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Fish fauna characterization after the onset of a turbid condition in a clear vegetated shallow lake

Caracterización de la ictiofauna tras el establecimiento de un estado turbio en un lago somero vegetado de aguas claras

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ABSTRACT

Shallow lakes are known to present either alternative states, clear or turbid water condition. Both scenarios can be usually found in the Pampa Plain, but less frequently one previously clear lake is witnessed to become a turbid environment. Kakel Huincul is a shallow lake that supports important recreational fisheries. Previous ichthyological contributions for this system indicate the existence of seven fish species inhabiting a clear water environment. Unfortunately, the lake has become very turbid in the last decade and the possible changes in the fish assemblages associated with this have not yet been assessed. In this context, we aimed to explore the fish fauna of this ecosystem after the onset of its turbid condition and to assess some relevant limnological parameters, based on a monthly survey performed from May 2022 to April 2023. Water was characterized by high values of both dissolved oxygen (8.9 ± 1.6 mg/L) and electric conductivity (6538 ± 2205 µS/C), whereas turbidity permanently oscillated within a high turbid range (145.6 ± 99.0 NTU). A total of 16 fish species were collected. All collected specimens belong to native species, except for the common carp *Cyprinus carpio*. The common carp and two Loricariidae species are first records for this lake. The occurrence of the previously unreported invasive common carp could be linked to the recent transition from clear to turbid water phase experienced by this ecosystem.

Keywords: *Cyprinus carpio*, fish assemblage, pampa plain, turbid waters.

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RESUMEN

Los lagos someros presentan dos estados de equilibrio alternativos, aguas claras o turbias. En la Llanura Pampeana, ambos escenarios son comunes, pero con menos frecuencia se observa que un lago previamente claro se convierta en un ambiente turbio. La laguna Kakel Huincul es un ambiente somero que sostiene importantes pesquerías recreacionales. Trabajos ictiológicos previos reportan la existencia de siete especies de peces en un sistema vegetado y de aguas claras. Sin embargo, en los últimos diez años la laguna se ha vuelto de agua turbia sin haberse evaluado aún las posibles variaciones en el ensamble de peces asociadas a este proceso. En este contexto, el objetivo del presente trabajo es caracterizar la fauna ictícola del ecosistema luego de su transición hacia un ambiente de aguas turbias y evaluar patrones limnológicos relevantes durante un programa de muestreo mensual de un año (mayo 2022 – abril 2023). La laguna se caracterizó por poseer altos valores de oxígeno disuelto (8.9 ± 1.6 mg/L) y conductividad (6538 ± 2205 µS/C), mientras que la turbidez del agua osciló dentro de un rango de valores elevados (145.6 ± 99.0 NTU). Se colectaron en total 16 especies de peces. Todas, excepto la carpa común *Cyprinus carpio*, fueron nativas. El presente trabajo representa el primer registro para la laguna de estudio de la carpa común, así como para dos especies de la familia Loricariidae. La ocurrencia de la carpa posiblemente esté relacionada con la reciente transición del sistema de lago somero de agua clara a un lago turbio.

Palabras clave: aguas turbias, *Cyprinus carpio*, ensamble de peces, llanura pampeana.

INTRODUCTION

The freshwater fish fauna of Argentina is composed of 543 freshwater fishes (Rosso and Liotta 2021) distributed throughout its territory in a wide range of climates and soil types, being one of the countries with greatest diversity of biogeographic units in the world (Bertonatti and Corcuera 2000). According to López *et al.* (2002), Argentina has eleven continental ichthyogeographic ecoregions, where the Salado River basin represents the southern range for many Neotropical fish species. Further inland, freshwater ecosystems are characterized by a pauperized paranoplatense fish fauna (Ringuelet 1975).

The Pampa Plain is a mosaic of aquatic environments within one of the most intensive cultivable arable lands in South America. In this landscape, there are more than 1400 shallow lakes with a main axis larger than 500 m (Gómez and Toresani 1998). These freshwater ecosystems are typically inhabited by 28 fish species under mean hydrological conditions (Rosso 2006). A clear vegetated lake in this region is characterized by a fish assemblage with higher abundances of piscivores such as thrairas of the genus *Hoplias* (Gill 1903), whereas turbid environments are dominated by zooplanktivores species such as silversides (genus *Odontesthes* Evermann & Kendall 1906), small filter-feeding silurids, and detritivores as *Cyphocharax voga* (Hensel, 1870) (Quirós *et al.* 2002). One of the main drivers for the structuration of the fish assemblages in the Pampa Plain is the degree of eutrophication largely influenced by patterns of soil use in the landscape (Quirós *et al.* 2006). Fish are not only known to respond to environmental patterns but also influence ecosystem processes. Indeed, some experimental approaches have already documented the effects of some fish species in the trophic condition of the ecosystems (Boveri and Quirós 2002). In this respect, proper knowledge of fish assemblages and limnological conditions in shallow lakes of the Pampa Plain seems mandatory for a comprehensive understanding of their dynamics as well as a base for better management and conservation tools.

Shallow lakes are known to experience two alternative equilibrium states that form two different scenarios: a clear-vegetated water or a turbid water environment (Scheffer *et al.* 1993). In the Pampa Plain, the transition between these alternative states involves a complex interaction between climatic characteristics, nutrient concentrations, and land use and is intimately related to changes in main limnological conditions and fish fauna (Quirós 2005, Boveri and Quirós 2002, 2007).

