Working with the natives

Development of aquaculture technology for the Mexican silverside or pescado blanco, *Chirostoma estor estor* Jordan

By Lindsay G Ross, Institute of Aquaculture, University of Stirling, UK and Carlos A Martinez-Palacios, INIRENA, Universidad Michoacana de San Nicolàs de Hidalgo, Morelia, Michoacán, México

AQUACULTURE has developed strongly in the last 40 years, but most aqua-business is understandably risk-averse and has focussed on known technologies and species. Aquaculture and Fisheries departments responsible for aquaculture development have also tended to follow this path and so world production of cultured fish is still based on a very limited set from the 30,000 or so known species. Although this worked well during the rapid development of the sector in the late 20th century, this is now changing as there are substantial concerns in many parts of the world not only over the effects of introduction of species for aquaculture but also the transplantation of strains within the natural range of a species. This has resulted in a considerable and growing worldwide interest in focusing on native species for future aquaculture, including in many countries where there have already been numerous introductions.

Seine netting on Lake Patzcuaro

Beginning in 1999, two long-term collaborators on native species for aquaculture in Mexico, Professor Lindsay Ross of IoA and Dr Carlos Martínez-Palacios of INIRENA, established a major project to investigate the potential for culturing the endangered pescado blanco of Lake Patzcuaro in the Mexican Altiplano. pescado blanco is a major species in the relict flock of Atherinopsid fishes unique in central Mexican lakes. This large group, also known as silversides, 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 the Pacific and Atlantic oceans. The *Chirostoma* species flock were isolated from their traditional migratory routes relatively recently by tectonic upheavals and have now become totally freshwater in habit.

Pescado blanco, *Chirostoma estor estor*

Sustaining livelihoods

Our work seeks to develop an aquaculture technology appropriate for small scale stakeholders in communities whose livelihoods have suffered due to rapid decline in the fishery for the high-value but endangered pescado blanco, and its close relatives. The species is a symbol of the area and for centuries has been the basis of an artisanal fishery with a high cash value (currently 25$ US/kg) 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.

Protecting biodiversity

There is no doubt that the entire *Chirostoma* group has been over-fished and *C.estor estor*, although not officially on the IUCN Red List, 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. Fishing continues. 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. All of these issues are being addressed directly by this project. 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.

Practical progress

There have been numerous attempts to culture pescado blanco over the last 30 years. These studies contributed to knowledge, but were relatively inconclusive. Our initial focus was on developing a detailed understanding of the species and in the last five years work has surged ahead on a wide range of aspects of the biology, physiology and culture of pescado blanco. Significant results are already emerging.

We have now clearly established that the species is a stomachless zooplanktivore which uses ram-suction feeding techniques coupled with cross-flow filtration to extract zooplankters from the environment with substantial prey specificity at all life stages. Based on this, considerable advances have been made in live feed systems to maximise growth and survival of juveniles and detailed work on nutrition and development of micro-diets and appropriate artificial feeds is in progress.

We have devised safe techniques for handling of larvae and juveniles and have established the optimum temperatures for growth and survival. We have shown that the species still retains considerable euryhalinity which may be linked to its recent evolutionary history. This is particularly valuable as careful use of saline environments is now used to eliminate the previously massive deaths of eggs and larvae caused by *Saprolegnia*.

Gaining experience of pond management

An exciting and important feature of our work has been the closure of the reproductive cycle in captivity for the first time so removing dependence upon an endangered wild stock for eggs and sperm. Initial problems with native leech infestations have also been conquered.

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. The intention is that this will enable sustainable aquaculture for restocking, so as to ensure survival of the species and some restoration of the fishery. The local P'urhepecha community are involved in field trials and in this way will be engaged in maintenance and management of their natural resources, and so enabled to diversify their activities through aquaculture, while simultaneously improving their earning capacity and boost their own consumption of protein.

Our longer-term goal is to promote a network of campesino nurserymen and on-growers that will produce pescado blanco for sale or restocking. We are facilitating stakeholder on-growing developments using appropriate farming systems and a scaled-up hatchery in development at INIRENA will provide the initial support to stakeholders in terms of supply of juveniles. However, the involvement of SME's as juvenile suppliers for the long term is a major objective which 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.

