water

MDPI

Brief Report

A Note of a Unique Inland, Saline Water Fishery: Brine Flies (Diptera: Ephydridae) of Lake Cuitzeo, Mexico

Jaquelina Beatríz Calderón-Arreola [1], Javier Alcocer [2,*] and Luis A. Oseguera [2]

[1] Facultad de Biología, Universidad Michoacana de San Nicolás de Hidalgo, Avenida Francisco J. Múgica S/N, Ciudad Universitaria, Morelia 58030, Michoacán, Mexico; jcalderon@unla.edu.mx
[2] Grupo de Investigación en Limnología Tropical, FES Iztacala, Universidad Nacional Autónoma de México, Av. De los Barrios No.1, Los Reyes Iztacala, Tlalnepantla 54090, Estado de Mexico, Mexico; loseguera@unam.mx
* Correspondence: jalcocer@unam.mx

Abstract: Fisheries in Cuitzeo, the second largest Mexican lake, used to take place on the permanent freshwater East and Central Basins as opposed to the temporal, saline, and initially thought barren West Basin. The 1980 fisheries collapse forced fishers to look for non-conventional fishing products elsewhere in the lake. The West Basin's temporal, saline-alkaline, and shallow water provides exceptional habitat for ephydrids to flourish. Locally known as "pupa", ephydrids are collected in large numbers. Although consumed since pre-Hispanic times, no other commercial fisheries of ephydrids are known worldwide. This study records the species composition and abundance of the "pupa" throughout an annual cycle in the West Basin, where fisheries occur. Two species were found: *Ephydra hians* and *Lamproscatella muria*. Ephydrids co-occurred in June and July at the end of the dry season when salinity was highest. *L. muria* was more abundant (954 ± 2385 ind m^{-2}) than *E. hians* (94 ± 38 ind m^{-2}). The relatively low salinity of the West Basin favoured *L. muria* over *E. hians*, which prefers higher salinities. This "pupa" fishery is still unpredictable due to the astatic nature of the lake, and hence limited economic importance to the local fishers.

Keywords: *Ephydra hians*; *Lamproscatella muria*; fishery; soda-alkaline lake; tropical lake; Michoacán

check for updates

Citation: Calderón-Arreola, J.B.; Alcocer, J.; Oseguera, L.A. A Note of a Unique Inland, Saline Water Fishery: Brine Flies (Diptera: Ephydridae) of Lake Cuitzeo, Mexico. *Water* **2022**, *14*, 900. https://doi.org/10.3390/w14060900

Academic Editors: Nickolai Shadrin, Elena Anufriieva and Gonzalo Gajardo

Received: 7 February 2022
Accepted: 11 March 2022
Published: 14 March 2022

1. Introduction

Fisheries on Cuitzeo, the largest saline Mexican lake, have been traditionally based on diverse fish species, particularly on the highly appreciated silverside *Chirostoma jordani* Woolman, but also on other either native (e.g., *Goodea atripinis* Jordan, *Allophorus robustus* Bean, and *Algansea tincella* Valenciennes) or exotic (e.g., *Oreochromis* spp. Günther, *Cyprinus carpio* Linnaeus) fish species.

Lake Cuitzeo originally comprised of two basins, West and East, interconnected through a wetland area, differing in water depth and physical and chemical characteristics, decreasing in water depth while increasing salinity from the East to the West Basins. Subsequently, the construction of the 43 and 43D highways separated a Central from the West Basin (Figure 1). The Grande de Morelia River discharges through the Central Basin wetlands. Traditional fisheries take place mainly in the freshwater East (0.5 g L^{-1}) and Central (1.9 g L^{-1}) Basins, while almost none in the saline (10 g L^{-1}), soda-alkaline (Na_2CO_3, pH up to 9.6) West Basin [1].

Lake Cuitzeo is shallow (i.e., 1 m average depth), and water level fluctuates widely according to the tropical seasonality (rainy and dry season), superimposed on a long-term trend (i.e., decadal phenomena and climate change), leading to ample morphometric changes [2]. Consequently, the West Basin becomes seasonal, desiccating intermittently in the dry season.