Kakel Huincul is a permanent shallow lake of the Pampa Plain recognized for supporting recreational fisheries. It was historically dominated by clear waters and dense mats of macrophytes (Sánchez *et al.* 2017) but just recently it has entered a transition from a clear to a turbid environment (Izaguirre *et al.* 2022, Sánchez Vuichard *et al.* 2022). Few studies have been carried out to assess the ichthyological fauna of this lake (Berasain and Barchesi 1998, Argemi and Berasain 2007). Nevertheless, all of them were carried out before the first evidence for the transition from clear to turbid waters (Sánchez *et al.* 2017).

In this scenario, this study aims to characterize, for the first time, the fish fauna composition of a formerly clear water shallow lake after the onset of a turbid condition state and comment about the likely role of fishes during this transitional process.

MATERIALS Y METHODS

Study area

The Kakel Huincul (KH) is a permanent shallow lake with a mean depth of 1.5 m, and elevated nutrient levels (Silvoso *et al.* 2011). This lake belongs to the "Salado del Sur – Villamanca" ecoregion (López *et al.* 2002), but it is not directly influenced by the Río Salado basin or any other surface drainage. On the contrary, its water level is affected by the rainfall-evaporation cycle and during extraordinary floods by surface water from Channel two which flows into Samborombón Bay (Fig. 1). The climate is considered extremely humid (Aliaga *et al.* 2017), with an annual average rainfall of 987 mm and an average temperature of 15.1°C, with maximum in January (109.2 mm and 28.5°C) and minimum in July (62.1 mm and 3.8°C) (Estación Meteorológica Aeródromo de Dolores, 36°19' South, 57°43' West, Servicio Meteorológico Nacional 2022). According to Izaguirre *et al.* (2012) and Sánchez *et al.* (2017), KH is characterized as a clear-vegetated water body with abundant submerged macrophytes. As in other parts of the country, agriculture was implemented in this zone in the 1960s, and it was later intensified at the end of the 1980s, with an acceleration of the eutrophication process related to the adoption of soybean crops starting in 1995 (Sánchez Vuichard *et al.* 2022).

DATA COLLECTION

Different environments of KH (main lake and littoral environments) were sampled monthly from May 2022 to April 2023 to maximize the collection of different species. Water temperature, water conductivity, total suspended solids, salinity, dissolved oxygen and turbidity were measured in the main lake at 0.5 m depth during each sampling event using a multiparameter probe Horiba U-53.

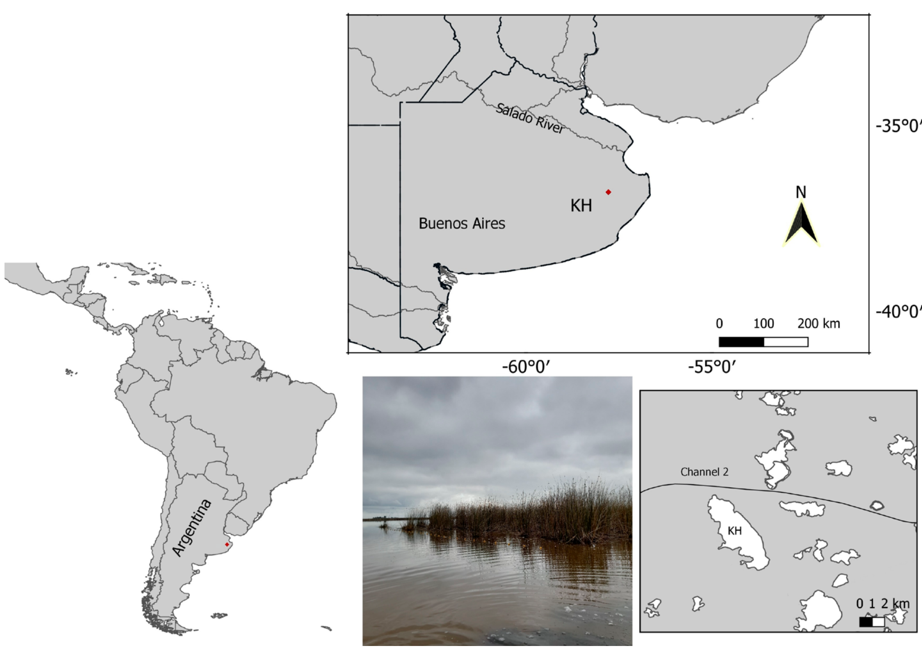

Figure 1. Study area, the Kakel Huincul (KH) lake. Buenos Aires, Argentina.