Extending and educating:

For the last three years we have worked with indigenous fisher families in Ichupio on Lake Patzcuaro to prepare the ground for future extension projects. Pescado blanco and related species are fished and traded as three products from the lake. The largest species is taken as "*pescado blanco*", reaching 25 to 30 cm. The intermediate sized "*charales*" are a mixture of smaller species and young pescado blanco. Finally, "*tripilla*" are tiny species mixed with the juveniles of all other species. This product size division is not species-related and has in itself probably contributed to the diminished recruitment of pescado blanco. Pescado blanco and charales are prepared in a number of ways and provide an important source of high quality protein and omega-3 fatty acids contributing to the diets of fisher families, as well as being a regular source of income.

To prepare the way for introducing aquaculture, we have provided a series of short training courses at INIRENA. One of the earliest was designed to introduce the concept of managing juvenile fish from the egg to on-growing stages. The participants were fascinated to see the young pescado blanco reared in the lab and initially thought they were charales or tripilla. Education and these simple experiences are everything and are vital.

We have also provided preliminary training in pond management based at the pond culture site at INIRENA. Monitoring water conditions and fertilising ponds so as to boost primary and secondary production is...

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very important. Fishing, and the new aquaculture which we hope to build, is very much a family affair. Women are involved at all stages of the work, including boat and net operations, processing and marketing of the product.

Promotional work

Getting the message out is very important to the success of a complex project such as this. As well as publishing in the science press, we have spoken at numerous conferences in Mexico and Latin America and miss no opportunity to speak locally.

In September 2003 we were visited by a team from the BBC, London, led by producer Michelle Jones. Michelle brought with her Barnaby who is a very famous "front-bear" for a children's series on geography and environmental issues. Barnaby made a special programme based at Lake Patzcuaro featuring fishing and aquaculture of pescado blanco at Ichupio as well as mask-making at nearby Tocuaro. Barnaby is seen here being filmed chatting to Dr Carlos Martinez our Mexican project leader and Juan-Pablo his young Mexican friend.

Dr Martinez talks to the BBC's Barnaby

What's next ?

Our overall goal is to simultaneously develop an aquaculture technology appropriate for small scale stakeholders and to fulfil two of the main tenets of the Convention on Biodiversity using the technology and juvenile production facilities developed at INIRENA. In late 2003 we commenced construction work on land provided by a collaborating fisher family. We have now completed 4 ponds for pilot scale on-growing of juvenile pescado blanco and stocking is due to commence in spring 2004. Other small aquaculture production projects are to be commenced later in 2004, in conjunction with already-identified campesino and SME business partners. Pond facilities will be constructed and training and support will be provided so as to enable stakeholders to conduct the on-growing themselves. The project will monitor progress so as to ensure a sound scientific validity for the outcomes. We intend to test efficacy of different farming systems, ranging initially from simple monoculture to integrated culture including native catfish and freshwater prawn. In preparation for this, pilot work with these native species is already underway at INIRENA.

We hope that the training provided and facilities created will, in conjunction with policy makers in the State Fisheries Department and the Department of Agriculture, ensure that the activity and relevant policy is sustainable. UK expertise, in collaboration with our Mexican counterparts, is now playing a strong part in eliminating poverty, developing more sustainable livelihoods and maintaining biodiversity. We remain committed to our long term goals and hope that similar approaches will be encouraged elsewhere.

With sincere thanks to our many sponsors and funders.

Our research in Mexico has been, and is still, supported by CONACyT, SAGARPA, SEP, SEMARNAT and other Mexican agencies. Mexican grants are held principally by Dr Carlos Martinez, with Prof Lindsay Ross as named international collaborator.

A link between IoA and INIRENA has been supported by the British Council/DFID for the last four years and has enabled several UK specialists to contribute directly to the project as well as enabling Mexican staff to undertake valuable study tours to Stirling.

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El pez blanco de Pátzcuaro (*Chirostoma estor estor* jordan 1879), especie exclusiva del estado de Michoacán, en México, en particular del lago de Pátzcuaro, es de gran importancia cultural, económica y social. Muy apreciado por su calidad, delicioso sabor y atractiva presencia, es uno de los platillos más representativos del estado, y ha mantenido a mil 500 familias de pescadores del lago. Pero su precio (entre 150 y 350 pesos por kilo) lo ha llevado casi a la desaparición, a la que se unen otras causas: la tala inmoderada de la cuenca, motivo de nuevos depredadores, y la contaminación del lago con aguas residuales industriales y agrícolas.