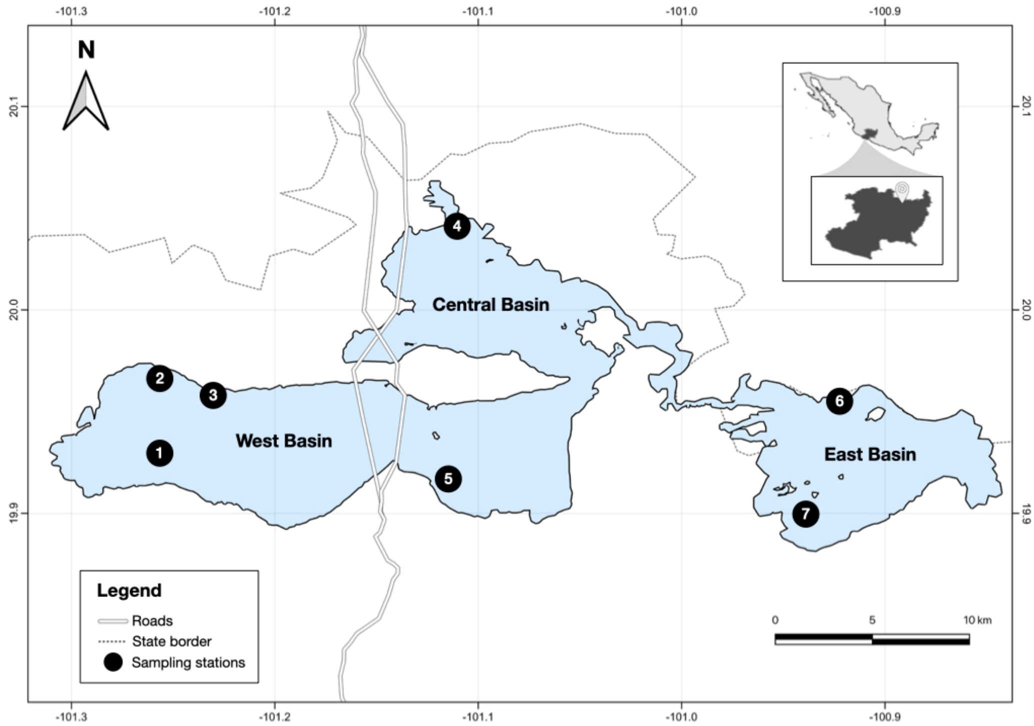

Figure 1. Lake Cuitzeo, Michoacán, in Mexico and Michoacán. (Sampling stations: 1—Congotzio, 2—Bordo, 3—Hacienda, 4—Jéruco, 5—La Palma, 6—Irámuco, 7—Queréndaro).

Fishers are organized in Fishermen's Unions, recognizing the general assembly as the highest governing body. The fishing families dedicated to this activity result from the cultural heritage of their ancestors. Most fishers are not landowners; those who own agricultural land, the terrain surface is limited to two or three hectares, barely for self-consumption. That is the origin of the fishing tradition in Lake Cuitzeo. By 2011, there were 49 Fishermen's Unions encompassing 2385 fishers [3]. Recent governmental information (unpublished CONAPESCA-Morelia 2021) reported a reduction in the number of Fishermen's Unions with 33, and in the number of registered fishers with 1782.

Water pollution (e.g., wastewater, fertilizers, and heavy metals, [4]) most likely explains the reduction in fish catches (unpublished CONAPESCA-Morelia 2006 fishing statistics) and the massive fish kills that impact the commercial yields affecting fishers and the local economy [5,6]. The traditional fisheries in Lake Cuitzeo—based mostly on the silverside—collapsed in 1980 and sustained low levels until 1986. Fisheries—now primarily based on tilapia—increased again from 1988 to 1997, but declined once again dramatically since 1998 (Figure 2, [3]).

Recently (2021), the Michoacán state government through the Secretaría de Agricultura y Desarrollo Rural (Secretary of Agriculture and Rural Development) organized a workshop (Taller con Investigadores: Entendiendo la problemática de la Cuenca del Lago de Cuitzeo) to run a diagnosis and indentation of the problematic (environmental, social, economic, political) of the Cuizeo basin, aiming to design a rehabilitation plan (measurements and actions) for Lake Cuitzeo (Diagnóstico y Plan Emergente para la Rehabilitación del Lago de Cuitzeo). Regarding the fisheries decline, the water quality/pollution issue (e.g., livestock, mostly pig farms, and agriculture, urban and industrial wastewaters) was identified as the primary cause followed by the lack of fisheries regulation (minimum catch size, fishing effort, types of fishing gear, minimum mesh size, fishery closure).

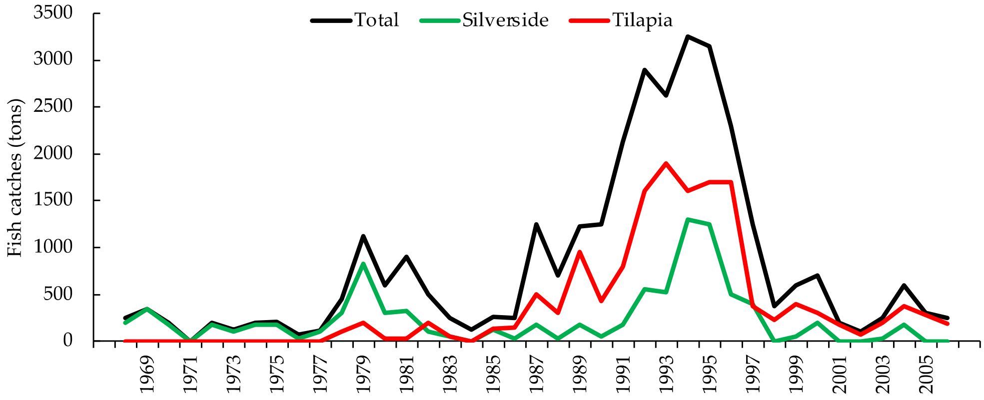

Figure 2. Annual catch volumes of fishery products in Lake Cuitzeo. (Modified from [3]).