Field sampling was conducted under a scientific fishing permit issued by the Ministerio de Agroindustria of Buenos Aires Province (Permission No. RESO-2022-44-GDE-BA-SSAGYPMDAGP). Fish sampling was performed using different nets and fishing devices: trammel nets (20 m), beach seine nets (10 m), and long lines (9 m). As field sampling conditions (accessibility, meteorology) were not always constant, fishing gears and techniques employed were not homogeneous throughout the study period. This constraint precludes obtaining informative comparative data about fish assemblage as species abundance and size structure. Irrespective of that, our main goal here was to provide a first comprehensive assessment of fishes' composition inhabiting an iconic fishing environment in the Pampa Plain, only known by two previous studies (Berasain and Barchiesi 1998, Argemi and Berasain 2007). Monthly sampling was not aimed at evaluating temporal patterns of fish abundance but to improve the probability of collecting some species likely occurring in particular seasons. Fish captured were euthanized by an overdose in benzocaine solution, fixed in 10 % formalin solution, and preserved in 70 % ethanol. Fish species were identified following Ringuelet *et al.* (1967), López *et al.* (1987), Casciotta *et al.* (2005), Rosso (2006) and Miquelarena *et al.* (2008). Valid species names, their authorities, year of publication, and synonyms were listed following Mirande and Koerber (2020) and Fricke *et al.* (c2024). Voucher specimens were deposited at the fish collection of the Instituto de Investigaciones Marinas y Costeras (UNMDP), in Mar del Plata, Argentina.

For comparative purposes, the fish fauna of the following shallow lakes was considered: Los Chilenos (Berasain and Velasco 2023), Quillalauquen and El Hinojal (Berasain and Velasco 2019, 2022), La Barrancosa (Bertora *et al.* 2019), La Salada de Monasterio (Berasain *et al.* 2019), Sauce Grande (Bertora *et al.* 2021), Mar Chiquita (Salado River Basin), Gómez and Carpincho (Rosso and Quirós 2010), Alsina (Miquelarena and López 1995) and Chascomús (Berasain and Velasco, 2021, Nuozzi *et al.* 2022). Also, selected limnological parameters available from previous works in the KH lake were explored.

RESULTS

Among the environmental variables analyzed, water temperature averaged 20.4 ± 8 (°C, SD), water conductivity averaged 6538 ± 2205 (µS/cm, SD), and turbidity averaged 145.6 ± 99 (NTU, SD) (Table 1). A marked increment in water turbidity and electric conductivity was observed when compared with values from previous years.

Fish sampling yielded a total of 16 species (Fig. 2), belonging to eleven families and five orders (Table 2). Characiformes and Siluriformes were the richest orders with five and six species, respectively (68 % of the total species collected) (Fig. 3a). Characidae was the most representative family with six species (Fig. 3b). The remaining fish families contained one species except for the Heptapteridae and Loricariidae, which were represented by two species

Table 1. Environmental characteristics in the Kakel Huincul lake during sampling (2022-2023) and comparative previous values. *Values from Silvoso *et al.* 2011 (samples during 2005/6) and Sánchez *et al.* 2017 (samples during 2010).

	Mean	Minimum	Maximum	2005/2006*	2010*
Temperature (°C)	20.4	8.3	31.2	10.7 – 24.3	23.5 - 25.8
Conductivity (µS/cm)	6538	4330	9730	1540 – 2187	3930 – 4950
Total suspended solids (mg/L)	4.0	2.7	6.1	2 – 12	41
Salinity (ppt)	3.4	2.3	5.5	-	-
Dissolved Oxygen (mg/L)	8.8	6.0	11.4	-	6.7 - 8.2
Turbidity (NTU)	145.6	28.1	315.0	2 - 4	22-28

