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Morphological, biological description and recommendations of measures for a better use of the resource of white fish (*Chirostoma estor*) Jordan 1879, Mexico

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Abstract

Chirostoma estor is one of the most important species in its natural habitat (Patzcuaro lake), because for its historical, economic and commercial value. The high demand and market price have led to a great overexploitation causing a decrease in its natural populations placing it in a state of vulnerability. Because of its the importance and the interest of various governmental and educational institutions, nowadays there are many researches of different aspects as taxonomic, descriptive, food, temperature and salinity effects, based on the above, it has been possible to conclude the life cycle in captivity, however it has not been possible to establish a manual of good practices of cultivation that allows to recover the population and to diminish the exploitation of the resource in its habitat. The present report has been prepared with available information on its different aspects that facilitates the knowledge, importance and identification of the same.

Keywords: *Chirostoma estor*, morphology, threats, cultivations, recommendations

1. Introduction

Chirostoma estor is a species that belongs to the family Atherinopsidae^[1], native and endemic to Lake Patzcuaro, Michoacan (Mexico). *C. estor* possesses a great ecological, cultural and commercial value at local, regional, national and international level, and has a high demand in the market due to its appreciation in the Mexican gastronomy (it should be noted that this species has been consumed since the prehispanic period and until the present), its price places it among the most expensive fish of fresh water paying \$200.00 pesos or \$80 dollars for kilo depending on the season^[2]. Unfortunately in the last decades its population has been decreasing because of different factors, such as physical and anthropogenic, in parallel it has been reported that *C. estor* reaches smaller weights and lengths, as a consequence of the great fishing effort to which this specimen has been subjected^[3,4]. Nowadays, the aquaculture has been the most viable alternative to contribute to the recovery of its populations, however the results have not been satisfactory due to the lack of knowledge in its different areas (nutrition, reproduction, health and culture technology) In addition it's an organism very susceptible to the stress, producing low growths or high mortalities.

2. Synonyms

Chirostoma estor estor (Jordan, 1880)
Atherinichthys albus (Steindachner, 1894)
Chirostoma estor pacanda (de Buen, 1940)
Chirostoma estor tecuena (de Buen, 1940)
Chirostoma michoacanae (de Buen, 1940)

3. Taxonomic Note

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Atheriniformes
Family: Atherinopsidae

4. Common names

Chirostoma estor is known as white fish in Mexico and Khuruchecha or Khurucha Urapiti by purhépechas and mestizo populations of the riverbank lake Patzcuaro, in the state of Michoacán [2, 4, 5].

5. Conservation status

Chirostoma estor has been reported as "vulnerable" according (IUCN), however in Lake Patzcuaro this species is categorized as threatened. This is reflected in the catch of live weight reported in Lake Patzcuaro in recent years: 122 tonnes in 1982, 9 tonnes in 1996, 4.1 tonnes in 1999, 1.2 tonnes in 2000, 0.32 tonnes in 2001, 0.11 tons in 2002 and since 2003 there are no catch reports [6].

6. Morphometric characteristics

The white fish has a thin, elongated, hydrodynamic, compressed and fusiform body with an average length of 15-22 cm and a weight of 35 gr [2] has a silvery and pronounced lateral band. Its head is small, triangular and is covered by squama; its eyes are relatively large in relation to the size of the head. The mouth is protruding terminal and directed upwards with a maximum opening of 21 mm in adult organisms (22 cm L_S). The jaws are composed of two bones in the upper part (maxilla and premaxilar) and three in the inferior (articular, angular and dental), the dentition is located on the premaxilar forming three to four rows of small unicuspid conical teeth fragile and little conspicuous, as well as pharyngeal teeth, on the other hand, in the lower jaw the teeth are distributed in the teeth of three to four rows (this jaw is slightly longer than the upper one), also they have pharyngeal teeth that are located after the fourth gill arch and over a pair of upper bones on the floor of the skull [7]. The digestive tract of juveniles and adults indicate that this fish is carnivorous, 1: 0.7 ratio (digestive tract-total length), however does not have a real anatomical and functional stomach, since this has been shown to have a high pH and a very low activity of the pepsin protease (this confirms that it does not have a true stomach) [8]. They have two well-separated dorsal fins, the first composed by 5-6 very flexible spines and the second by 1 spine and 10-12 spokes. In the anal fin, in addition to 10-21 spokes, it have a single spine, also flexible, their pelvic fins are in the abdominal position and the pectorals are inserted on the midline of the body they are rounded or slightly acute with silvery coloration [9] at the same time the second dorsal and anal fin have small ramifications [10]. The squama is usually cycloid and the pores of the lateral line are not visible to the outside, it has 40 predorsal squamas and 64 to 86 squamas with a longitudinal series. (Fig. 1-4).

