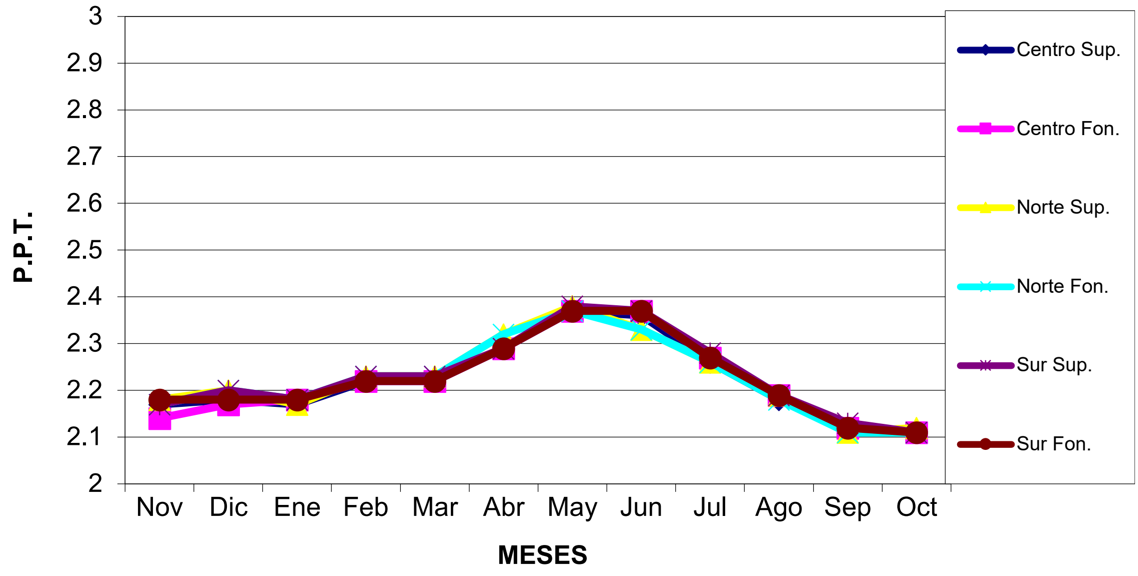

Figure 11. Salinity in parts per thousand, surface and bottom, of Lake *La Alberca*, during the months of November 2001 to October 2002.

Total dissolved solids (TDS) were lower for the month of October, and among them the lowest was for the bottom of the Central station with 2.47 g/liter having coincided in this aspect with the lowest salinity that was presented and the major TDS's were presented in the month of May, being the maximum in the surface of the South station with 2.79 g/liter, there is also a total coincidence with the major salinities presented (Figure 12).

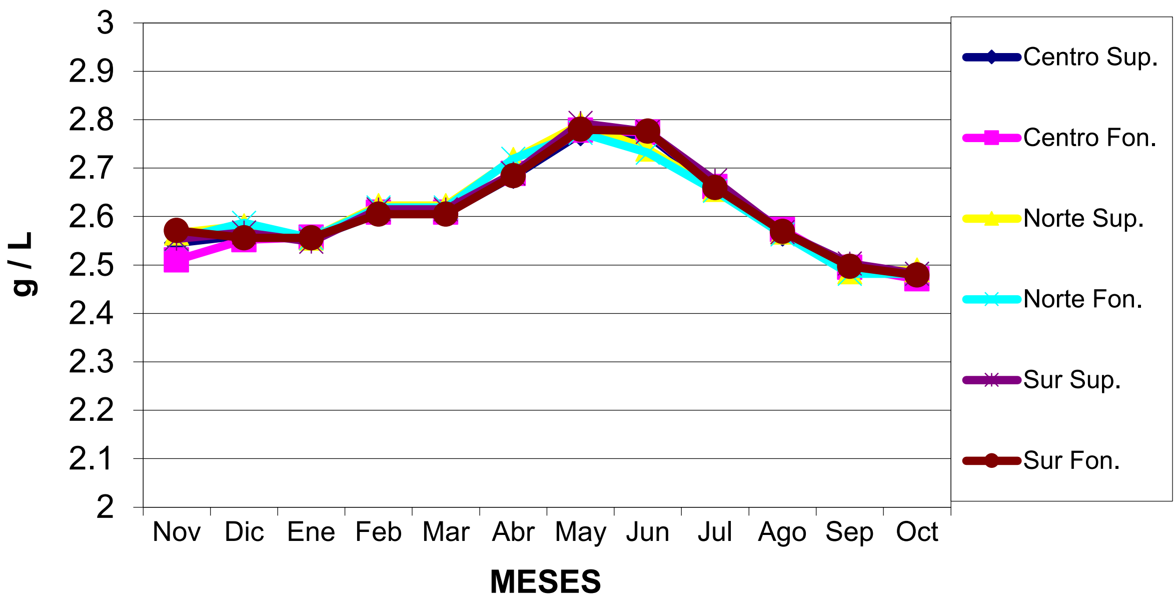

Figure 12. Total dissolved solids, in grams per liter, surface and bottom, in Lake *La Alberca*, during the months of November 2001 to October 2002.