The collapse forced fishers of Lake Cuitzeo to look for non-conventional fishing products elsewhere in the lake. The turbid, saline-alkaline, and shallow waters of the West Basin provide exceptional habitat for some invertebrate species to flourish almost free of predation and low competition: ephydrids, locally known as "pupa", branchiopods, locally known as "conchilla" [7], and hemipterans, locally known as "mosco" [8].

In pre-Hispanic times, ephydrid larvae and pupae were collected for human consumption, for example, in Mono Lake and other soda-alkaline lakes in Nevada and California, where the native Americans Paiutes named it "koo-chah-bee" or "koo-tsabe," or Lake Texcoco in Mexico basin, where Aztecs named it "puxi" [9–11].

In Lake Cuitzeo, the ephydrid larvae and pupae are found on the dry shore or floating on the lake's surface. Waves washed away the brine flies ashore, where they are swept with brooms made from bush branches, piled, and shoved into sacks. If floating on the water surface, fishers collect them with a chinchorro fishing net. The chinchorro is a canopy fabric with a very fine opening (2–5 mm mesh opening). The chinchorro measures from 60 to 100 m in length on the wings and from 3 to 5 m in length in the codend, and the height is from 1.30 to 3 m. The chinchorro has an upper rope line with wood or cork floats and a lower rope line with leads. In this way, the chinchorro mouth keeps open while trawled.

The operating fishing way is by spreading the chinchorro to form a semicircle from a canoe or, if shallow, by walking. The codend is left in the central part and is marked with a buoy. The chinchorro is then collected by closing the semicircle from a strongly anchored canoe or firmly still fisherman. In the final phase, one of the fishers grabs the bottom lead line with his hands and keeps it very close to the boat to prevent the organisms from escaping. This operation follows until the codend and the chinchorro are recovered.

Since there is no infrastructure to process the product, the treatment is rudimentary. Once collected, ephydrids are spread out in earthen patios and sun-dried. The product obtained is distributed among the participant fishers, while a percentage (~5%) is kept for the gear and equipment maintenance/repairment and eventual replacement with new ones. Intermediaries bought the final product and later resold it to national and international pet food companies (e.g., Grossman, Caribbean Tropical Pet Food). There is no sale in the local or regional market; all the product is sold abroad, mainly to the United States and Canada.

The brine fly fishery of Lake Cuitzeo was firstly recorded by the Federal Office of Fisheries of Cuitzeo in 1996. The record was 18 tons, but it seems the actual catch was about 90 tons, which were not reported but kept in private stores for further commercialization (comm. pers. Gustavo Barajas Mendoza, Head of the Federal Office of Fisheries of Cuitzeo). From then on, brine fly fishery records (e.g., unpublished reports of the Fisheries Statistics and Registry Area, Secretary of Agriculture, Livestock, Fisheries and Food, Fishing Sub delegation in Morelia, SAGARPA 2001) are erratic partially related to the fact that fishers do not report their catches to the authorities, but instead sell them to intermediaries. Also, the irregularity in the inundation pattern of Lake Cuitzeo leads to an unpredictable (from none up to 100 tons per season) brine fly supply to the market.

The shallow, ephemeral, and saline nature of the West Basin of Lake Cuitzeo prevents fish from inhabiting it. In this way, there is no interaction (e.g., predation) between fish and ephydrids. However, ephydrids share this habitat with the "conchilla" (2 species of branchiopods) [7] and with the "mosco" (5 species of corixids and 2 species of notonectids) [8].

Although the West Basin is ample and shallow, these organisms mainly develop on the peripheral shoreline and not in the central portion. In the same way, fisheries take place predominantly in the periphery.

Notwithstanding its relevance to the fishermen's economy, little is known about the "pupa" of Lake Cuitzeo. This paper reports data on diverse aspects of the taxonomy and ecology (habitat characterization, composition, distribution, abundance, and population structure) of the brine fly occurring in Lake Cuitzeo. To our knowledge, this is the first report of an inland water brine fly fishery. We provide the baseline information valuable to design conservation, sustainable exploitation, and potential aquaculture projects of this valuable aquatic resource.