PÁTZCUARO HOY:

RESCATE DEL PEZ

CARLOS A. MARTÍNEZ-PALACIOS Y LINDSAY G. ROSS

BLANCO

Estanques piloto en Ichupio, Michoacán.

En la actualidad, su rescate es un hecho gracias al trabajo integral de profesores y alumnos del laboratorio de Acuicultura y Nutrición de la Universidad Michoacana de San Nicolás de Hidalgo, en Morelia, coordinado por quien esto escribe, y el apoyo múltiple del Consejo Nacional de Ciencia Tecnología (CONACYT), la Universidad de Stirling, (Escocia, Reino Unido), la Facultad de Química y el Instituto de Ciencias del Mar y Limnología de la Universidad Nacional Autónoma de México (UNAM), la Universidad Iberoamericana (UIA), el Centro de Investigaciones Biológicas del Noroeste (CIBNOR), el Centro de Investigación en Alimentación y Desarrollo-Mazatlán (CIAD-Mazatlán) y el Centro de Investigaciones y de Estudios Avanzados-Mérida (CINVESTAV-Mérida). Se han sentado las bases para su cultivo a través de una secuencia metodológica iniciada en 1999, con investigaciones de ciencia básica y aplicada que permiten decir que el pez blanco de Pátzcuaro es una especie que puede cultivarse en ciclo completo con fines comerciales o de repoblación.

→ APRENDER SOBRE LA MARCHA

El camino no fue fácil. Desde la década de 1960 se dieron importantes intentos, con pocos progresos. Entre los problemas principales estaban los siguientes: no se le había domesticado, es nadador veloz en las profundidades, es muy sensible al manejo, y sus huevos y larvas son muy pequeñas, lo que dificulta su alimentación.

De entrada requeríamos registrar su crecimiento, lo conseguimos empleando una *video técnica:* filmamos y grabamos imágenes de los pequeños peces en el agua, para después ampliarlas en una pantalla y medir su longitud con precisión, sin dañarlos, misma que relacionamos con su peso individual. Esto permitió establecer modelos matemáticos para determinar el peso de los animales. Así, desarrollamos un plan de alimentación exitoso. Además, como son de sangre fría (*poikilotermos*), requieren de una adecuada temperatura para tener un crecimiento óptimo. Pudimos determinarla: 25°C.

Pero, el aprendizaje más importante fue darnos cuenta de que era una especie *no típica* de agua dulce. Pertenece a un grupo que se originó

→ El pez blanco se originó a partir de una población marina que se alejó de este medio por movimientos tectónicos durante el Cuaternario temprano