The potential of Hydrogen (pH) in Lake La Alberca, was lower in December, being the smallest in the surface of the Central station with 7.08 units and the highest pH were presented in the month of April being the largest in the bottom of the South station with 9.26 units (Figure 13).

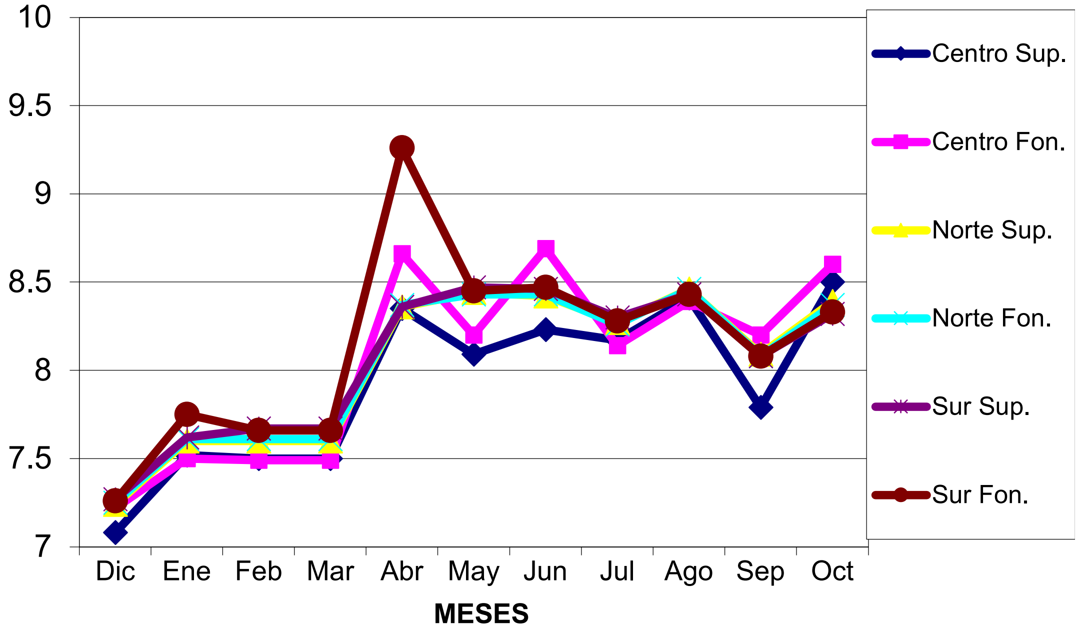

Figure 13. Potential hydrogen (pH), surface and bottom of Lake *La Alberca*, during the months of November 2001 to October 2002.

Electrical conductivity (µS/cm) was in increase in the dry season from November to May, since by the evaporation suffered by the lake in that season there is concentration of ions and decreased in the rainy season by the diluent effect of rainwater (Figure 14).

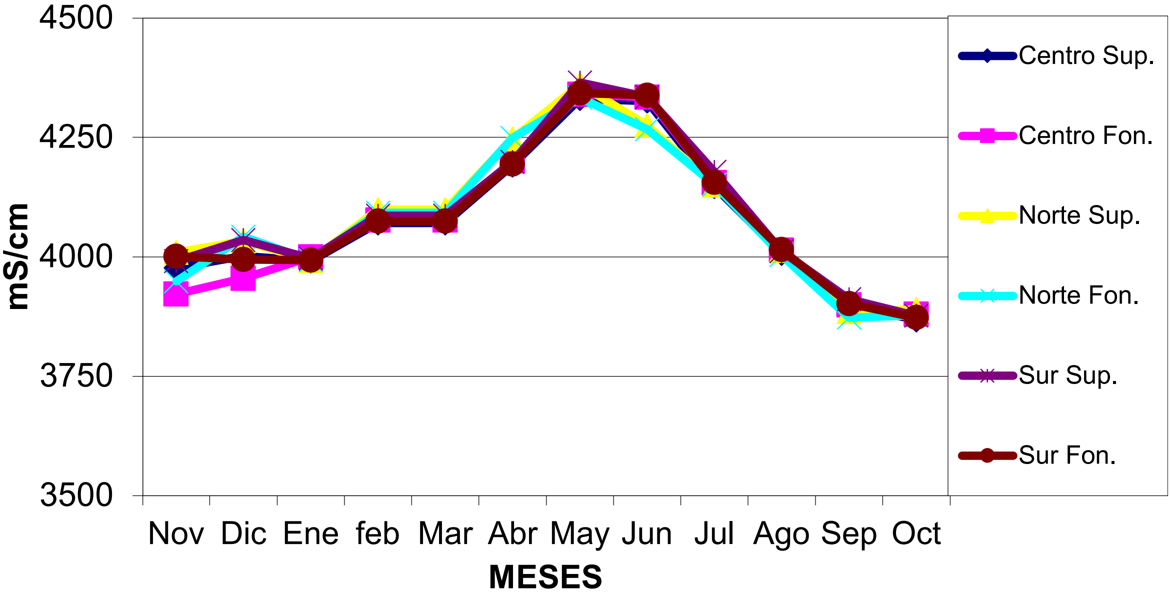

Figure 14. Electrical conductivity in µS/cm, surface, and bottom of Lake *La Alberca*, during the months of November 2001 to October 2002.

