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Poblana alchichica: A threatened silverside species?

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Introduction

The status of local endemic species such as *Poblana alchichica* is difficult to assess, and therefore conservation measures are not efficiently implemented. However, in recent years several methods have helped compare status of different species based on objective criteria. The method to evaluate the extinction risk of Mexican native species (MER), partially based on Gärdenfors et al. (2001), considers 4 criteria regarding the taxon: (1) distribution extent in Mexico, (2) habitat condition, (3) intrinsic biological vulnerability, and (4) human impact on the species. Numerical values are assigned to each criterion in ascending risk order. According to Tambutti et al. (2002), each criterion is independent from the others, and the addition comes to be an accumulative evaluation of risk (SEMARNAT 2002). Even if independently evaluating criteria 2 and 4 is difficult, the grade of each criterion is required to obtain the final assessment.

The lack of studies on *P. alchichica* (Pisces: Atherinidae) – and quite probably for many other species – prevents the accurate quantification of 3 of these 4 criteria (except distribution extent) required for the extinction risk assignation. Previous studies on *P. alchichica* (Fig. 1) are solely taxonomic. De Buen (1945) described the new silverside species collected from Lake Alchichica. Later, Álvarez (1950) and Guerra Magaña (1986) considered Alchichica's silverside to be a subspecies (*P. alchichica alchichica*). However, Miller (1986), in his study on the origin and geography of the fishes of Central Mexico, and Espinosa et al. (1993), in their list of Mexican freshwater fishes, re-evaluated the specific status of *P. alchichica*.

Our study aimed to provide scientific data to support (a) the actual risk status of *P. alchichica* by identifying the factors imposing risk to the species through habitat alteration and population status, and (b) to design adequate protection programs for this species.

Key words: fish, Lake Alchichica, Mexico, *Poblana alchichica*, risk category

Study site

Lake Alchichica is located at 19°24'N; 97°24'W and 2300 m a.s.l. in the endorheic Oriental basin of Central Mexico. Alchichica is situated in the high-altitude plateau of Llanos de San Juan. It is a deep lake (mean = 40.9 m, max = 62 m) with a surface area of 2.3 km^2, (max length = 1.7 km; max width = 1.4 km). The lake held $94.21 \times 10\ m^3$ of saline ($8.5 \pm 0.2\ g\ L^{-1}$) and alkaline water (pH = 9.0 ± 0.1, total alkalinity of 37 $meq\ L^{-1}$), the chemistry of which was dominated by sodium-magnesium and chloride-bicarbonate ions (Vilaclara et al. 1993, Alcocer & Hammer 1998, Filonov et al. 2006). Alchichica is a unique Mexican saline aquatic system characterized by endemic biota (in addition to *P. alchichica*, the ambystomatid salamander *Ambystoma taylorii*, and the isopod crustacean *Caecidotea williamsi*, were present) and unique features such as tufa towers.

Methods

We used a laboratory-calibrated echosounder (GARMIN GPSMAP 168 Sounder) to quantify abundance and vertical and horizontal distribution of fish >1 cm in length. Perpendicular transects covering the whole area of the lake were carried out at each of the 4 characteristic hydrodynamic periods of the lake (i.e., circulation and early, well-established, and late stratification) as recognized by Alcocer et al. (2000). The transducer (150 watts -RMS-, 1200 watts -peak to peak-, frequency 200 KHz, cone angle 20°, coverage one-third water depth) was transom mounted, 3/8 inch below the aluminum hull. We collected fish with the help of local people in the littoral area for gut analysis and population size structure. Additional information came from Flores Negrete (1998).