Larvas de pez blanco

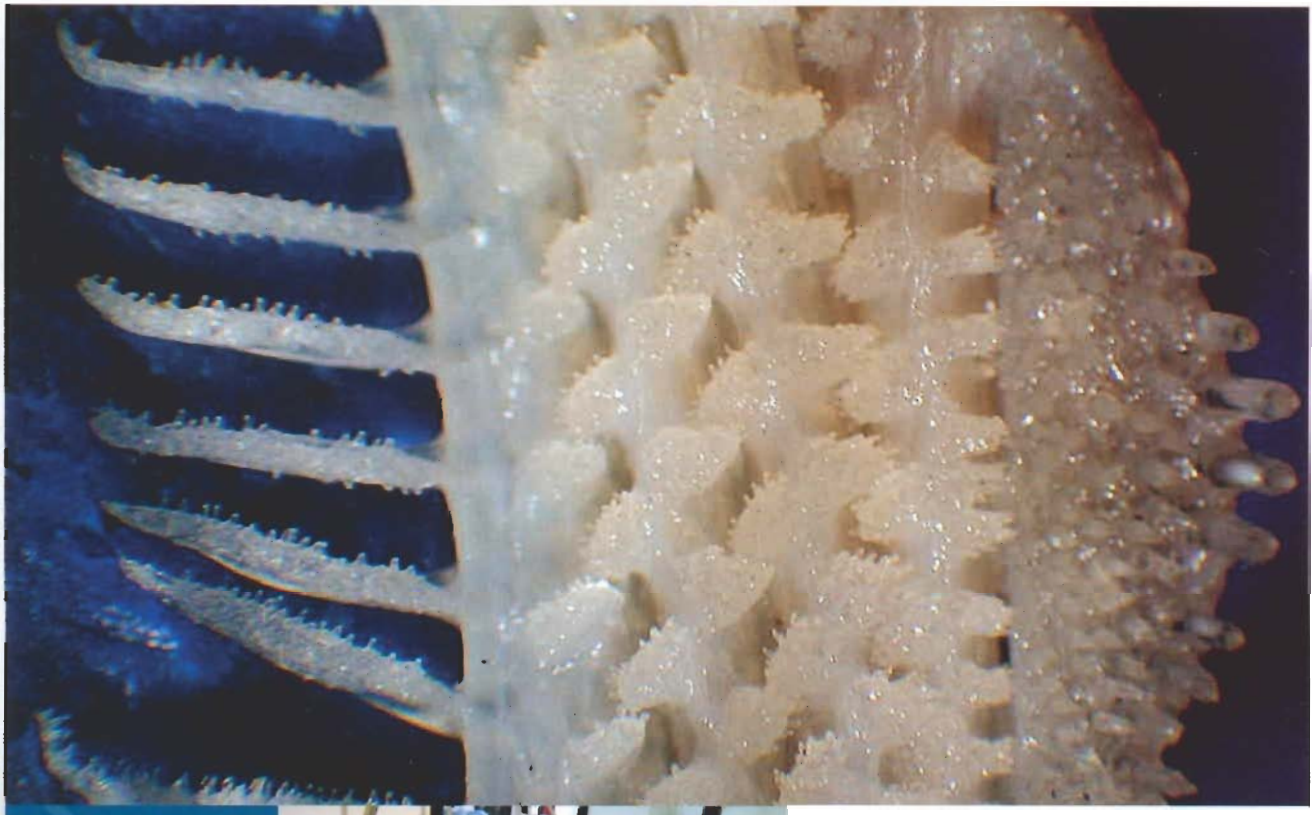
a partir de una población de origen marino, que quedó aislada de este medio por los movimientos tectónicos del temprano Cuaternario (hace 1.6 millones de años). Desde entonces se establecieron los ancestros de los modernos peces blancos en la mesa central de México. Como los salmones, el pez blanco tiene una considerable *eurihalinidad* (tolera amplias variaciones de concentraciones salinas en el medio ambiente), por lo que puede vivir en aguas dulces o salobres. Con una cuidadosa adaptación a la salinidad, los individuos jóvenes sobreviven en salinidades de hasta 15 g/l, con crecimientos superiores a los del agua dulce, en iguales condiciones de temperatura y alimentación.

Tambien descubrimos que la salinidad incrementa la supervivencia de los huevecillos al eliminar enfermedades y parásitos (como los hongos acuáticos parásitos del género *Saprolegnia* (ver gráfica) que no la soportan. Al haber más huevecillos vivos, hay más larvas, es decir la *eclosión* es mayor en altas salinidades. Mediante una *secuencia de optimización del medio salino* de las larvas, incrementamos su índice de supervivencia y logramos presiones osmóticas equilibradas (*isotonía*), reduciendo así el estrés causado por un medio agresivo.

→POR LA BOCA VIVE EL PEZ

Cuando iniciamos nuestras investigaciones teníamos la idea de que los individuos adultos del pez blanco se alimentaban de otros peces (*ictiófagos*), pero descubrimos que no es así: comen zooplancton (*zooplanctófagos*). A esta conclusión llegamos tras alimentarlos con mezclas de estas microestructuras biológicas, cuya anatomía estudiamos al detalle con la técnica de *microscopía electrónica de barrido* (MEB), donde se recubren con oro para que los electrones emitidos por el microscopio puedan definir sus contornos, luego fotografiados. Se demostró que la especie es zooplanctófaga *selectiva*, y se pudo diseñar una secuencia de alimentación acorde a la estructura anatómica del pez, con excelentes resultados en lo que a crecimiento se refiere.

