# Towards a culture technology for pescado blanco, *Chirostoma estor estor*

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Professor Lindsay Ross of IoA and Dr Carlos Martínez-Palacios of UMSNH have collaborated for 20 years in research designed to exploit native species for aquaculture in Mexico.

In 1999 we established a major project to investigate the potential for culturing the endangered Pescado Blanco, *C. estor estor*, of Lake Patzcuaro in the Mexican Altiplano. This is a major species in the relict flock of Atherinopsid fishes unique in central Mexican lakes. The Atherinopsidae are a large group, also known as silversides, which includes the well-known Pejerrey (*Odontesthes bonariensis*) of South America and the brackish water Menidia group. The Altiplano lakes of Mexico are remnants of a vast inland sea, once connected to both the Pacific and Atlantic oceans and it is considered that the *Chirostoma* species flock became isolated from their traditional migratory routes relatively recently in evolutionary terms.

## Endangered species

There is little doubt that the entire *Chirostoma* group has been over-fished and that *C. estor estor* is now endangered, having experienced a dramatic recent reduction in its natural population due to over-exploitation, changes in land use, poor environmental management, loss of habitat, and the introduction of exotic species. Other species in the flock are under similar pressure and the current, unconfirmed, view in the ichthyology community is that there have been extinctions in the last 20 to 30 years.

The species is a symbol of the area and for centuries has been the basis of an artisanal fishery which sustained large numbers of fisher families from the indigenous P'urhepecha community. Rural communities involved in this activity have a mixed economy similar to crofting and collapse of the fishery has reduced both their income and this source of high quality protein. Not only have the families who previously depended upon this resource suffered, but the species itself is now under extreme pressure especially given its high cash value (35$ US/kg during Semana Santa 2004).

## Protecting biodiversity

Our work has sought to develop an aquaculture technology at a number of appropriate scales, particularly for small-scale stakeholders in communities whose livelihoods have suffered due to the decline in the fishery. The conservation of the species flock is consequent upon development and adoption of small scale aquaculture, as well as better management of wild fisheries. Introduction of the technology would allow fisher communities to continue to exploit the species while reducing pressure on the natural stocks. The National Biodiversity Strategy in Mexico consists of four prioritised strands: Protection and Conservation, Valuation of Biodiversity, Understanding and Management of Information and Diversification of use. This project satisfies aspects of each theme and, as it is based on a production activity it satisfies strand 4 particularly strongly. The components of strand 4 are: Diversification of production, and Promotion and Commercialisation of sustainable, "green" Markets, all to be achieved through diversification of production methods which benefit the natural environment and local communities. Our project addresses all of these factors.

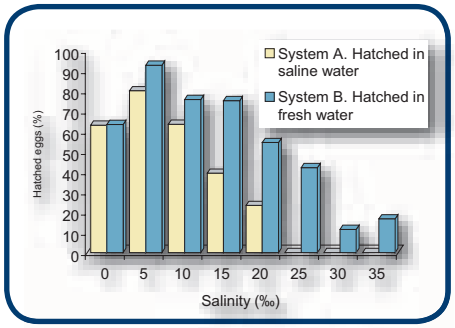
## Practical progress

There have been a number of attempts to culture the species over the last 30 years, although most of these projects resulted in little progress. One of the principal problems in studying *C. estor estor* is that the animals are undomesticated, fast, pelagic swimmers and the eggs and larvae are very small, similar in size to many marine fishes. This makes handling of any life stage very difficult. We resolved this for the early stages by devising a simple video technique for measuring linear dimensions on live fish in water and relating these to body mass, thus enabling growth studies to take place. From this we were able to quickly establish the optimum temperatures for growth and survival and to develop a successful feeding plan based on a rotifer-artemia-microdiet sequence

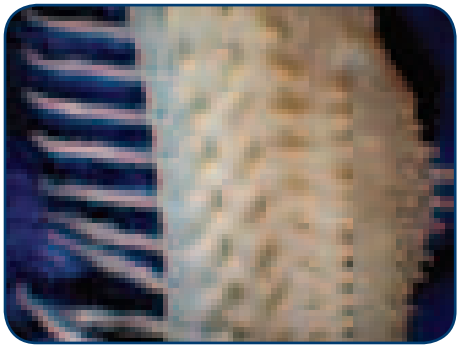
An important concept from the start was that we were not dealing with a classical freshwater fish. The flock almost certainly arose from a Menidia-like migratory stock and was isolated relatively recently by the tectonic upheavals which formed central Mexico. We have now shown that the species still retains considerable euryhalinity which may be linked to its recent evolutionary history. With careful acclimation, the young stages easily withstand salinities up to 15‰ and survival and growth is best at these salinities. However, hatching is greatly improved in freshwater and so we now routinely use a sequence of optimised saline environments to maximise survival, reduce stress and to eliminate the previously massive deaths of eggs and larvae caused by *Saprolegnia*.