In the present work in none of the months sampled were ammonium ion, total ammonia, or nitrates detected, so it can be considered that these waters do not yet suffer some kind of organic contamination.

3.2. Weight ratio - length of fish.

When calculating the weight (Y) standard length (X) ratio of C. consocium (Figure 15) the equation was obtained:

$$Y = 0.0099\,X^{3.0813}$$

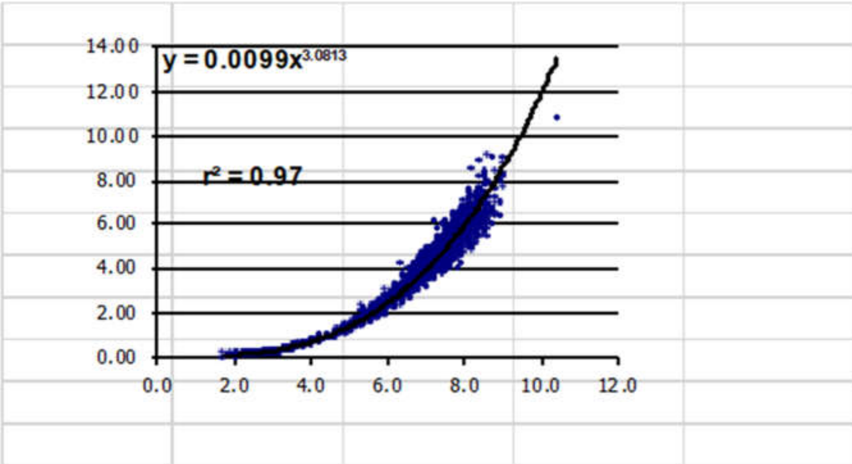

Figure 15. Weight vs. length curve. *Chirostoma consocium* November 2001-March 2002. N = 2890 individuals.

The individuals collected from this species had a minimum size of 1.7 cm and maximum size of 10.4 cm, when observing the histogram of frequencies of standard lengths, it is seen that, the modal pattern length interval, ie the most frequent sizes, were 7.1 to 7.5 cm. n = 2,890 individuals (Figure 16).

The weight (y) pattern length (x) ratio for C. jordani (Figure 17) was:

$$Y = 0.0074\,X^{3.3113}$$

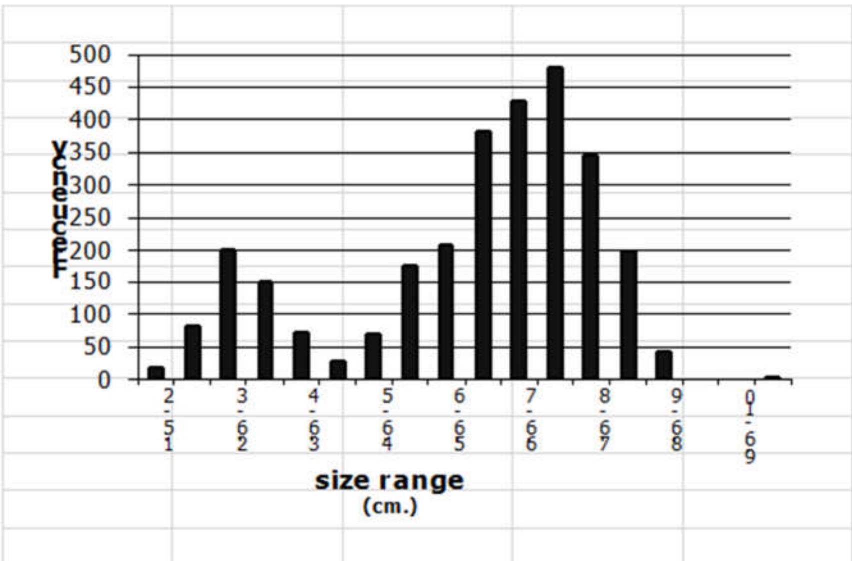

Figure 16. Frequency of individuals by size range of *Chirostoma consocium* November 2001-March 2002. n = 2890 individuals. Minimum size: 1.7 cm, Maximum size: 10.4 cm.