El secreto está en los *arcos branquiales* del pez blanco: en especial del segundo al cuarto cuentan con una serie de haces de espinas sobre-



Espinas largas branquiales en el arco 1 (izquierda), haces de espinas imbricadas en los arcos 2 a 4 (medio) formando una superficie filtrante y los dientes faríngeos (derecha).

puestas, que forman en la cavidad bucal una pequeña superficie filtrante flexible y continua. La comparación entre las presas atrapadas y los espacios en esta superficie muestra que no se trata de un simple filtro: es un *mecanismo de filtración de flujo transverso*, utilizado en forma amplia por diversas industria en procesos de filtrado.

En nuestros peces, las partículas filtradas se *aglutinan* (pegan unas a otras), a causa de la acción del moco segregado por las membranas branquiales, y forman otras, en apariencia mayores al tamaño del poro del filtro. El pez las traslada atrás de la cavidad bucal gracias al patrón de flujo mencionado, y tal vez con la ayuda de la flexibilidad de los arcos que forman la superficie filtrante. Así el filtro permanece limpio y sin bloqueos. En la parte trasera están los dientes faríngeos: muelen a la partícula, previo a su entrada en el esófago y, después, al tracto digestivo (carente de estómago), donde es atacada y digerida por poderosas enzimas.

→ NACER Y SOBREVIVIR PARA CRECER

Sistemas de incubación y tanques de crecimiento se diseñaron para garantizar al máximo la supervivencia de huevos y larvas. Junto al paralelo *método de primer crecimiento en recirculación* (el agua se reusa por medio de filtración física y biológica), estos sistemas llevaron a la creación de *Robestor*, pequeño robot que los limpia, elimina el manejo excesivo de peces, reduce las causas de su estrés y los costos de una limpieza manual, y conserva el alimento vivo durante esta etapa.

Comenzamos la reproducción inducida del pez blanco a partir de peces silvestres desovados por nosotros en 1999. Nuestros reproductores fueron sus hijos, y hoy trabajamos con sus descendientes. Algunos se mantienen en el laboratorio para asegurar las características hereditarias (*genómicas*) y trabajar sin recurrir a las poblaciones del lago de Pátzcuaro.

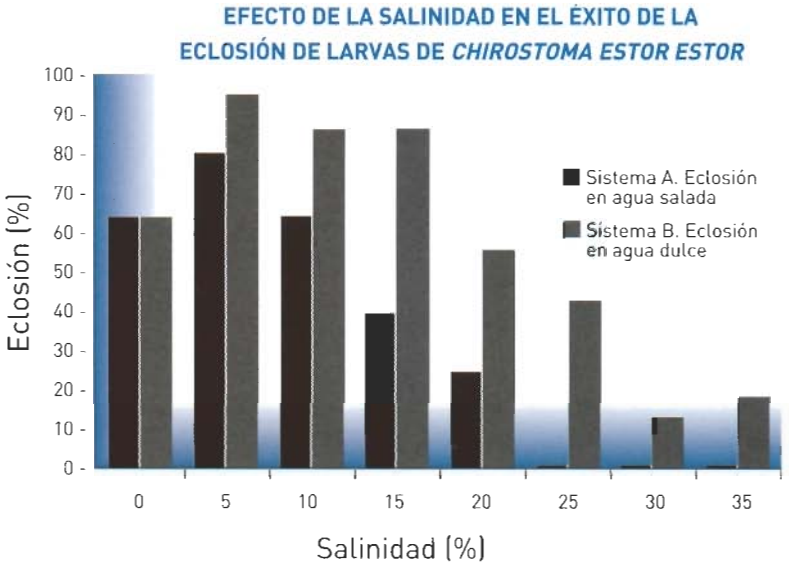
Por otro lado, por un año controlamos la reproducción gracias al uso del *fotoperiodo*. Tomando en cuenta las etapas de luz, observamos que el desove se activa con más de 12 horas de luz (días