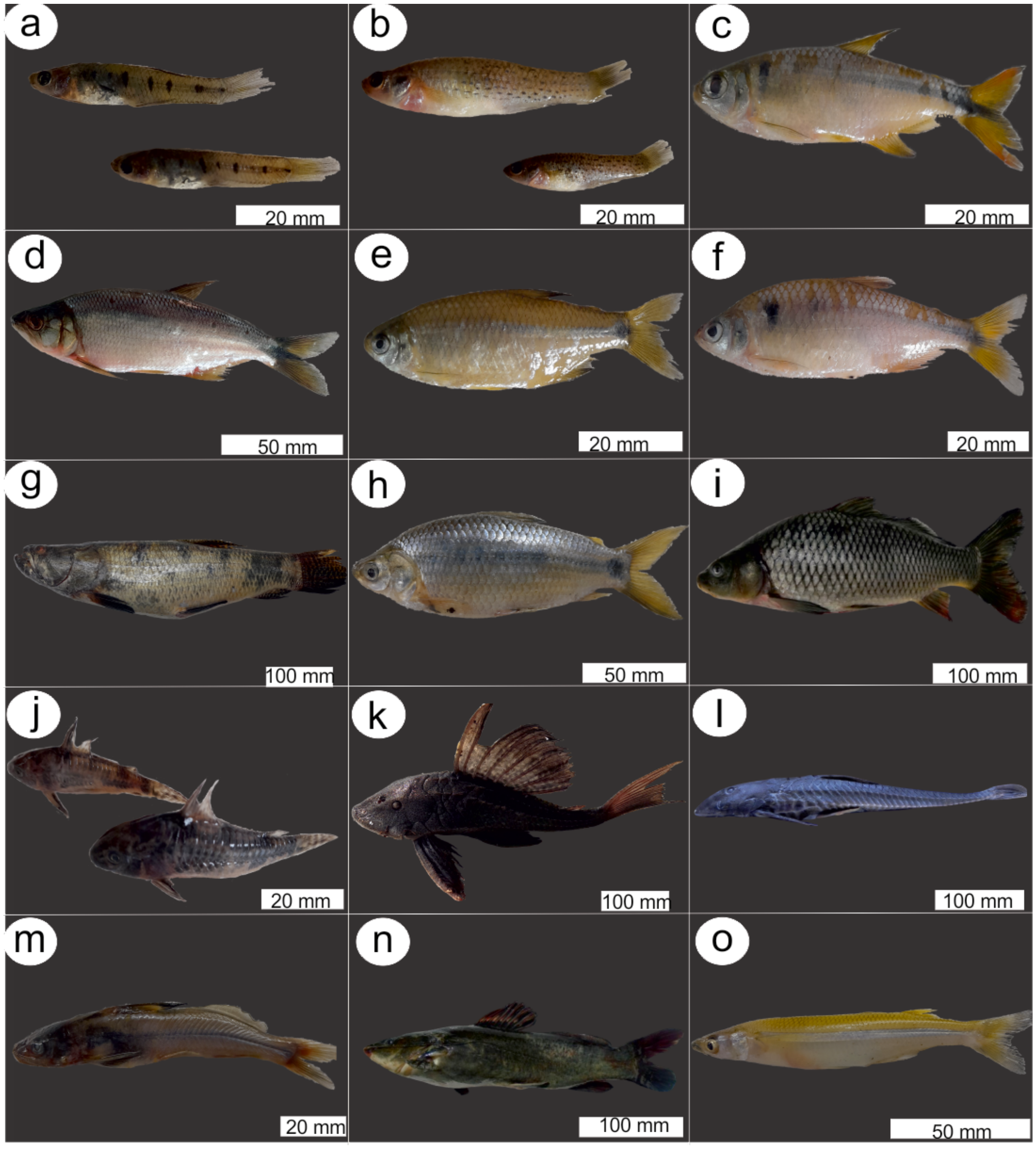

Figure 2. Fishes from the Kakel Huincul lake, Buenos Aires, Argentina. a. ***Cnesterodon decemmaculatus***, b. ***Jenynsia lineata***, c. ***Psalidodon pampa***, d. ***Oligosarcus jenynsii***, e. ***Cheirodon interruptus***, f. ***Bryconamericus iheringii***, g. ***Hoplias argentinensis***, h. ***Cyphocharax voga***, i. ***Cyprinus carpio***, j. ***Corydoras paleatus***, k. ***Hypostomus commersoni,*** l. ***Loricariichthys anus***, m. ***Pimellodella laticeps,*** n. ***Rhamdia quelen***, o. ***Odontesthes bonariensis.***

each. Seven of the sixteen species are the first records for this lake. All collected fishes are native, except for *Cyprinus carpio* Linnaeus, 1758. Comparatively, the species richness of Kakel Huincul was among the highest in the region (Fig. 4).

DISCUSSION

A marked increment in water turbidity was observed when comparing the current environmental conditions of KH lake with previous works (Silvoso *et al.* 2011, Sánchez *et al.* 2017). In the Pampa Plain, high electrical conductivity values are associated both, to extensive drought periods or to the resuspension of minerals in a turbid water state as opposed to a clear one (Quirós *et al.* 2002). The increase in area of arable land surrounding the Kakel Huincul lake (Sánchez Vuichard *et al.* 2022) together with, at least, four-year period (2019 - 2023) of Niña meteorological conditions (ENSO phenomenon, Vera *et al.* 2023) may explain large values of water conductivity registered during

Table 2. List of species collected in the Kakel Huincul lake, Buenos Aires province, Argentina. *indicates first record

Order	Family	Species	Author
Cyprinodontiformes	Poeciliidae	*Cnesterodon decemmaculatus* *	(Jenyns, 1842)
	Anablepidae	*Jenynsia lineata* *	(Jenyns, 1842)
	Rivulidae	*Austrolebias robustus* *	(Günther, 1883)
Characiformes	Characidae	*Psalidodon pampa*	(Casciotta, Almirón & Azpelicueta, 2005)
		Oligosarcus jenynsii	(Günther, 1864)
		Cheirodon interruptus	(Jenyns, 1842)
		Bryconamericus iheringii *	(Boulenger, 1887)
	Erythrinidae	*Hoplias argentinensis*	Rosso, González-Castro, Bogan, Cardoso, Mabragaña, Delpiani, & Díaz de Astarloa, 2018
	Curimatidae	*Cyphocharax voga*	(Hensel, 1870)
Cypriniformes	Cyprinidae	*Cyprinus carpio* *	Linnaeus, 1758
Siluriformes	Callichthyidae	*Corydoras paleatus*	(Jenyns, 1842)
	Loricariidae	*Hypostomus commersoni* *	Valenciennes, 1836
		Loricariichthys anus *	(Valenciennes, 1835)
	Heptapteridae	*Pimelodella laticeps*	(Eigenmann, 1917)
		Rhamdia quelen	(Quoy & Gaimard, 1824)
Atheriniformes	Atherinopsidae	*Odontesthes bonariensis*	(Valenciennes, 1835)

our study. There was not so clear pattern in suspended solid values, but differences in the experimental techniques may be explaining this discrepancy (while this study obtained all environmental variables from a multi-parameter instrument, others made specific measurements using dissolved solids measurement techniques). However, interestingly this increment in water turbidity was visually evidenced by the person in charge during the last fifteen years. The change from a clear to a turbid lake can be due to a multifactorial effect (Scheffer *et al.* 1993), consistent with an increase in the land devoted to agricultural activities, as occurred in this area in the last 25 years (Sánchez Vuichard *et al.* 2022). This scenario promotes acceleration in the eutrophication process, increasing the values of nutrients (phosphorus and nitrogen), and phytoplankton biomass and lowering drastically the water transparency (Izaguirre *et al.* 2022). Once a shallow lake becomes turbid and loss macrophytes, the role of wind-induced resuspended sediments in the overall water transparency may become critic (Scheffer *et al.* 1993, Quirós *et al.* 2006).