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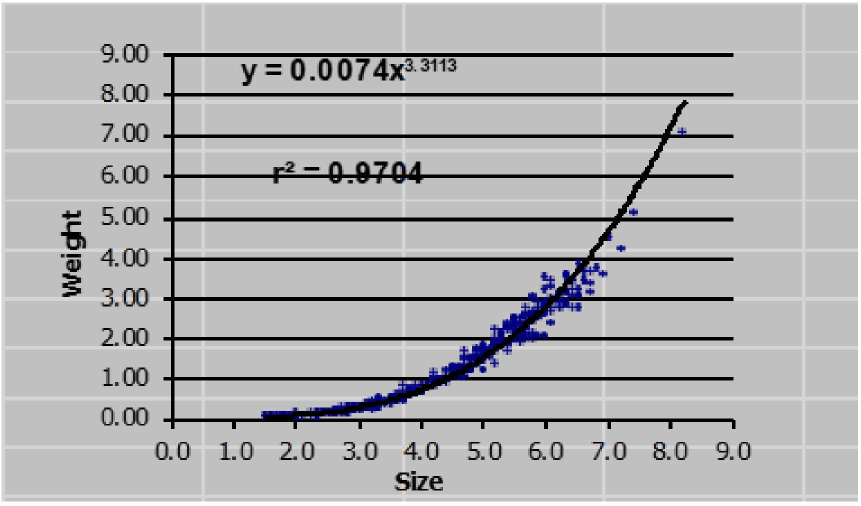

Figure 17. Weight curve vs. length. *Chirostoma jordani,* November 2001 - March 2002. N = 395 individuals.

The minimum size was 1.5 cm and the maximum size was 8.2 cm, the modal pattern length interval was 2.6 - 3 cm. n = 395 individuals (Figure 18)

The weight (Y) length pattern (X) ratio for C. chapala (Figure 19) was:

$$Y = 0.0068\ X^{3.2837}$$

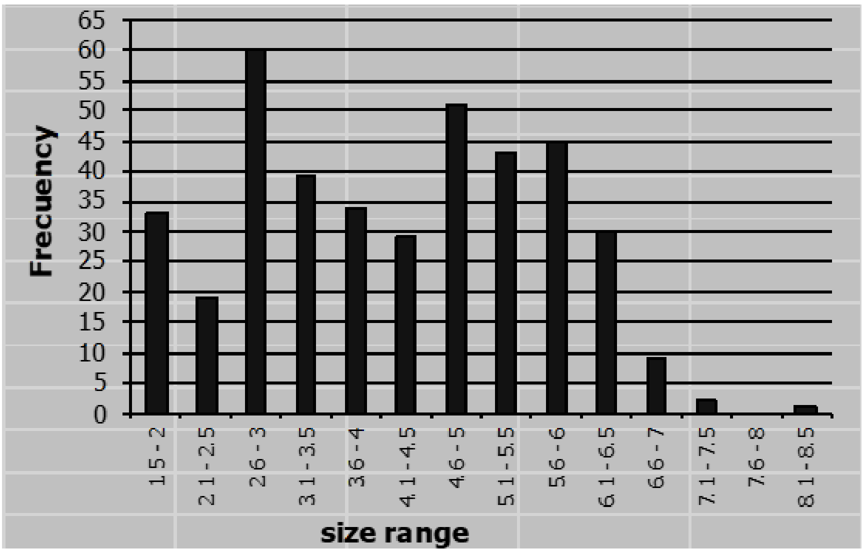

Figure 18. Frequency of individuals by size range of *Chirostoma jordani*. November 2001 - March 2002. N = 395 individuals. Minimum size = 1.5 cm, Maximum size = 8.2 cm.

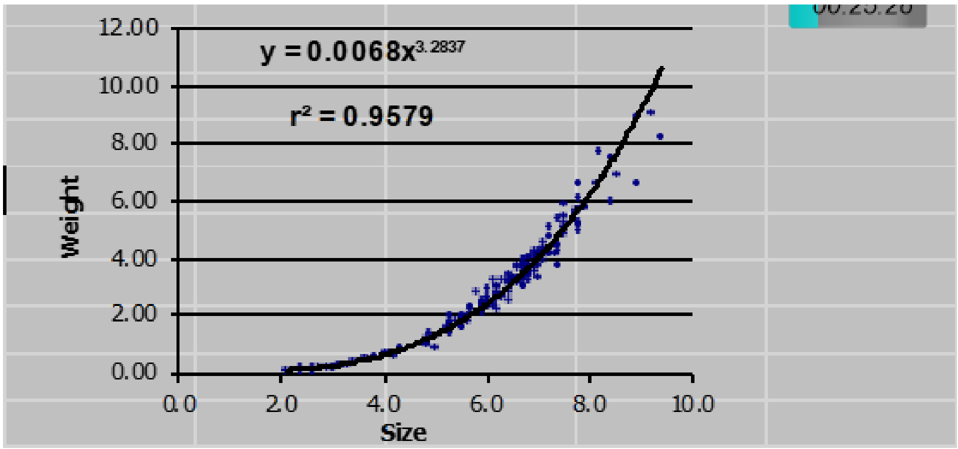

Figure 19. Weight curve vs. length. *Chirostoma chapalae* November 2001-March 2002. N = 181 individuals.