→ El binomio ciencia-tecnología permitió comercializar con éxito el pez blanco y evitar su extinción

largos), y provocamos esta función orgánica en grupos de animales que permanecen con periodos de luz menores (a través del alargamiento de éstos hasta 18 horas). En consecuencia, extendimos la temporada de reproducción, obteniendo huevos de pez blanco durante todo el año, sin restricción, y compensando la poca cantidad que de manera natural pone cada hembra. Complementamos esto probando con sencillos experimentos de manejo que los peces blancos pueden crecer hasta etapa adulta comiendo sólo zooplancton. Con nuestro conocimiento básico acerca del desarrollo y la madurez de sus individuos, generamos a la par una *biotecnología para la implementación del cultivo del pez blanco en la región*. Su base es el uso indirecto de la fertilización de los estanques de cultivo con fertilizantes inorgánicos, lo que multiplica el zooplancton. Los peces blancos se alimentan de la productividad natural del estanque, reduciendo los costos de producción al no tener que invertir en alimentos balanceados.

En 2004 iniciamos el cultivo de peces blancos en estanques de tierra, construidos en la ribera del lago de Pátzcuaro con la cooperación de los purhépechas del poblado de Ichupio, municipio de Tzintzuntzan a orillas del lago de Pátzcuaro, pero esperamos expandir la actividad este 2005. A principios de 2004 obtuvimos un significativo apoyo por parte del CONACYT, (a través de *fondos mixtos* con el estado de Michoacán) para producir 200 mil crías, lo que nos permite construir y operar a principios de 2005 la primera planta piloto productora comercial de individuos jóvenes de pez blanco para repoblación y engorda, y por primera vez transferir tecnologías de cultivo a otras especies: hemos podido reproducir con éxito el pez blanco de Chapala (*Chirostoma promelas*). Tenemos suficientes crías, lo cual beneficiará a los pobladores de sus alrededores.

A la vez recibimos un sustancial respaldo del Deparment for Environment Food and Rural Affairs (DEFRA), por medio de la Iniciativa Darwin, del Gobierno Británico, cuyo compromiso es mantener la biodiversidad en diferentes ecosistemas. En nuestro caso, el acuático, a través de la acuicultura particular del pez blanco y de su sustentabilidad. Así, en el lago de Pátzcuaro, la comunidad podrá generar el cultivo comercial de esta especie de alto valor que pertenece por tradición a su quehacer



cultural, alimenticio y económico. Por el lado ecológico, este cultivo de especies nativas permitirá su recuperación y conservación, así como el del ecosistema en el que están. La alternativa potencial que presenta el cultivo de los peces blancos para mejorar la calidad de vida de algunos grupos en México e impulsar una acuicultura nacional competitiva, es clara. Gota de agua necesaria en el tormentoso mar actual.

Efecto de la salinidad en el éxito de la eclosión de larvas de *Chirostoma estor estor*.

Para mayor información sobre especies nativas mexicanas y *Chirostoma*, favor de ver: www.aquaculture.stir.ac.uk/gisap/chirostoma

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

Lindsay Ross and Carlos Martínez Palacios

IoA: Institute of Aquaculture, University of Stirling, Scotland
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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.

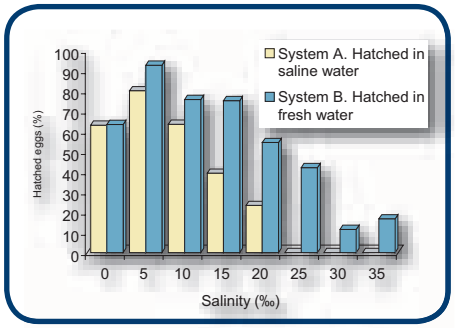
Practical progress

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

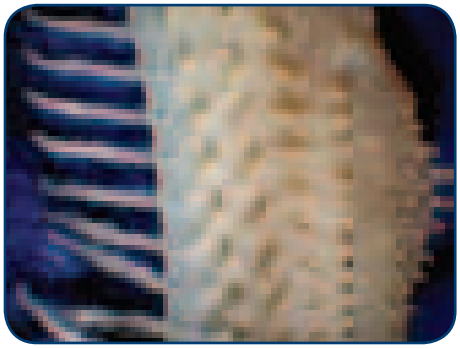
An important concept from the start was that we were not dealing with a classical freshwater fish. The flock almost certainly arose from a Menidia-like migratory stock and was isolated relatively recently by the tectonic upheavals which formed central Mexico. We have now shown that the species still 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/

Training workshop on participatory community appraisal (PCA) in Michoacan, Mexico

Jack Morales, Systems Group

A training workshop on participatory community appraisal was held at the Laboratorio de Acuicultura, Universidad Michoacana de San Nicolas de Hidalgo (UMSNH) from July 06 to 09, 2005. The trainees included staff of the Darwin Initiative project on Pescado Blanco (reported in the edition 31), as well as seven students of UMSNH. This training was designed to produce facilitators that could conduct community appraisal in communities where the Darwin-funded project is working.