On the other hand, the appearance of the common carp (not recorded in Argemi and Berasain 2007) could also be a significant contributing factor to the observed increase in water turbidity over recent years. This species is well known for its harmful effect on water quality, by increasing turbidity and nutrient concentrations affecting the trophic dynamics of the ecosystem (Vilizzi *et al.* 2015). In the Pampa Plain, these changes are likely to create an unfavorable environment for large piscivores such as thrairas (*Hoplias argentinensis* Rosso, González-Castro, Bogan, Cardoso, Mabragaña, Delpiani, & Díaz de Astarloa, 2018) and enhance the thriving of zooplanktivorous such as inland silversides (*Odonthestes bonariensis* (Valenciennes, 1835)) (Quirós 2005). This new record of the common carp in KH could be related to lateral displacements during the high floods, as well as to the creation of non-mediated agricultural irrigation canals (Maiztegui *et al.* 2019), as has already been seen in other surrounding lagoons with no hydrological connectivity with freshwater ecosystem of the pampa plain (González-Castro *et al.* 2015). As the scope of this survey did not include aspects of fish size and abundance, before-after analyses evaluating the role of particular species in the dynamics of water transparency were not possible. Therefore, this could be considered as a new thread in the gap to be studied.

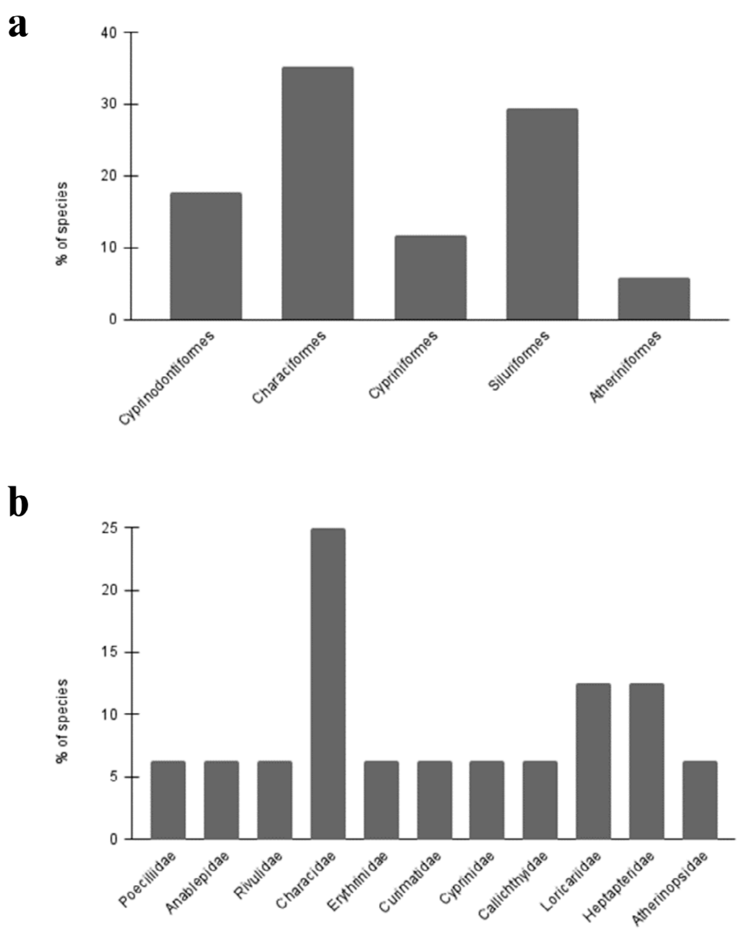

Figure 3. Number of species for each order (a) and family (b) expressed as percentages of the total species collected in the Kakel Huincul lake