2. Materials and Methods

Lake Cuitzeo, Michoacán, is the second-largest Mexican lake (425 km^2) and the largest saline. It is a shallow (average depth 1 m), turbid, warm polymictic, and hypertrophic lake [12]. The sampling design consisted of seven sites throughout the lake (Figure 1), including the main brine fly fishery areas: three sites in the west (Hacienda, Bordo, and Congotzio), one in the northwest (Jéruco), one in the central portion (La Palma), and two in the eastern portion (Irámuco and Queréndaro). The seven sites were sampled every 15 days from July 1998 to September 1999. The analyses were accomplished at the time, but the preparation for publication was not possible until now. Therefore, these historical data are a valuable baseline for assessing the dynamics of the ephydrids of Lake Cuitzeo and its fishery.

Physical and chemical parameters were recorded at each sampling site on every visit. Water depth was recorded with a tape measure, temperature with a mercury thermometer, pH with a Quikchem model 106 Pocket pH meter (QuickChem, Lachat, Loveland, CO, USA), and electrical conductivity with an ATI ORION Conductivity meter, model 130 (ATI Orion, Boston, MA, USA). Water samples kept cold and in darkness were transported to the laboratory and analyzed within 24 h for dissolved oxygen, alkalinity, and hardness [13]. Surface sediment was also analyzed for texture (dry sieving techniques (sands) and wet pipetting (silt and clay)) [14], and the percentage content of organic matter (loss on ignition -LOI- at 550 °C) [15].

Ten 1-m long trawls were carried out in each site with a net (0.20 cm $\times$ 10.5 cm, 0.25 mm mesh size), covering a total area of 2 m^2 (10 $\times$ 0.2 m^2). Attached emergent (*Typha*, *Scirpus*, *Cyperus*, *Eleocharis*, *Phragmites*) followed by attached submerged hydrophytes (*Potamogeton pectinatus*) are the dominant aquatic vegetation in Lake Cuitzeo growing mainly on the East, less in the Central, while lacking in the East Basins [16]. Although vegetation may have impacted the gear efficiency of trawl surveys, we took care of representing both naked and vegetated substrates when present. However, ephydrids inhabit muddy vegetation-free substrates. Organisms were first fixed in 4% formaldehyde and later conserved in 70% ethanol. Taxonomic identification followed [17–19]. Dr. David B. Herbst (Sierra Nevada Aquatic Research Laboratory, University of California) ratified the identification.

3. Results

3.1. The Habitat

Since there was a complete absence of ephydrids in the Central and East Basins, from here on, the results refer only to the West Basin (i.e., Hacienda, Bordo, and Congotzio) (Figure 2). The West Basin was flooded all year round (from August 1998 to July 1999) in Hacienda or Bordo, while Congotzio dried up from August to October 1998. Water depth ranged from a maximum of one meter (rainy season) just down to a centimetre (dry season); water depth averaged 0.2 ± 0.1 m.

The sampling sites' shallowness resulted in warm (22.0 ± 6.0 °C) and well-oxygenated (>4.0 mg L^{-1}) water columns. The chemical nature of Lake Cuitzeo (i.e., Na_2CO_3 > NaCl > Na_2SO_4 > KCl, [1]) explained the high alkalinity (pH ≈ 9, up to 3400 mg L^{-1}),= and total hardness (161 ± 6 mg L^{-1}). In July, the electrical conductivity increased through evapotranspiration, reaching the highest values (>13,000 µS cm^{-1}). The sediments were silty sands (sand 46%, silt 34%, clay 20%) and terrigenous with ≈2% organic matter.

3.2. The Ephydrids

The "pupa" in Lake Cuitzeo is composed of two co-existing species of Ephydridae: the alkali fly *Ephydra hians* Say, and the shore flies *Lamproscatella muria* Mathis. Although fishermen and [20] reported the presence of "pupa" in Jéruco, Hacienda, and Congotzio, in the present investigation, we found ephydrids only in Congotzio, but lacking in Hacienda and Bordo. Moreover, ephydrids appeared during a brief period, June and July, coinciding with the highest values of salinity and lowest water levels. Congotzio was already dried in August.

L. muria with 954 ± 2385 ind m^{-2} was more abundant than *E. hians* with 19 ± 38 ind m^{-2}. *L. muria* larvae composed 57% (545 ± 1881 ind m^{-2}) of the population while pupae 43% (409 ± 1225 ind m^{-2}). Quite differently, *E. hians* larvae comprised 92% (18 ± 36 ind m^{-2}) of the population, while pupae only 8% (2 ± 4 ind m^{-2}). Larvae and pupae were more numerous in July, while swarms of adults were seen flying around at the end of July and August (Figure 3).