Early reports suggested that the adults were ichthyophagous but we now know that this was a consequence of a zooplanktivourous feeding habit. Based on detailed anatomical studies using SEM and experimental studies in which fish were fed on zooplankton mixtures we have now elucidated the feeding mechanisms of the species and have confirmed that they are selective zooplanktivores throughout their life cycle. The gill arches, especially arches 2 to

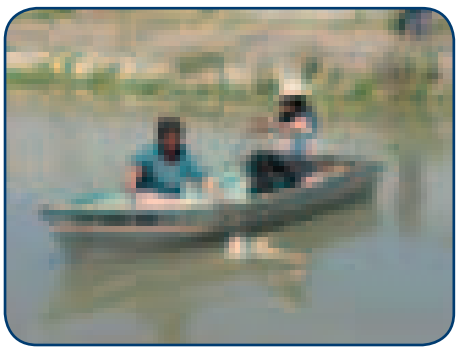
Pescado blanco, *Chirostoma estor estor*




The effect of salinity on hatching success of eggs of *Chirostoma estor estor*.



Long gill rakers on arch 1 (left), interlocking pads on arches 2 to 4 (middle) forming the filter bed and pharyngeal teeth (right).



Our P'urhepecha collaborators fertilising ponds while receiving training at CAMRA, UMSNH.

4, posses a series of interlocking spiny pads which form a continuous, flexible filter mat in the buccal cavity.

Analysis of the size of prey items trapped and comparison with the spacing of the pads and their adorning spines shows that this is not a simple dead end filter as the pore size is too great to trap all but the largest prey items. In fact, it has all the characteristics of a cross-flow filtration mechanism which is widely used in industrial processes. In cross-flow filtration, the filtered particles are agglutinated together, probably with the contribution of mucus in these fishes, forming particles which are much larger than the apparent filter pore size. These particles are then swept towards the back of the buccal cavity by the flow pattern in the cavity, probably assisted by the flexure of the gill arches which form the filter bed. This technique keeps the filter permanently clean and unblocked while the progressively concentrated particles are moved towards the pharyngeal teeth at the back of the buccal cavity. The pharyngeal teeth are fine unicuspid molars arranged on opposing dorsal and ventral pads and here the food items are pre-ground before passing into the stomachless alimentary tract where they are broken up by powerful enzymes. This data has helped us to design a feeding sequence which is well-suited to the body design of the animal and which gives excellent growth results.

As the fishery declines, accessing broodstock from the wild becomes more difficult and less acceptable. Previous attempts at culturing the species have always relied upon wild stock for gametes but an exciting and important feature of our work has been the closure of the reproductive cycle in captivity for the first time. Broodstock taken from the wild 5 years ago have reproduced in ponds at the lab and we are now working with an F1 stock. Several pools of broodstock are maintained so as to ensure a broad gene pool and we can now work independently of the endangered wild stock.

A further important development is the ability to control spawning using photoperiod. We have shown that a day length greater than 12h is required to initiate spawning and that groups of animals held on shorter photoperiods can be brought into spawning by increasing day length to 18h. This has enabled us to extend the spawning period greatly and gives the opportunity to produce eggs all year round.

Importation of fresh broodstock brought another native species – leeches – to the site. With help from Stirling's parasitologists we were able to improve health management techniques substantially and now have such problems under control.

Simple pond trials have already shown that on-growing to adulthood is feasible and this, coupled with the growing core of knowledge, has enabled the development of a culture methodology suitable for implementation in the region. We are now involved in pond trials with the local P'urhepecha community and are intending to expand this activity over the next year.

## Aquaculture, Biodiversity and Livelihoods

Apart from the inherent interest of the biology and the science, our longer-term goal is to promote a network of campesino nurserymen and on-growers that will produce pescado blanco for sale or for restocking. We are facilitating stakeholder on-growing developments using appropriate farming systems. However, the involvement of SME's as juvenile suppliers for the long term is also a major objective as it will ensure sustainability of supply. This in turn will allow small scale stakeholders to focus on nursery and on-growing activities which are less technically demanding.

Earlier this year we were awarded significant funding to continue this work. The Mexican National Research Council, CONACyT, through its **Fondos Mixtos** scheme, has given us support to create a pilot scale hatchery which will produce juvenile *C. estor estor* in quantity for the first time. This will enable us to support the planned expansion of field trials of pond culture and will also provide large numbers of juveniles which can be used for restocking.

In parallel with this, and very much dependent upon it, we have received substantial support from DEFRA through the **Darwin Initiative**. This seeks to support UK collaboration with other countries to maintain biodiversity and in this case it will be achieved through aquaculture which will both support livelihoods and help conserve the species as well as helping to shape biodiversity policy for the future.

**Acknowledgements:**

DARWIN INITIATIVE

CONACYT

**Although it is impossible to name everyone, a vast number of staff and students of both institutions have contributed to this work. We are extremely grateful to everyone - and so is the pescado blanco.**

**For more information on Mexican native species and Chirostoma see:**

**http://www.aquaculture.stir.ac.uk/gisap/chirostoma/**