Results and discussion

The geographic range of *P. alchichica* is restricted to Lake Alchichica. According to MER, the distribution extent in Mexico was assessed with the highest risk value of this criterion, or "very restricted". This category applies to microendemic species with limited distribution

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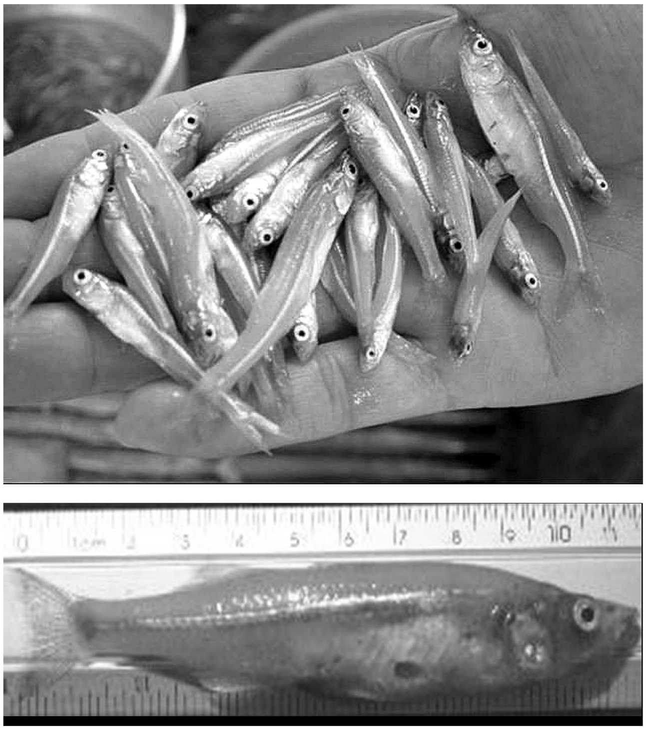

Fig. 1. *Poblana alchichica*, the endemic silverside species from Lake Alchichica; the customary size (above) and the largest organism ever photographed (below).

in Mexico (<5 % of the Mexican territory). Alchichica surface area (2.3 km^2) is 0.0001 % of the Mexican territory (1.96 × 10^6 km^2).

Moreover, *P. alchichica* showed an uneven distribution within the lake (a donut-like distribution); most (>67 %) of the fishes inhabited the perimeter of the lake close to the tufa ring (70 % of the total surface area of the lake), and the others (<33 %) were found in the pelagic central zone (30 % of the total surface area of the lake). This seems to be a characteristic behavior of atherinids; GALLARDO CABELLO (1977) found that *Chirostoma chapalae*, the silverside from Lake Chapala, preferred littoral habitats.

The bathymetric distribution of *P. alchichica* was from the surface to 55 m deep but often not deeper than 40 m. In contrast to *C. chapalae*, which regularly lived close to the surface and midwater, *P. alchichica* was observed close to the bottom. The observed distribution is explained by its feeding preferences and the hypolimnetic dissolved oxygen concentration. Different from other silversides that are mostly zooplanktivorous, *P. alchichica* is largely benthivorous (i.e., roughly 70 % benthic and 30 % planktonic preys; FLORES NEGRETE 1998). In addition, the hypolimnion (from 40 m to the bottom) remains anoxic from July or August until late December or early January when the lake circulates.

Density values for *P. alchichica* ranged from 0.000015 to 0.0078 org. m^{-2} (0.0047 ± 0.0033 org. m^{-2}) in the pelagic zone, and from 0.0091 to 0.0191 org. m^{-2} (0.0141 ± 0.0041 org. m^{-2}) in the perimeter; fish mean density in the basin was 0.0094 ± 0.0061 org. m^{-2}.

Studies in oligotrophic water bodies showed much higher fish densities. The brown trout (*Salmo trutta*) mean density in the Lake Redó, Spain, was 0.0597 org. m^{-2} (ENCINA & RODRÍGUEZ-RUIZ 2003); the common whitefish *Coregonus lavaretum* density in Lake Paasivesi, Finland, was between 0.026 and 0.053 org. m^{-2} (JURVELIUS et al. 1984); and the density for same species in the Wahnbach reservoir, Germany, was 0.010 to 0.050 org. m^{-2} (BRENNER et al. 1987).

Furthermore, there is a large difference between the sizes of the fish species involved. The brown trout (30 to >60 cm) and the whitefish (>27cm) are larger than Alchichica's silverside (average 6–7 cm, maximum 11–12 cm; Fig. 1). Consequently, fish biomass in Alchichica should be at least 3 times lower than abundance data reports.

Estimated total abundance of *P. alchichica* >1 cm in length was between 12 510 and 29 200 organisms. Does this amount guarantee a healthy and self-sustained population? What is the minimum size population for a fish species to be considered threatened or endangered? Although these issues are not addressed in the criteria described in the Mexican Official Norm (SEMARNAT 2002), the number seems low for a fish of small size.