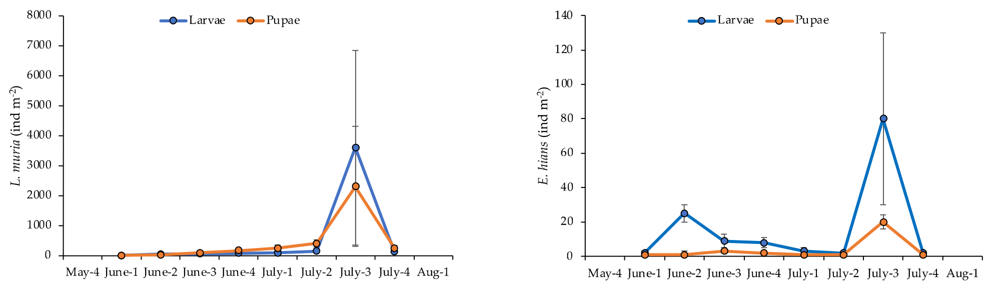

Figure 3. Temporal variation of *Lamproscatella muria* (**left**) and *Ephydra hians* (**right**) in Congotzio. (Dates are indicated in weeks of each month).

4. Discussion

E. hians has been reported in the states of Guanajuato [21,22], Puebla [23,24], Puebla-Tlaxcala [25], Hidalgo [26], Mexico City [27], and now Michoacán as new Mexican state record. *L. muria* is new record for both Michoacán and Mexico. A similar ephydrid composition with *E. hians* but *Lamproscatella salinaria* Sturtevant and Wheeler instead of *L. muria* were found inhabiting the saline playa lakes of California by Kubly and Cole (1979 in [28]).

The ephydrid species richness of Lake Cuitzeo with two species (*E. hians* and *L. muria*) is similar to that reported in other studies of saline lakes which varies between one species (*E. cinerea* Jones) in the Great Salt Lake, Utah [29] and Mono Lake, California (*E. hians* [30]), two species (*E. hians* and *E. gracilis* Packard) in Harper Dry Lake in the Mojave Desert of California [31], three species (*E. thermophila* Cresson, *E. bruesi* Cresson, and *Paracoenia turbida* Cresson) in Yellowstone, Wyoming, Montana, and Idaho [32], and four species of *Ephydra* (*E. hians*, *E. gracilis*, *E. packardi* Wirth, and *E. auripes* Aldrich) in the Great Basin, Nevada, Utah, California, Idaho, Oregon, and Wyoming [33].

Ephydrids' highest abundances and emergence timing in Lake Cuitzeo is similar to *Lamproscatella dichaeta* Loew—August—in saline habitats of northeastern Ohio [34], and *E. cinerea*—June—in the Great Salt Lake [29]. Larvae and pupae development time becomes shorter as temperature increases [30]. The warm temperatures (>20 °C, up to 35 °C) of the shallow West Basin of Lake Cuitzeo explained the fast life cycle (two months) of the ephydrids.

The *E. hians* density found in this study is like some saline lakes in Alberta and Saskatchewan, Canada, particularly with Gooseberry and Aroma Lakes (1–9 ind m^{-2}), but lower compared to Lakes Reflex and Little Manitou, Canada (10–99 ind m^{-2}) [35]. Contrasting, [30] reported very high densities of *E. hians* in Mono Lake, California (1000–34,000 ind m^{-2}), and [24,25] in Lakes Tecuitlapa Norte and Totolcingo, Puebla and Tlaxcala, Mexico (250–12,899 ind m^{-2}).

Diverse environmental and biological factors interplay to favor the dominance of one ephydrid species over another (e.g., [32,33]). The following could be mentioned: salinity (fresh to hypersaline), ionic dominance (sodium chloride or sodium bicarbonate), pH (acidic to alkaline), water permanence (ephemeral to perennial), and biological (larval food availability, predation, and competition) variables.

The alkaline carbonate waters of the West Basin should favour the alkali fly *E. hians* over the shore fly *L. muria*. Nonetheless, [36,37] found the salinity range of *E. hians* is 20 to 200 g L^{-1}, optimum 50 g L^{-1}, developing abundantly mostly in hypersaline environments (e.g., 53–56 g L^{-1} in Rincón de Parangueo [22], 100 g L^{-1} in Mono Lake [30]. The West Basin of Lake Cuitzeo is hyposaline (i.e., maximum 10 g L^{-1}), probably restraining *E. hians* and favouring *L. muria*.

Furthermore, while *E. hians* prefers hard substrates to develop [29,30,38], the West Basin sediments are silty sands, with no hard substrate availability disfavored *E. hians*. Moreover, the West Basin's ephemeral nature could also play a role in favoring *L. muria* over *E. hians*. However, [37] found that *Ephydra*'s adaptation to ephemeral and low salinity conditions may be accomplished by the fast adult colonizing ability and rapid larval development rates. Nonetheless, the dominance of *L. muria* over *E. hians* is indicative that the overall environmental characteristics of the West Basin and the biology of the species allows both species to inhabit the West Basin, but favors *L. muria* over *E. hians* explaining the higher numbers of the former.