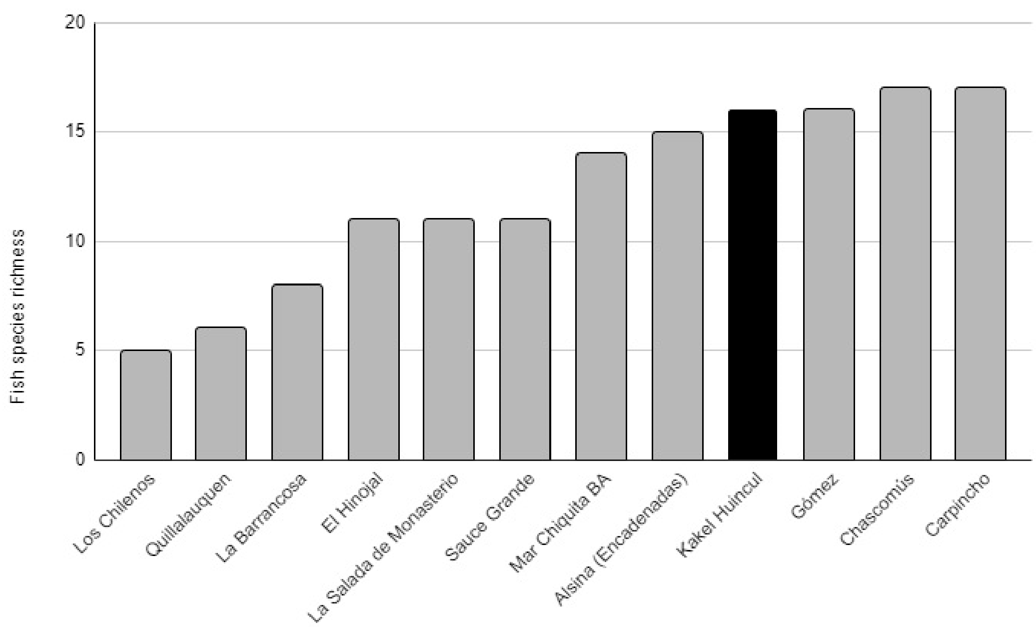

Figure 4. Fish species richness in the Kakel Huincul lake and selected shallow lakes of the Pampa Plain.

Together with the non-native common carp, fifteen other species were recorded in KH. The observed species richness was higher than in previous studies (Berasain and Barchesi 1998, Argemi and Berasain 2007) due to the first record of seven species, including *C. carpio*. We also report for the first time for this lake two large, armored catfish of the family Loricariidae, *Hypostomus commersoni* Valenciennes, 1836 and *Loricariichthys anus* (Valenciennes, 1835) as well as three species within the order Cyprinodontiformes (*Cnesterodon decenmaculatus* (Jenyns, 1842), *Jenysia lineata* (Jenyns, 1842) and *Austrolebias robustus* (Günther, 1883)), and one in the order Characiformes (*Bryconomericus iheringii* (Boulenger, 1887)). The presence of some of these species, particularly Loricariidae, suggests a recent contact with the fish fauna of the Salado River basin which could enter this system by overflow during high floods and the opening of the communication with Channel two. The role of artificial channels as waterways for fish species displacement and colonization was already observed in aquatic ecosystems of the Pampa Plain (Bertora *et al*. 2018) and lower Paraná River (Marzuoli *et al*. 2023).

Lake KH presents a high species richness when compared to other shallow lakes of the Pampa Plain (Fig. 4). Of particular interest is the fact that KH, being historically isolated from the Salado River basin, nowadays parallels the species richness of several lakes as Salada Grande, Hinojal and Chascomús that were historically connected with the Salado River. Perhaps, the occasional connection with Channel two and by this course with the lower Salado River basin at the Samborombón Bay, helps explain the high species richness of the KH. Similarly, lake Alsina, which is artificially connected to the Salado River by the Vallimanca stream, presents a high count of species richness.

Overall, the diversity observed in KH closely resembled what is expected in a highly diversified fish community of shallow lakes in the Pampa Plain (Rosso 2006). Lake KH is an important center for sport fishing in the region. Sustained monitoring over time is necessary to characterize the dynamics of this important shallow lake under ongoing environmental change. Here we focused on conducting a field sampling program intended to collect information about species composition of a poorly known fish assemblage in a drastically changing environment. We modestly believe this is a critical first step towards a better understanding of the likely role of fish fauna in the recent environmental modifications of this environment. But certainly, further quantitative studies accounting for main patterns of fish species abundances and size classes are needed. This would certainly contribute to appropriate management as well as provide valuable information for similar regional ecosystems.

AUTHOR CONTRIBUTIONS

All authors equally participated in the study design, collection of specimens in the field and the preparation of the manuscript.

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CITED LITERATURE

Aliaga VS, Ferrelli F, Piccolo MC. 2017. Regionalization of climate over the Argentine Pampas. Inter J Climatol. 37(S1):1237–1247. doi: https://doi.org/10.1002/joc.5079

Argemi F, Berasain G. 2007. Laguna de Kakel Huincul Partido de Maipú. In: Campaña de Relevamientos Limnológicos e Ictiológicos. Buenos Aires: Subsecretaría de Actividades Pesqueras, MAA Prov. Bs. As. Technical report nº 104: 1-20 [website]: https://www.gba.gob.ar/desarrollo_agrario/pesca/informes/estudios/estudios_continentales

Berasain G, Barchiesi E. 1998. Estudio de la laguna Kakel Huincul (Pdo. de Maipú). In: Campaña de Relevamientos Limnológicos e Ictiológicos. Buenos Aires: Subsecretaría de Actividades Pesqueras, MAA Prov. Bs. As. Technical report nº 15: 1-26 [website]. https://www.gba.gob.ar/desarrollo_agrario/pesca/informes/estudios/estudios_continentales

Berasain G, Colautti D, García de Souza J, Miranda L. 2019. Laguna La Salada de Monasterio, Partido de Lezama. In: Campaña de Relevamientos Limnológicos e Ictiológicos. Buenos Aires: Subsecretaría de Actividades Pesqueras, MAA Prov. Bs. As. Technical report nº 188: 1-21 [website]. https://www.gba.gob.ar/desarrollo_agrario/pesca/informes/estudios/estudios_continentales

Berasain G, Velasco C. 2019. Laguna El Hinojal, Partido de Lezama. In: Campaña de Relevamientos Limnológicos e Ictiológicos. Buenos Aires: Subsecretaría de Actividades Pesqueras, MAA Prov. Bs. As. Technical report nº 191: 1-12 [website]. https://www.gba.gob.ar/desarrollo_agrario/pesca/informes/estudios/estudios_continentales