During the training, participants were introduced to the importance of the participatory approach as well as the different characteristics of a good facilitator. The main part of the training was the demonstration of a number of participatory tools.

The dos and don'ts were discussed for each tool, and sample outputs from previous community appraisals were also presented to the participants to help them understand the topic being discussed. After discussing important participatory tools, participants were given the chance to practice the different methods through simulation or "role playing". Each of the tools discussed were practiced by the participants

Tools	Uses
Village mapping	To understand the important resources, services, and infrastructures in the community
Historical transect	To understand the different major events that had happened in the community that influence the development in the community
Transect walk	Ground truths. To be more familiar with the community and to have a better understanding of the different resources in the community
Well-being ranking	Understand the social composition of the community. This will also help outsiders understand how local villagers view wealth.
Seasonal calendars	To understand the situation of the village throughout the year. This can describe the different livelihood activities in the village including social and religious activities
Preference ranking	Understand how villagers prioritized things. This can also explain the different criteria that villagers used in determining the importance of such resources
Bio-resource flow	It describes the interaction of the different unit/resources in the community or those resources that are important to the villagers. This can illustrate the different benefits that villagers get form each resources
Institutional analysis	To understand the different organizations and institutions that are present in the community. What role do the different organization play in the community and who are benefiting.
Trend analysis	This will illustrate how specific things (aquatic animals) behave from the previous years to present.

Table. 1 Different PCA tools discussed during the training

To apply the learning from the PCA training, field activities were conducted and the trainees facilitated three community appraisals in three sites around Patzcuaro Lake; San Jeronimo, Erongaricuaro and Ichupeo. Participants were assigned to facilitate different groups of villagers in the three communities. The groups used several participatory tools to be able to understand the livelihoods of the community. During the first day, participatory tools such as village mapping; transect walk, historical transect and well-being ranking were used to understand the general situation in the village. The next day of the field activity focused more on the villagers. PCA tools such as seasonal calendars and preference ranking were used to understand the different livelihood activities. Important activities, resources, food being consumed and aquatic animals were all identified during the preference ranking/ scoring activities. During the final stage of the field work, focused group discussion was used by the PCA team to understand the different perceptions, priorities, and the situations of the different groups (men, women, fishermen, and farmers) in the communities.

From this, our group learned that:

- It is very important to build rapport with the community first before doing any appraisal.
- Giving people/villagers a chance to express their thoughts, ideas, and feelings is a fulfilling experience for all concerned.
- The PCA team should have a very flexible plan to adopt and adjust with the situation in the field.
- Although living in the same place, people have different views in life.
- Working as a team to understand the community is important.

Particular challenges identified were:

- Lack of community's interest to participate in group activities.
- Some key persons in the community have difficulty participating in PCA due to their other commitments (jobs).

Overall, this participatory community appraisal workshop created an opportunity for the participants to learn and apply participatory tools to understand the livelihoods of the villagers in the community. The results provide the Darwin project with a sound social basis on which to build and develop aquaculture of Chirostoma.

The Darwin Initiative project "Sustaining livelihoods and protecting biodiversity through development of Pescado Blanco aquaculture" is a collaboration between the Institute of Aquaculture, University of Stirling and UMSNH in Morelia, Mexico, with funding from the UK Department of Environment, Farming and Rural Affairs (DEFRA).

First Latin American & Third Mexican Conference on Culture of Native Fish Species

Lindsay Ross, Institute of Aquaculture and Carlos Martínez Palacios, Universidad Michoacanade San Nicolás de Hidalgo, Morelia, México

Biodiversity is extremely rich in much of Central and South America and so uncontrolled introductions of exotic fishes, or any other species for that matter, are cause for concern. Many Latin American countries are facing up to this reality and, for example, in Chile (the biggest aquaculture producer in the region by far) biodiversity issues are already a prime consideration with introductions and translocations now being very tightly regulated.