Food availability and type are essential for ephydrid's successful development. Benthic diatoms, filamentous green algae, and cyanobacteria were present in Congotzio. The larvae of *E. hians* consume the same food items [30]. Bradley and Herbst [39] carried out tests of unialgal diets (diatoms, cyanobacteria, and chlorophytes) on *E. hians*, indicating a generalist herbivore's behaviour. The ephydrids of Lake Cuitzeo digestive tract analysis confirmed they consume diatoms and filamentous cyanobacteria (e.g., *Navicula cuspidate* Kutzing, 1844, *Nodularia spumigena* Mertens ex Bornet & Flahault, 1888).

Waterbirds and shorebirds predate ephydrids and other invertebrates inhabiting saline lakes (e.g., [40,41]), playing a key role in the food webs of these extreme ecosystems. However, the high turbidity of Lake Cuitzeo West Basin associated with the sediment resuspension counteracts predation, allowing the ephydrids populations to increase. Predation on ephydrids by fish and amphibians (e.g., the Montezuma leopard frog *Lithobates montezumae*) is discarded since these species are absent in the saline waters of the West Basin. The only known reported species sharing habitat with the ephydrids are branchiopod crustacea, and corixid and notonectid insects; among them, notonectids could predate on ephydrids.

Despite being a valuable resource that, when present, supports the economy of the Lake Cuitzeo fishers, the natural environmental variability (temporally astatic) of the West Basin makes the ephydrid harvest still unpredictable. As far as is known, the "pupa" catches vary yearly, from the absence of the product to a maximum of close to 100 tons. However, part of the uncertainty is due to the lack of accurate fishing records, since fishermen do not always report their harvests to the Federal Office of Fisheries of Cuitzeo.

5. Conclusions

The ephydrid assemblage of Lake Cuitzeo is restricted to the West Basin, a temporal, shallow, turbid, alkaline saline, rich in benthic diatoms, filamentous green algae, and cyanobacteria, constituting a suitable habitat for ephydrids to flourish. *Ephydra hians* and *Lamproscatella muria* composed the ephydrid assemblage. A similar species richness (1–4 species) is commonly found in saline lakes. *L. muria* (954 ± 2385 ind m^{-2}) outnumbered *E. hians* (94 ± 38 ind m^{-2}). Most likely, the relatively low salinity (≤10 g L^{-1}) of the West Basin of Lake Cuitzeo favours *L. muria* since *E. hians*' salinity preference is >20 g L^{-1}. Also, it has been found that at low salinities, *E. hians* population densities are limited by biotic factors (e.g., predation and competition). Moreover, the low salinity stimulates a rapid larval development rate explaining that the ephydrids of the West Basin of Lake Cuitzeo complete their life cycle in two months, at the end of the dry season concurrent with the shallowest water column and the highest salinities. Although economically important, the variability of the West Basin of Lake Cuitzeo turns the "pupa" fishery into an unpredictable and then unreliable resource to Lake Cuitzeo fishers.

Author Contributions: Conceptualization, J.B.C.-A. and J.A.; Data curation, J.B.C.-A.; Formal analysis, J.B.C.-A., J.A. and L.A.O.; Funding acquisition, J.B.C.-A.; Investigation, J.B.C.-A. and J.A.; Methodology, J.B.C.-A., J.A. and L.A.O.; Resources, J.B.C.-A.; Software, J.A. and L.A.O.; Supervision, J.A.; Validation, J.B.C.-A., J.A. and L.A.O.; Visualization, J.B.C.-A. and J.A.; Writing—original draft, J.B.C.-A., J.A. and L.A.O.; Writing—review & editing, J.B.C.-A., J.A. and L.A.O. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are available from the authors upon reasonable request.

Acknowledgments: SIMORELOS-CONACYT and Caribbean Tropical Pet Food, S.A. de C.V. provided partial financial support. We acknowledge the laboratory facilities provided by the School of Biology, UMSNH. We appreciate the invaluable help in the field and laboratory of Sonia González-Santoyo and Araceli Martínez-Pantoja. Sonia González-Santoyo also provided valuable information about the traditional fisheries at Lake Cuitzeo. We thank Mariana Vargas for drawing the figures. We are particularly grateful to two anonymous reviewers whose positive and encouraging comments and suggestions greatly improved this paper.