Berasain G, Velasco C. 2021. Laguna Chascomús, Partido de Chascomús. In: Campaña de Relevamientos Limnológicos e Ictiológicos. Buenos Aires: Subsecretaría de Actividades Pesqueras, MAA Prov. Bs. As. Technical report nº 201:1-15 [website]. https://www.gba.gob.ar/desarrollo_agrario/pesca/informes/estudios/estudios_continentales

Berasain G, Velasco C. 2022. Laguna Quillalauquen, Partido de Laprida. In: Campaña de Relevamientos Limnológicos e Ictiológicos. Buenos Aires: Subsecretaría de Actividades Pesqueras, MAA Prov. Bs. As. Technical report nº 211: 1-16 [website]. https://www.gba.gob.ar/desarrollo_agrario/pesca/informes/estudios/estudios_continentales

Berasain G, Velasco C. 2023. Laguna Los Chilenos, Partido de Saavedra. In: Campaña de Relevamientos Limnológicos e Ictiológicos. Buenos Aires: Subsecretaría de Actividades Pesqueras, MAA Prov. Bs. As. Technical report nº 215: 1-19 [website]. https://www.gba.gob.ar/desarrollo_agrario/pesca/informes/estudios/estudios_continentales

Bertonatti C, Corcuera J. 2000. Situación Ambiental Argentina 2000. Buenos Aires: Fundación Vida Silvestre Argentina; 440 pp.

Bertora A, Grosman F, Sanzano P, Cardoso YP, Rosso JJ. 2018. Taxonomic revision of the southernmost population of *Hypostomus commersoni* Valenciennes, 1836 (Siluriformes: Loricariidae) and comments on dispersal routes. Historia Natural 8 (1): 25-34. doi: https://doi.org/10.5281/zenodo.15724745

Bertora A, Grosman F, Sanzano P, Rosso JJ. 2021. Longitudinal patterns in distribution of native and non- native fish species in a regulated temperate Neotropical river. Acta Limnol. Bras., 33:2. doi: https://doi.org/10.1590/S2179-975X11519

Bertora A, Sanzano P, Grosman F (editores). 2019. Ni Nemo ni Dory, con ustedes: Los peces de la laguna La Barrancosa. In: Destino: La Barrancosa. Una invitación a conocer lagunas pampeanas. Tandil: Universidad Nacional del Centro de la Provincia de Buenos Aires, 1: p. 199-210. ISBN 978-950-658-495-5.

Boveri MB, Quirós R. 2002. Trophic interactions in Pampean shallow lakes: evaluation of silverside predatory effects in mesocosm experiments. – Verh. Int. Ver. Theoret. Angew. Limnol. 28(3): 1274–1278.doi: https://doi.org/10.1080/03680770.2001.11902661

Boveri MB, Quirós R. 2007. Cascading trophic effects in pampean shallow lakes: results of a mesocosm experiment using two coexisting fish species with different feeding strategies. In: Gulati RD, Lammens E, De Pauw N, Van Donk E, editors. Shallow Lakes in a Changing World. Developments in Hydrobiology, vol 196. Dordrecht: Springer. doi: https://doi.org/10.1007/978-1-4020-6399-2_20

Casciotta JR, Almirón AE, Azpelicueta MDLM. 2005. *Astyanax pampa* (Characiformes, Characidae), a new species from the southernmost boundary of the Brazilian subregion, Argentina. Rev. suisse zool. 112(2):401-408. doi: https://doi.org/10.5962/bhl.part.80305

Fricke R, Eschmeyer WN, van der Laan R., editors. 2024. Eschemeyer's catalog of fishes: genra, species, references. [Last accessed: 20 Apr 24]. http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp

Gómez SE, Toresani NE. 1998. Pampas: 99-114. In: Canevari P, Blanco DE, Bucher E, Castro G, Davidson I, editors. Los humedales de la Argentina - Clasificación, situación actual, conservación y legislación, Wetlands International 46. 208p

González-Castro M, Rosso JJ, Lajud NA, Castellini DL, Díaz de Astarloa JM. 2015 Occurrence of *Cyprinus carpio* (Linnaeus, 1758) in a World Biosphere Reserve, the Mar Chiquita Coastal Lagoon (Argentina); Wiley Blackwell Publishing, Inc; J. Appl. Ichthyol. 31(4): 749-751. doi: https://doi.org/10.1111/jai.12780

Izaguirre I, Allende L, Escaray R, Bustingorry J, Pérez G, Tell G. 2012. Comparison of morpho-functional phytoplankton classifications in human-impacted shallow lakes with different stable states. Hydrobiologia. 698: 203–216. doi: https://doi.org/10.1007/s10750-012-1069-1

Izaguirre I, Zagarese H, O'Farrell I. 2022. The limnological trace of contemporaneous anthropogenic activities in the Pampa Region. Ecología Austral: 32(2): 650–662. doi: https://doi.org/10.25260/EA.22.32.2.1.1884

López H, Menni R, Miquelarena A. 1987. Lista de los peces de agua dulce de la Argentina. Biología Acuática 12: 1-50.