Through a series of conferences associated with collaborative projects on the endangered pescado blanco *Chirostoma estor estor*, reported in Aquaculture News 31, Professor Lindsay Ross, Dr Carlos Martinez Palacios and partners have raised the profile of the need for sustainable aquaculture development while conserving and protecting indigenous species. These projects have received significant funding from the Darwin Initiative, who further supported the previously Mexican focused conferences that have now been broadened to include all Latin American countries. Hence between 18th and 20th October 2006, the First Latin American and Third Mexican Conference on Native Fish Species for Aquaculture were jointly held in the "Casa de Gobierno", Morelia, Mexico.

The meeting

The conference was extremely successful and was attended by approximately 100 researchers. A series of 10 talks by invited keynote speakers from Mexico, Cuba, Brazil, Argentina, Chile, Japan, Canada and UK was interspersed with 24 selected experience papers from across the continent covering a wide range of species and subject areas. In order to reach as wide an audience in the continent as possible, both during and after the conference, almost all talks were given in Spanish or in "Portuñol".

The first half of the meeting explored the wide variety of Latin American marine species, with leading presentations by Dr Daniel Bennetti of the University of Miami, Dr Andrei Sampaio of the Universidade do Rio Grande do Sul, Brasil, and Dr Luis Lajonchere, CIAD, Mazatlan, Mexico.

The second half of the meeting focused principally on freshwater species, with leading presentations by Dr Phil Scott of Universidade Santa Ursula, Rio de Janeiro, Dr Carlos Strussman of the University of Fisheries, Tokyo, Dr Gustavo Somoza of IINTECH Argentina, Dr Roberto Mendoza of Universidad de Nuevo Leon Mexico, Dr Alfonso Mardones of Universidad de Temuco Chile and Dr Carlos Martinez of INIRENA Mexico.

Dr Alfonso Mardones gave a superb summary of the developmental work behind culture of Puye (*Galaxias*) in Chile, a small fish which commands a massive price in the international market ($600/kg), leading on to a wide ranging consideration of other native species in the region.

Prizes were award for the best student posters, judged by four of our invited speakers. The first prize was divided between Lidia Ambriz Cervantes (INIRENA-UMSNH) and F.Ribeiro (UFSC-Brazil).

Day four brought the meeting to a close with a relaxing field visit to our pilot farm and demonstration site at Ichupio, Tzintzuntzan, where a trial netting assured us that our fish were doing well. To everyone's delight, the family prepared a huge lunch of fried charales (small Atherinids) with fresh hand-made tortillas accompanied by fresh salsas and chillies.

The future

Staging this conference has had the major effect of focusing the interest of many key people on the issues of the Convention on Biodiversity (CBD), use of native species in aquaculture development as well as use of aquaculture as a powerful tool to maintain biodiversity and livelihoods. The pressure on nations to comply with CBD is also giving a strong impulsion to indigenous species development, even extending to changes in the law regarding importations. There could be many species currently under threat, even extending to extinction, and a reconsideration of the effects and future role of aquaculture linked to conservation is timely. The approach of the present Darwin Initiative project has given a lead to many workers who need to contend with this new situation.

The event has already spawned further meetings on native fish species for aquaculture in Brazil, Argentina and Chile as well as the strong prospect of a series of biennial pan-Latin American meetings to follow up this one. This is a very significant measure of success for the DI project and the timeliness of our original concept.

The conference website has been transformed into a reporting and linking point for all interested in this vital topic; see: http://www.aqua.stir.ac.uk/GISAP/Conference/ where you will also find a full list of our sponsors.

First Latin American & Third Mexican Conference on Culture of Native Fish Species *continued from page 10*

Lindsay introduces the background to CBD and culture of native species.

Dr Herve Migaud enjoying a taco of fresh, hot, hand-made tortilla

Dr Andrei Sampaio outlining experiences with Paralichthys

Dr Alfonso Mardones receiving his recocnocimiento from Dra Mayra Toledo Cuevas who organised the entire event