Conflicts of Interest: The authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

References

1. Alcocer, J. Saline lake ecosystems of Mexico. *Aquat. Ecosyst. Heal. Manag.* **1999**, *1*, 291–315. [CrossRef]
2. Alcocer Durand, J.; Bernal-Brooks, F.W. Long-term ecological research in epicontinental aquatic bodies. *Rev. Dig. Univ.* **2009**, *10*. Available online: http://www.revista.unam.mx/vol.10/num8/art52/int52.htm (accessed on 6 February 2022).
3. Arellano Torres, A.; Meléndez Galicia, C.; Hernández Montaño, D.; Hernández Zárate, N. Ordenamiento pesquero del Lago de Cuitzeo, Michoacán-Guanajuato. In *Centro Regional de Investigación Pesquera Pátzcuaro*; INP, SAGARPA: Pátzcuaro, Mexico, 2011; p. 31.
4. Franco, C.; Galicia, L.; Durand, L.; Cram, S. Análisis del impacto de las políticas ambientales en el lago de Cuitzeo (1940–2010). *Inv. Geog.* **2011**, *75*, 7–22. [CrossRef]
5. Pompa, L.I.Y. Deterioro Ambiental en la Cuenca del Lago de Cuitzeo y su Impacto en Organizaciones de Pescadores de la Ribera. Master's Thesis, Universidad Autónoma de Chapingo, Estado de México, Mexico, 1995.
6. Alvarado Díaz, J.; Zubieta Rojas, T.; Ortega Murillo, R.; Chacón Torres, A.; Espinoza Gómez, R. Hipertroficación en un lago tropical somero (Lago de Cuitzeo, Michoacan, Mexico). *Biológicas* **1985**, *1*, 1–22.
7. Martínez-Pantoja, M.A.; Alcocer, J.; Maeda-Martínez, A.M. On the Spinicaudata (Branchiopoda) from Lake Cuitzeo, Michoacán, México: First report of a clam shrimp fishery. *Hydrobiologia* **2002**, *486*, 207–213. [CrossRef]
8. González-Santoyo, S.; Alcocer, J.; Oseguera, L.A. The "mosco" (Hemiptera: Corixidae and Notonectidae) of Lake Cuitzeo, Mexico: An unusual inland water fishery. *Limnology* **2020**, *21*, 119–127. [CrossRef]
9. Adler, P.H.; Courtney, G.W. Ecological and Societal Services of Aquatic Diptera. *Insects* **2019**, *10*, 70. [CrossRef]
10. Aldrich, J.M. The biology of some Western species of the dipterous genus Ephydra. *J. N. Y. Entomol. Soc.* **1912**, *20*, 77–99.