Size class composition of *P. alchichica* differed among habitats in Lake Alchichica. In the shallow area between the lake edge and the tufa ring, fish larvae and juveniles (≤36 mm) dominated (~70 % of total abundance). In contrast, adults (≥36 mm) dominated (>90 %) in the pelagic zone close to the tufa. Unfortunately, the littoral area is currently highly reduced because of declining water levels, thus decreasing habitat availability for the larvae and juveniles of *P. alchichica* to develop.

Historical aerial photographs (1974–1995) reveal a reduction in Alchichica's water level. Furthermore, higher water-level marks are now far away from today's shoreline. A large portion of the tufa deposits, formerly submersed, are now exposed to sunlight, dry and devoid of aquatic life (ALCOCER & ESCOBAR-BRIONES 2007).

Extraction of groundwater for irrigation and water supplies to towns and cities can be mostly responsible for the lake's desiccation process, although climate change should not be overlooked. Agriculture is a very important and increasing activity in the basin, especially irrigated agriculture. In addition, being located at high altitude (i.e., >2300 m a.s.l.), the extensive groundwater resources are considered a potential water source to be transported by gravity to Mexico City (NRC, AIC & ANI 1995).

Local communities contribute additional risk due to fishing in the littoral area. An efficient fishing technique created by women from the region employs bed sheets as fishing nets. The minute net apertures allow even small fish larvae to be caught. There is no information regarding population abundance through time, but experienced local fishermen consider that *P. alchichica* population is declining in number and individual size.

P. alchichica showed endo- and ectoparasites, the most important being the tapeworm *Ligula intestinalis*. Other parasites were the tapeworm *Bothriocephalus acheilognathi*, the nematode *Rhabdochona*, and the leech *Myzobdella*. There were from 1 to 18 *L. intestinalis* in almost every fish (96–100 %) >36 mm in length throughout the early stratification (Apr–Jun). During the rest of the year, fish percentage with *L. intestinalis* ranged from 10 to 70 %. A bloom of the copepod *Leptodiaptomus novamexicanus*, the intermediate host of the parasite, took place before the highest infestation period. During the coldest months (Nov–Feb) fish displayed the lowest infestation percentages (10–18 %).

Parasites, especially *L. intestinalis*, caused injuries in the fish intestines as well as necrotic ulcers. This parasite can induce death or illness in infested organisms leading to the fish population decline. Such was the case of the parasitic infection of *L. intestinalis* on the roach *Rutilus rutilus* (Kennedy et al. 2001, Loot et al. 2001).

Parasite infections in fish have been associated with, and in some cases have been shown to result in, changes in foraging efficiency, time budget, habitat selection, competitive ability, predator-prey relationships, swimming performance, and sexual behavior, and mate choice (Barber et al. 2000). During sampling, it was common to find fishes erratically swimming at the water surface, especially during the stratification, where they could be easily seen and caught by birds, the final host of the parasite. The high degree of parasitic infestation endangers the reproductive effectiveness of *P. alchichica*, perhaps jeopardizing its survival.

There are other human impacts on Lake Alchichica and its biota. The pools of the littoral area are used for washing, so bleaches and detergents are discharged into the littoral zone without control. Moreover, domestic wastewater is being discharged into the same area from the houses around the lake. Finally, it is highly probable, but not yet evaluated, that other pollutants such as pesticides and fertilizers are being delivered into the lake from the surrounding agricultural land as well as petrol from the gas station located close to the lake.

Poblana alchichica fits the "threatened species" risk category (SEMARNAT 2002) because its minute distribution area (microendemism), reduced population, and several risk factors endanger the survival of this silverside by altering its habitat and by diminishing its population size. After reviewing the whole set of risk factors, however, we believe *P. alchichica* should be changed to the next risk category, "in danger of extinction," which is, "those species whose distribution area or their population size in the national territory has drastically diminished risking their biological viability in their natural habitat, because of factors like habitat destruction or drastic modification, unsustainable use, illness or predation, among others factors." Extinction risk is correlated with the size of the population and the extension of the distribution range.

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