The larvae at the time of hatching have an average size (4.1 mm L_S), they have a clear elongated body, markedly pigmented black and green eyes, a fold-shaped membrane surrounding the body, with an ellipsoidal yolk sac, show pigments in the cephalic part, in the ventral part of the abdominal region, in the dorsal region and in the lateral line (from the second day after hatching) Figure 5. The flexure of the urostyle or tail appears from (5.2 mm L_S) and the differentiation of the first dorsal fin starts from (10.02 mm L_S) [11].

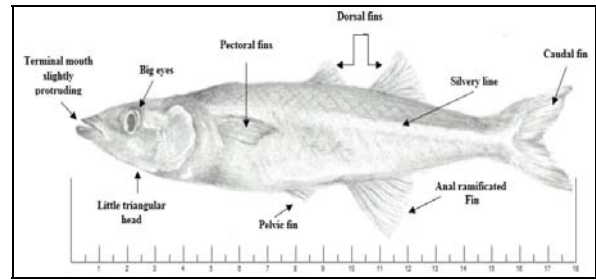


Fig 1: Scheme of the external morphology of *Chirostoma estor*, in which is observed the shape of the body, fins, lateral line, size of eyes and head. Biometry 17.5 cm (L_T) y 50.7 (g) (Picture from Velasco. S. J.)

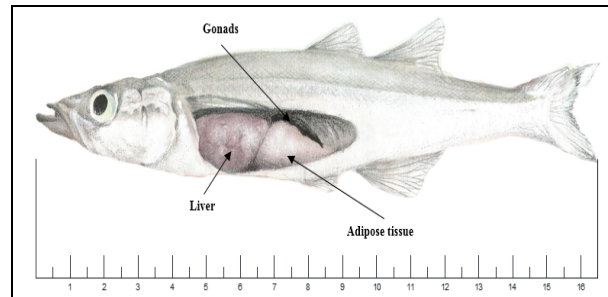


Fig 2: Scheme of the morphology of *Chirostoma estor*, in which is denoted the inner organs of the organism. Biometry 16.5 cm (L_T) y 40.3 (g). (Picture from Retana. O. D.A.)

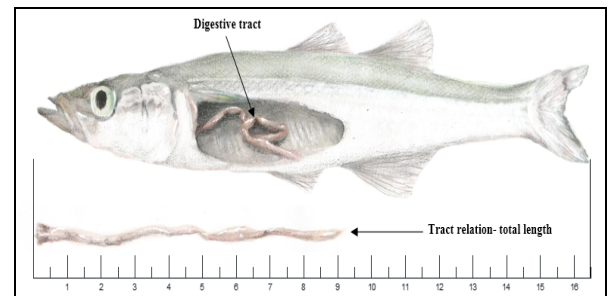


Fig 3: Scheme of the inner morphology of *Chirostoma estor*, in which is observed the position of the digestive tract and its relation (TD- L_T), at the same time it can be appreciated the lack of a "true" stomach. Biometry 16.5 cm (L_T) and 40.3 (g), digestive tract (9 cm). (Picture from Retana. O. D.A.)

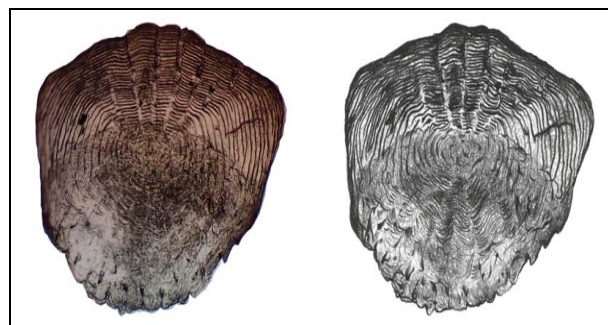


Fig 4: Fin cycloid of a reproducer of *Chirostoma estor*. (Photo and picture from Velasco. S.J.)



Fig 5: Eggs and larvae of *Chirostoma estor*, where it's seen the drops of oil and filaments, as well as the larval morphology. (Photos from Peralta-Martínez M.A. and SAGARPA, 2014) [12].

7. Distribution

Chirostoma estor has a range of natural distribution, the lake of Patzcuaro and the lake of Zirahuén in the state of Michoacán. In the 1960s its distribution extended to other reservoirs such as those in Chihuahua, Puebla, Tamaulipas, Hidalgo, Querétaro, Guanajuato and the State of Mexico, however there is no trace of its existence in these same states of the republic [13].

8. Habitat

The fish bank is a nearctic species of lentic waters, located at altitudes near 2035 msnm, clear or medium turbid with little vegetation, sandy or gravel bottoms, the banks with light waves and submerged vegetation; It grows in temperatures between 14-24 °C with preference in temperate waters of 18 °C; alkaline pH from 8.1 to 8.3, oxygen concentration greater than 6.1 ppm and transparency from 30 to 40 cm [14], this specimen prefers the limnological zones of greater depth that are located in the northern part of the lake of Patzcuaro [15].