11. Wirth, W.W. The Brine Flies of the Genus Ephydra in North America (Diptera: Ephydridae). *Ann. Èntomol. Soc. Am.* **1971**, *64*, 357–377. [CrossRef]
12. Chacón Torres, A.; Rosas-Monge, C.; Alvarado-Díaz, J. The effects of hypereutrophycation in a tropical Mexican lake. In *Aquatic Ecosystems of Mexico: Status and Scope*; Munawar, M., Lawrence, S.G., Munawar, I.F., Malley, D.F., Eds.; Backhuys: Kerkwerve, The Netherlands, 2000; pp. 89–101.
13. APHA; AWWA; WPCF. *Standard Methods for the Examination of Water and Wastewater*; APHA: Washington, DC, USA, 1989; p. 1193.
14. Folk, R.L. A Review of Grain-Size Parameters. *Sedimentology* **1966**, *6*, 73–93. [CrossRef]
15. Dean, J.W.E. Determination of Carbonate and Organic Matter in Calcareous Sediments and Sedimentary Rocks by Loss on Ignition: Comparison with Other Methods. *J. Sediment. Res.* **1974**, *44*, 242–248. [CrossRef]
16. Moreno, J.R.; Retana, A.N. Flora y vegetación acuáticas del Lago de Cuitzeo, Michoacán, México. *Acta Bot. Mex.* **1995**, 1–17. [CrossRef]
17. Lehmkuhl, D.M. How to know the aquatic insects. In *The Pictured Key Nature Series*; Wm C. Brown Co.: Dubuque, IA, USA, 1979; p. 168.
18. Merrit, R.W.; Cummins, K.W.; Berg, M.B. *An Introduction to the Aquatic Insects of North America*; Kendall Hunt: Dubuque, IA, USA, 1978; p. 1158.
19. Usinger, R.L. *Aquatic insects of California. With Keys to North American Genera and California Species*; University of California Press: Berkeley, CA, USA, 1956; p. 508.
20. Pompa, L.I.Y. Composición y Estructura del Perifiton Animal del Lago de Cuitzeo, Michoacán, Mexico. Bachelor's Thesis, Escuela de Biologia, Universidad Michoacana de San Nicolás de Hidalgo, Morelia, Mexico, 1990.
21. Green, J. Associations of zooplankton in six crater lakes in Arizona, Mexico and New Mexico. *J. Zool.* **1986**, *208*, 135–159. [CrossRef]
22. Alcocer, J.; Lugo, A.; Oliva, M.G. The crater lakes of Valle de Santiago, Guanajuato. In *Lagos y Presas Mexicanos*; de la Lanza, G., García-Calderón, J.L., Eds.; Centro de Ecología y Desarrollo: Mexico City, Mexico, 2002; pp. 193–212.
23. Alcocer, J.; Escobar, E.; Lugo, A.; Peralta, L. Littoral benthos of the saline crater lakes of the basin of Oriental, Mexico. *Int. J. Salt Lake Res.* **1998**, *7*, 87–108. [CrossRef]
24. Alcocer, J.; Escobar, E.G.; Lugo, A.; Oseguera, L.A. Benthos of a perennially-astatic, saline, soda lake in Mexico. *Int. J. Salt Lake Res.* **1999**, *8*, 113–126. [CrossRef]
25. Alcocer, J.; Lugo, A.; Escobar, E.; Sánchez, M. The macrobenthic fauna of a former perennial and now episodically filled mexican saline lake. *Int. J. Salt Lake Res.* **1996**, *5*, 261–274. [CrossRef]
26. Ramos Elorduy, J.; Pino, J.M.; Conconi, M. Ausencia de una reglamentación y normalización de la explotación y comercia-lización de insectos comestibles en México. *Folia Entomológica Mex.* **2006**, *45*, 291–318.
27. Alcocer, J.; Williams, W.D. Historical and recent changes in Lake Texcoco, a saline lake in Mexico. *Int. J. Salt Lake Res.* **1996**, *5*, 45–61. [CrossRef]
28. Geddes, M.C.; De Deckker, P.; Williams, W.D.; Morton, D.W.; Topping, M. On the chemistry and biota of some saline lakes in Western Australia. *Hydrobiologia* **1981**, *81*, 201–222. [CrossRef]
29. Collins, N. Population ecology of Ephydra cinerea Jones (Diptera: Ephydridae), the only benthic metazoan of the Great Salt Lake, USA. *Hydrobiologia* **1980**, *68*, 99–112. [CrossRef]
30. Herbst, D.B. Distribution and abundance of the alkali fly (Ephydra hians) Say at Mono Lake, California (USA) in relation to physical habitat. *Hydrobiologia* **1990**, *197*, 193–205. [CrossRef]
31. Herbst, D.B. Salinity controls on trophic interactions among invertebrates and algae of solar evaporation ponds in the Mojave Desert and relation to shorebird foraging and selenium risk. *Wetlands* **2006**, *26*, 475–485. [CrossRef]
32. Collins, N.C. Mechanisms Determining the Relative Abundance of Brine Flies (Diptera: Ephydridae) in Yellowstone Thermal Spring Effluents. *Can. Entomol.* **1977**, *109*, 415–422. [CrossRef]
33. Herbst, D.B. Biogeography and physiological adaptations of the brine fly genus Ephydra (Diptera: Ephydridae) in saline waters of the Great Basin. *Great Basin Nat.* **1999**, *59*, 127–135.
34. Scheiring, J.F.; Foote, B.A. Habitat distribution of the shore flies of Northeastern Ohio (Diptera: Ephydridae). *Ohio J. Sci.* **1973**, *73*, 152–166.
35. Hammer, U.T.; Sheard, J.S.; Kranabetter, J. Distribution and abundance of littoral benthic fauna in Canadian prairie saline lakes. *Hydrobiologia* **1990**, *197*, 173–192. [CrossRef]
36. Herbst, D.B. Comparative population ecology of Ephydra hians Say (Diptera: Ephydridae) at Mono Lake (California) and Abert Lake (Oregon). *Hydrobiologia* **1988**, *158*, 145–166. [CrossRef]
37. Herbst, D.B. Gradients of salinity stress, environmental stability and water chemistry as a templet for defining habitat types and physiological strategies in inland salt waters. *Hydrobiologia* **2001**, *466*, 209–219. [CrossRef]
38. Herbst, D.B.; Bradley, T.J. A population model for the alkali fly at Mono Lake: Depth distribution and changing habitat availability. *Hydrobiologia* **1993**, *267*, 191–201. [CrossRef]
39. Bradley, T.J.; Herbst, D.B. Growth and Survival of Larvae of Ephydra hians Say (Diptera: Ephydridae) on Unialgal Diets. *Environ. Entomol.* **1994**, *23*, 276–281. [CrossRef]
40. Roberts, A.J. Avian diets in a saline ecosystem: Great Salt Lake, Utah, USA. *Hum. Wildl. Interact.* **2013**, *7*, 158–168. [CrossRef]

41. Senner, N.R.; Moore, J.N.; Seager, S.T.; Dougill, S.; Kreuz, K.; Senner, S.E. A salt lake under stress: Relationships among birds, water levels, and invertebrates at a Great Basin saline lake. *Biol. Conserv.* **2018**, *220*, 320–329. [CrossRef]