Individuals of this species had a minimum size of 2.1 cm and a maximum size of 9.4 cm, the modal length interval was 4.1 - 4.5 cm. n = 181 individuals (Figure 20).

The ratio of weight (Y) to standard length (X) for C. contrerasi (Figure 21) was:

$$Y = 0.0179\ X^{2.7104}$$

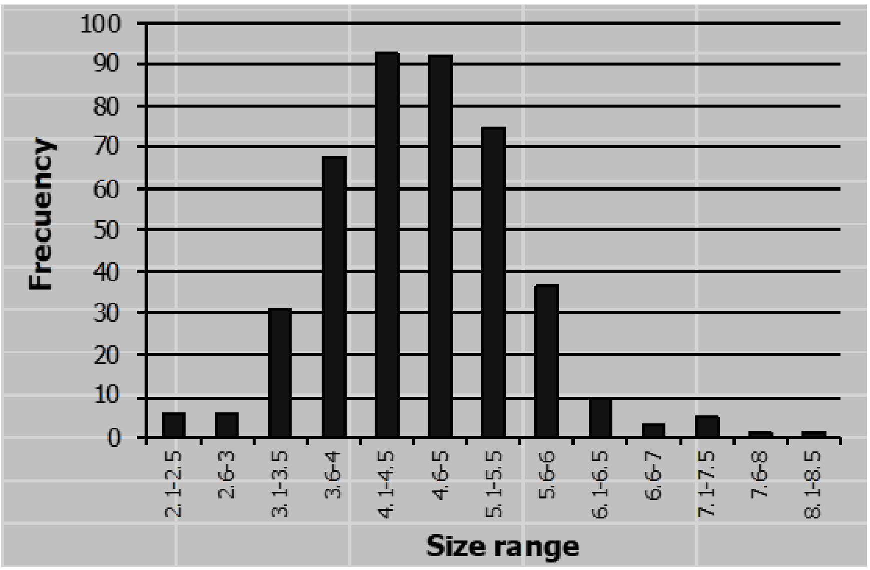

Figure 20. Frequency of individuals by size range of *Chirostoma chapalae*. November 2001-March 2002. N = 181 individuals. Minimum size = 2.1 cm, Maximum size = 9.4 cm.

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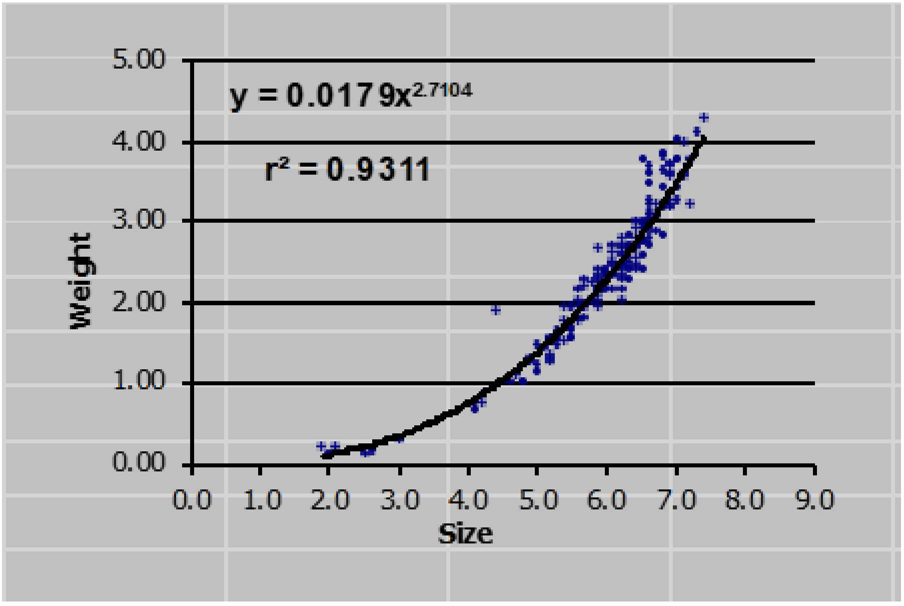

Figure 21. Weight curve vs. length. *Chirostoma contrerasi.* November-March. N = 156 individuals.