9. Diseases

The whitefish is attacked by various pathogens: fungi (*Saprolegnia parasitica*), bacteria (*Pseudomonas* cocci, diplococci and streptococci Gram positive and bacilli Gram negative flexibacter, myxobacteria or flavobacteria) Protozoa (*Mixobolus* sp., *Trichodina*, *costia* and *Ichthyophthirius*), Trematode (*Allocreadium mexicanum*, *Diplostomum*, *Posthodiplostomum minimum*, *Gyrodactylus* sp., and *Clinostomum complanatum*) Cestode (*Bothriocephalus acheilognathi*, *Proteocephalidae* sp., *Ligula intestinalis* and *Cyclophyllidae*), nematodes (*Capillaria patzcuarensis*, *Spinitectus carolini*, *Spinitectus osorioni*, *Pseudocapillaria tormentosa* and *Eustrongyldes* sp.), Acanthocephalus (*Arhythmorhynchus brevis*) Worm-licees (*Myzobdella patzcuarensis*) Crustaceans (*Argulus* sp. and *Lernaea* sp.) and some spinal malformations (lordosis and scoliosis) exophthalmia, of nutritional origin or by physical factors [2].

10. Feeding habits

During the first days of life, this organism feeds from the content of its yolk sac: when it reaches the stage of youth larva and youth it is predominantly zooplankton feeding rotifers (*Brachionus rubens*, *Brachionus plicatilis* and *Anuraeopsis fissa*), copepods (*Diaptomus* sp. and *Cyclops* sp.) and cladocerans (*Daphnia magna*, *Moina macrocopa*, *Bosmina* sp. and *Ceriodaphnia* sp.) [12, 16, 17, 18, 19]. When they are youth they have a preferentially insectivorous diet and as adults they are ictiofagos feeds from small fish of the same genus (*C. bartoni*, *C. grandocule* and *C. patzcuaro*) and decapods (*Cambarellus patzcuarensis*). Under captive conditions they are offered nauplii and adults of *Artemia franciscana*, mosquito larvae (*Culex* sp.), as well as fresh fish

fillet (tilapia, trout and carp), since there is no commercial balanced food specifically formulated for this specimen generally is offered food of another species (*Oncorhynchus mykiss*) without oil in its different presentations [2] of the Brand Silver Cup El Pedregal.

11. Reproductive biology

C. estor reproduction is oviparous and synchronous because it spawns all the year in its natural habitat and in captivity, nevertheless, there are two reproductive cycles identified during the year, the most productive one is from January to June increasing significantly in the period between March and June [13, 20, 21, 22] and a second period from September to November [21], with the gonadal maturation from December to July. The eggs are spherical amber translucent 1 mm of diameter with several drops of oil (1 to 3), have 6-9 adherent filaments [14], on the other hand, a difference from other types of eggs of other species of fresh water, is the limited amount of yolk, accompanied by a large globule of oil as an energy reserve that is consumed during larval development and can be observed as a remnant until 3 to 4 days after hatching. The average production of eggs varies from 15,000 to 20,000 per female with a weight of 300 g in the wild and in captivity from 800 to 1500 eggs on average, weighing 15 to 20 gr, since it has been observed that there are reproductive problems so it has been reducing quality and quantity, resulting in low fertilization, low hatching percentage and deformed fingerlings [23, 24]. The sex ratio for reproduction is 1: 3 H: M, in addition these organisms do not present nesting or parental care habits [25].

12. Threats

In recent years, it has been observed that its natural population has declined, due to several factors such as high fishery, overexploitation, volume reduction and extraction of water for different uses, moreover the pollution by sewage, pesticides, eutrophication and finally the introduction of exotic species (*Oreochromis aureus*, *Cyprinus carpio*, *Cyprinus rubrofusculus*, *Ctenopharyngodon idella* and *Micropterus salmoides*) in their natural habitat have led this organism to be threatened in Lake Patzcuaro [26, 8, 11, 4, 27], in captivity the greatest problem is in the larval stage, with the highest mortality because the enzymatic activity in their digestive tract is not well developed.

13. Recommendations for Conservation

Although there is a great deal of information about the white fish's life history, there is still a need to go deeper, since the study that recently corroborates the condition of the natural populations that exist in Lake Patzcuaro, so it is urgent an efficient strategy to be able to recover this organism in its natural habitat from the sanitation and recovery of the lake, training to producers and settlers on the biological importance of this specimen, promoting conservation campaigns through education and extension programs, support of repopulation practices and production, as well as comply with the Official Norms allowing a better use of the resource, extensive and intensive fish farming techniques for commercial purposes this in order to not overexploit the species more in the lake, provide live food enriched with probiotic strains isolated from the digestive tract for the inhibition of pathogenic agents and finally researches that generate a greater knowledge about the deficiencies existing in the cultivation of this specimen, being able to obtain a manual of good practices for the cultivation of *Chirostoma estor*.

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