Topical issues in genetic diversity and breeding

Genes and Fish

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Chinese researchers have carried out a lot of interesting research and development of red strains of common carp, like this glass red, which have been selected not only for colour but also for growth and body shape (picture courtesy of Dr Li Sifa).

As this issue is intended to be in circulation during the forthcoming World Aquaculture Society meeting in Beijing and the theme of the issue is distinctly Chinese, I thought I should write something in the column about the highly significant contribution made to fish breeding and fish genetics by Chinese researchers and aquaculturists.

My first problem is that I've spent very little time in China and feel quite ignorant about Chinese aquaculture, and indeed I'm really looking forward to my visit there to try to learn more of the story behind the extraordinary aquaculture production that is coming out of China. However, I do know enough about the history of aquaculture to know the important impact that early Chinese research on induced spawning of fish has had on aquaculture production, particularly carps in Asia. It was back in 1921 that Chinese ichthyologists first experimented with artificial fertilization in carps. It was not until the early 1950s that work on artificial induction of spawning, or "estrualization" as it was then called, began using carp pituitaries and human chorionic gonatropin (HCG). By the late 1950s and early 1960s Chung Ling and his colleagues had successfully induced spawning in all the important Chinese major carps. This work was mirrored shortly afterwards by Indian researchers with the Indian major carps.

This technology, which became known as the Linpe method (after the names of the two principal researchers, Lin Hao-Ran and Richard Peter), is today the standard technology for induction of spawning in a wide range of aquaculture species and has thus contributed very significantly to the spread of aquaculture of these species worldwide. Together with a Canadian scientist, Chinese researchers were also instrumental in the development of improved, more sophisticated and effective methods of hypophysation using Leutinizing Hormone Releasing Hormone analogues (LHRH) alone and later in combination with dopamine antagonists.

Induced spawning has enabled the lifecycle of many fish to be completed within artificial environments, effectively permitting the domestication of a large number of finfish species. As discussed in previous columns, domestication itself has significant impacts on the genetic status and, long term, on the performance characteristics of aquaculture species. In the case of the carps, which are generally highly fecund, induced spawning methods, combined with effective artificial incubation and larval rearing techniques, enables us to produce very large numbers of fry from relatively few numbers of broodstock, encouraging low effective population sizes and thus promoting inbreeding with its negative consequences.

Chinese researchers have also been at the forefront of the application of genetic based technologies to cultured species. Considerable work has been done on characterising the broad diversity of fish fauna in the country both at the level of species diversity (the Yangtze river for example has the largest diversity of species in Asia with over 314 recorded) and at the level of genetic diversity. Genetic diversity has been characterised at the cytogenetic, biochemical and molecular level for populations of most of the commercially important cultured species.

However, it is in genetic improvement programmes, only possible since the successful domestication of the species, that many significant and in some cases unique advances have been made in China.

The priority species for aquaculture genetics to date in China has been the common carp. A number of red varieties have been developed through selective breeding for traits such as colour, growth rate and body shape. These various selected strains are also used in hybrid crosses, many of which have been certified as good varieties by the National Certification Committee on Wild and Bred Aquatic Varieties. In perhaps a unique example of a combined breeding program, family selection, crossbreeding and gynogenesis were combined in the development of the Jian carp, now one of the most widespread cultured common carp in the country.

In addition to the major carps recent attention has been focused on the blunt snout bream or Wuchang bream (*Megalobrama amblycephala*),

Above: Early Chinese research on induced spawning has impacted on seed production world-wide (Photo: D.C. Little).

Below: The blunt snout bream or Wuchang bream (Megalobrama amblycephala) is an increasingly important species in Chinese aquaculture and a focus for recent research on genetic improvement.

A Jiang farmer carrying red Chinese carps to the market.

an increasingly important aquaculture species with a production of over 400,000 MT per annum. A mass selection programme from 1986 to 1999 produced a 29% increase in daily weight gain. Efforts have now focused on trying to induce tetraploidy in this fish with the medium term objective of using these as broodstock to produce high yielding sterile triploids.

Genetic improvement has not been limited to indigenous species, and indeed some of the work done in China on the introduced tilapia is close to my heart. I spent part of my early career developing a breeding program for the production of YY supermales in the Nile tilapia *Oreochromis niloticus* for the mass production of all-male progeny without the need for hormonal sex reversal. Whilst the principles behind this technology are relatively simple, we initially believed that we were doing original science. A few years into the research I unearthed some data from a paper, originally published in Chinese, demonstrating that Chinese scientists had developed the same ideas for *O. mossambicus* more than a decade earlier! The Chinese were successful in developing YY "supermale" *O. mossambicus* but do not appear to have taken this up to the scale of mass production of all-males. Perhaps I'll learn differently again when I'm in Beijing in April!

Some particularly innovative genetics research was carried out in the 1960s and 80s. This work developed nuclear transfer methods which involves transferring the nucleus from a germ cell of one species to the cell of another (from which the nucleus has been removed). This creates fish with different and uniquely combined nuclear and cytoplasmic genotypes. Three generations of common carp–crucian carp nuclei-transfer fish have been produced and have exhibited faster growth rates than the parental common carp strain. It is however not clear whether this method could ever lead to commercial applications.

China is also leading the way in the development of transgenic fish (issues related to which were discussed in this column in the July-September 2001 issue of this magazine) having carried out some of the earliest research of this type on common carp. Priority species for this research are again the common carp, crucian carp and the blunt snout bream.

China is however not only focused on genetic improvement to increase fish productivity but is also conscious of the need to conserve its key aquatic resources. Live gene banks are maintained for most of the commercially important cultured species and recently a fish sperm cryopreservation gene bank has been established at the Yangtze Fisheries Institute where sperm from the major culture carp species is stored.

There is no doubt that Chinese research in fish breeding has had worldwide impact and their genetics research is undoubtedly contributing significantly to aquaculture production within China. As a geneticist and a fish breeder I'm very much looking forward to my forthcoming trip to China and have little doubt that important new innovations in the field will be on show there.

Xingguo red common carp, photo courtesy of Dr Li Sifa