Minimum size is 1.9 cm maximum size is 7.4 cm and the modal length interval was 6.1 - 6.5 cm. n = 156 individuals (Figure 22)

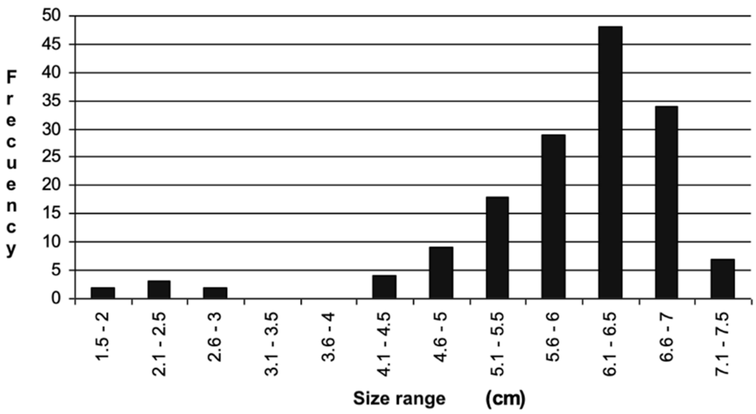

Figure 22. Frequency of individuals by *Chirostoma contrerasi* size range. November 2001-March 2002. N = 156 individuals. Minimum size = 1.9 cm, Maximum size = 7.4 cm.

The weight (Y) pattern length (X) ratio for C. lucius (Figure 23) was:

$$Y = 0.0216\ X^{2.6575}$$

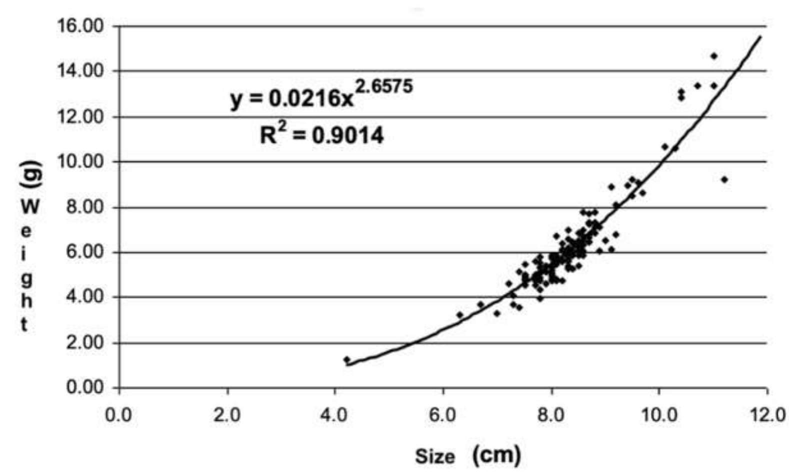

Figure 23. Curve of Weight vs. length of *Chirostoma lucius* November 2001- March 2002. N = 136 individuals**.**

Minimum size was 4.2 cm and the maximum size was 11.9 cm, the modal pattern length interval was 3.1 - 3.5 cm. n = 136 individuals (Figure 24)

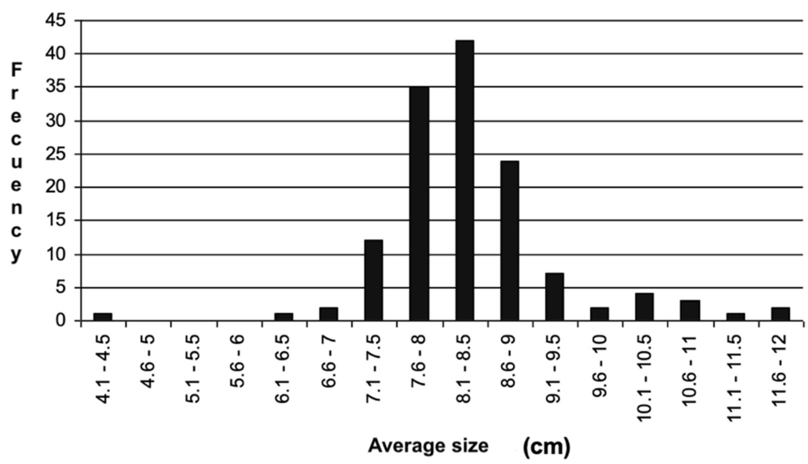

Figure 24. Frequency of individuals by size range of *Chirostoma lucius* November 2001- March 2002. N = 136 individuals. Minimum size = 4.2 cm, Maximum size = 11.9 cm. **.**

3.3. Index of Value of Importance (IVI)

When analyzing the Importance Value Index during the entire sampling period for the Central and Southern station, it is seen that C. consocium is the dominant species; except for the month of December in the South station, where it dominated C. chapalae. In the North station C. consocium dominates in the months of December, January, February. March, and October; in November it dominates C. chapalae. and C. jordani dominates in the months of April, July and September; C. contrerasi dominates in the month of August; the white fish C. lucius dominates in this season in the months of May and June.