López H, Morgan C, Montenegro M. 2002. Ichthyological Ecoregions of Argentina. Probiota, FCNyM, UNLP, Serie Documentos. 1. ISSN 1666-731X

Maiztegui T, Baigún CR, de Souza JRG, Weyl OL, Colautti D. 2019. Population responses of common carp *Cyprinus carpio* to floods and droughts in the Pampean wetlands of South America. NeoBiota, 48: 25-44. doi: https://doi.org/10.3897/neobiota.48.34850

Marzuoli J, Mancini M, Salinas V, Casalinuovo M, Dominino J, Rosso JJ. 2023. Nuevas localidades e hipótesis sobre rutas de dispersión del dorado *Salminus brasiliensis* en la provincia de Córdoba (Argentina). Revista del Museo Argentino de Ciencias Naturales, 25(2): 197-308.

Miquelarena AM, López HL. 1995. Fishes of the lagunas Encadenadas (Province of Buenos Aires, Argentina), a wetland of international importance. Freshwater Forum, 1(5): 48-53.

Miquelarena A, Mantinian J, López H. 2008. Peces de la Mesopotamia Argentina (Characiformes: Characidae: Cheirodontinae). In: Aceñolaza F editors, Temas de la Biodiversidad del Litoral III, Universidad Nacional de Tucumán, 51-90.

Mirande JM, Koerber S. 2020. Checklist of the Freshwater Fishes of Argentina. 2nd edition. (CLOFFAR-2); Peces Criollos; Ichthyological Contributions of Peces Criollos, 72: 1-81

Nuozzi G, Rocha CS, Sagua M, Llames ME, Huber P, Metz S, Lagomarsino L, Shiaffino MR. 2022. Structure and dynamics of bacterioplankton from four pampean shallow lakes of the Salado River basin (Buenos Aires, Argentina). Ecología Austral, 32(2), 343–360. doi: https://doi.org/10.25260/EA.22.32.2.0.1811

Quirós R. 2005. La ecología de las lagunas de las Pampas. Investigación y Ciencia, 1(6), 1-13.

Quirós R., Boveri MB, Petracchi CA, Rennella AM., Rosso JJ, Sosnovsky A, von Bernard HT. 2006. Los efectos de la agriculturización del humedal pampeano sobre la eutrofización de sus lagunas, 1-15. In: Tundisi GJ, Tundisi TM, Galli CS editors. Eutrofización en Sudamérica: causas, consecuencias y tecnologías para manejo y control. ISBN 85-87418-05-X.

Quirós R, Rosso JJ, Rennella A. 2002. Análisis del estado trófico de las lagunas pampeanas (Argentina) Interciencia, 27(11), 584-591

Ringuelet RA. 1975. Zoogeografía y ecología de los peces de aguas continentales de la Argentina y consideraciones sobre las áreas ictiológicas de América del Sur. Ecosur, 2.

Ringuelet RA, Arámburu RH, Alonso de Arámburu A. 1967. Los peces argentinos de agua dulce. La Plata, Comisión de Investigaciones Científicas de la Provincia de Buenos Aires (CIC), 602p.

Rosso JJ. 2006. Peces pampeanos: guía y ecología. Literature of Latin America, Buenos Aires, 224pp. ISBN 950-9725-66-8

Rosso JJ, Quirós R. 2010. Patterns in fish species composition and assemblage structure in the upper Salado River lakes, Pampa Plain, Argentina. Neotrop. Ichthyol., 8(1): 135-144. doi: https://doi.org/10.1590/S1679-62252010005000007

Rosso JJ, Liotta J. 2021. Peces Continentales. In: Bauni V, Bertonatti C, Giacchino A editors, Inventario Biológico Argentino – Vertebrados. Fundación de Historia Natural Félix de Azara, 135-198.

Sánchez ML, Rodríguez P, Torremorell AM, Izaguirre I, Pizarro H. 2017. Phytoplankton and Periphyton Primary Production in Clear and Turbid Shallow Lakes: Influence of the Light Environment on the Interactions between these Communities. Wetlands, 37(1): 67-77. doi: https://doi.org/10.1007/s13157-016-0840-x

Sánchez Vuichard G, Tonello MS, Stutz S, Navarro D, Vazquez C. 2022. Pampa Plain (Argentina) Wetland History through a Lake Case Study: Kakel Huincul Environmental History during the Last 600 Years. Wetlands 43, 15. doi: https://doi.org/10.1007/s13157-023-01660-z

Scheffer M, Hosper SH, Meijer ML, Moss B, Jeppesen E. 1993. Alternative equilibria in shallow lakes. Trends Ecol. Evol. 8: 275279. doi: https://doi.org/10.1016/0169-5347(93)90254-M

Silvoso J, Izaguirre I, Allende L. 2011. Picoplankton structure in clear and turbid eutrophic shallow lakes: A seasonal study, Limnologica, 41(3): 181-190. doi: https://doi.org/10.1016/j.limno.2010.10.001.

Vera C, Skansi M, González M. 2023. Características de las sequías en el sur de Sudamérica. SISSA-ART-001-2023

Vilizzi L, Tarkan AS, Copp GH. 2015. Experimental evidence from causal criteria analysis for the effects of common carp Cyprinus carpio on freshwater ecosystems: a global perspective. Rev. Fish. Sci. Aquac. 23(3): 253-290. doi: https://doi.org/10.1080/23308249.2015.1051214