4. Discussion

4.1. Fish community

4.1.1. Atherinopsidae

The genus Chirostoma is virtually restricted to the southern part of the Mexican Plateau. The distribution center of the 18 species and 6 subspecies of the genus is the system Lerma - Chapala - Santiago (Barbour 1973). In Lake Chapala there are 8 of these species

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and in Lake *La Alberca*, of them there are only five; missing: *C. labarcae, C. Sphyraena and C. promelas.*

Only fish of the genus Chirostoma were found at the Centro station throughout the sampling period, this perhaps because it is a deep area whereas food the fish would only find plankton, which is the main food of the *charales;* Since there are *charales*, there are *pescado blanco* (*C. lucius*) that feed on them.

In the Central and South stations, which are deep seasons, the dominant species throughout the year was C. consocium, except for the month of December in the South station where it dominated C. chapalae.

In contrast in the North station, which is shallow, the dominance was shared, *C. consocium* dominated in the months of December, January, February, March and October; this is consistent with the season of greatest reproduction found in Lake Chapala, Aguilera-Taylor, in 2003, which is from mid-January to mid-June, with a second reproduction peak, of lower intensity, between September and October. *C. jordani* has the highest breeding peaks in the same months as *C. consocium*, had its highest dominance in April, July and September; *C. lucius* was dominant in May and June; *C. chapalae* dominated in November and *C. contrerasi* in August.

In the breeding season Atherinopsidae approach the shore to deposit their eggs in vegetation, stones, or other submerged objects, is to say that they approach the shore not only to feed or seek shelter from predators, but also to look for breeding areas.

4.2. General community

The specific richness in the ichthyofauna of the lake is composed of 13 species belonging to 13 genera within 5 families, of which 11 are native, of these, then 5 species belong to the family Goodeidae, and 5 to the family Atherinopsidae, and one to the family Poecilidae (Table 1).

Table 1. List of fish of *La Alberca* [6].

Cyprinodontiformes
Family Goodeidae
1. *Chapalichthys encaustus* Jordan y Snyder (1900) N
2. *Goodea atripinnis* Jordan y Snyder (1900) N
3. *Xenotoca variata* Bean, 1887 N
4. *Zoogoneticus purhepechus* Domínguez-Domínguez *et al.*, 2008 N
5.*Aloophorus robustus* Bean (1892) N
Familia Poeciliidae
6. *Poeciliopsis infans* Woolman (1894) N
Atheriniformes
Family Atherinopsidae
7. *Chirostoma jordani* Woolman (1894) N
8. *Chirostoma contrerasi* Barbour, 2002 N
9. *Chirostoma consocium* Jordan y Hubbs (1919) N
10. *Chirostoma chapalae* Jordan & Snyder, 1899 N
11. C*hirostoma lucius* Boulenger (1900) N
Perciformes
Family Cichlidae
12. *Tilapia rendalli* Steindachner (1864) E
Family Centrarchidae
13. *Lepomis macrochirus* Rafinesque (1819) E

N = Native, E= Exotic.

Lake *La Alberca* has a little less than half of the species of Lake Chapala (11 to 26), but Chapala is 2,813 times larger. In other words, *La Alberca* presents a great diversity of species regarding its size. And the populations of the species in Chapala are much diminished, it is difficult to find *C. lucius*, *X. variata*, *Z. purhepechus* and *A. robustus*, contrary to what happens in *La Alberca*, characteristic that makes it an important conservation site.

It should be noted that no small introduced ornate species were found, which is a good symptom of ecosystem integrity and in terms of conservation of native species. The introduction of these species must be prevented at all costs, because they have a high proliferation capacity, due to high rates of breeding, and are resilients, which creates competition over species that are native.

The coexistence of a relatively large number of species, responds to the structure of the habitat and to the different eating habits: spatial-temporal and trophic segregation. Other examples are given in the lagoon of [9], in *Naranja de Tapia, Zacapu* and *Bellas Fuentes, Coeneo* (Michoacán)[10], these sites being similar to Lake *La Alberca,* in the fact that they are all remnants of larger bodies of water that were dried up at the beginning of the last century.

5. Conclusions

In Lake *La Alberca*, there are only four of the five species of *charales* existing in Lake Chapala, missing *C. labarcae*.

Of the three species of *Pescado blanco* (white fish) from Lake Chapala, only *C. lucius* was found here, missing *C. sphyraena and C. promelas*.

The dominant species in the Central and Southern sampling stations throughout the year was *C. consocium*. The exception to this was in the month of December in the South, where the dominant species was *C. chapalae*.

C. consocium dominated in December, January, February, March, and October; *C. jordani dominated* in April, July and September; *C. lucius* dominated in May and June; *C. chapalae* was dominant in November and *C. contrerasi* in August.

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The plankton of Lake *La Alberca* is composed of Diatoms, Rotifers, Copepods and Cladocers (ordered from highest to lowest abundance). The oligotrophy of the body of water is ratified. The physico-chemical parameters directly influence the planktonic communities, highlighting the temperature, salinity and chlorides depending on the dry season or rainfall.

The highest abundances in 2016 were for the species of *Poeciliopsis infans, Goodea atripinnis* and *Lepomis macrochirus* (both latter exotic species). In the case of biomass, the species that contribute the most are: *Lepomis macrochirus, Tilapia rendalli and Goodea atripinnis* (the first two exotic species). Then, that over the years these proportions have changed drastically: from 2002 to 2016 the abundance of *Lepomis macrochirus* increased 209 times (See Appendix A).

Due to the number of fish species (ichthyological richness) and its abundance in this lake, which take advantage of the different ecological niches, the existence of species that for its high sensitivity to pollution, that no longer exist in Lake Chapala and the analysis of water quality, allow us to conclude that: Lake *La Alberca* has a good state of health, which must be taken care so that all these species continue to exist in it and the ecological balance is preserved.

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Appendix A

Three sampling cycles were compared in the months of March, May, August, and November for the years 2002, 2008 [6] and the one carried out in this study in 2016. There were variations in relative abundances over time, mainly in species such as *Lepomis macrochirus* (introduced species), which increased from 3 organisms caught in 2002 to 606 in 2016, on the other hand, the relative abundance of *Poeciliopsis infans* (See Fig A1).

In 2016, approximately 51% of the total annual lake biomass is related to *L. macrochirus*, followed by 23% corresponding to *T. rendalli*. (Fig. A3).Therefore, 74% of the annual biomass in the southern part of the lake is of introduced species, while the remaining 26% belongs to native species, of which *G. atripinnis* owns half, with the remaining 13% distributed among nine species (Fig. A2)

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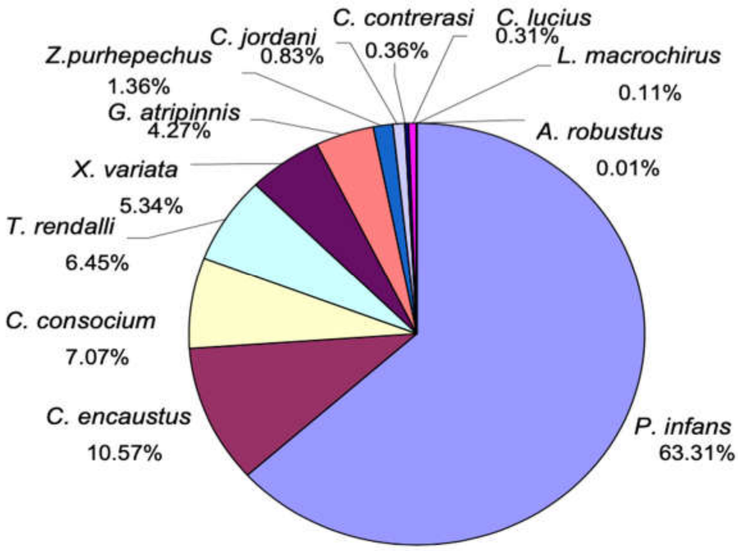

Figure A1. Relate biomass community in 2001-2002 [6].

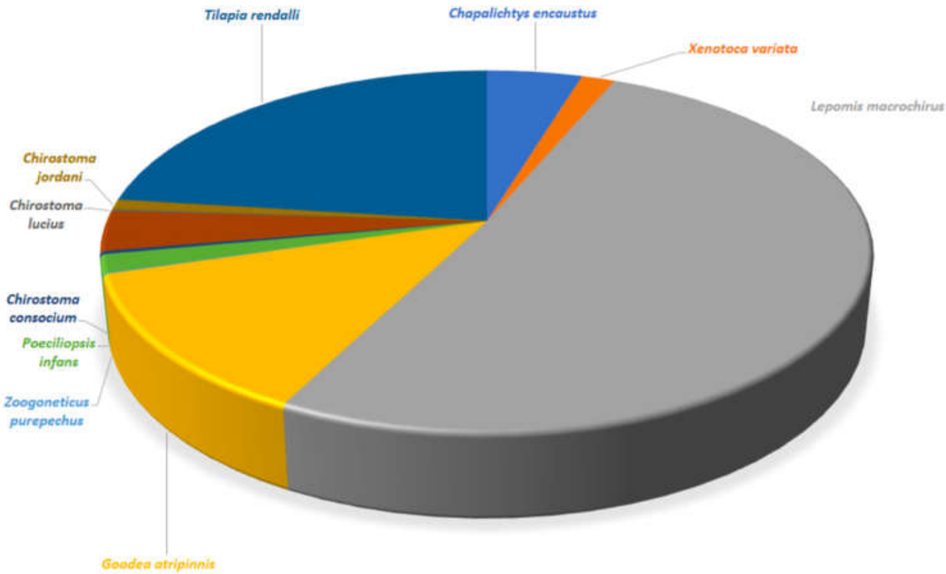

Figure A2. Relate biomass community in 2016 [7].

(a) (b)

Figure A3. (a)Lepomis macrochirus and (b)Tilapia rendalli.

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