Topical issues in genetic diversity and breeding

Genes and Fish

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Hybridisation – More trouble than its worth?

Hybridisation

"Hybridisation" in this article refers to the crossing between fish species - I prefer to use the alternative term "crossbreeding" to describe crosses between stocks or strains, within a species. We are lucky, or in the context of this article perhaps unlucky, that the biological species concept based on reproductive isolation or "non-crossability" of species, does not apply very well in fish. We know that it is possible to make crosses and produce viable and fertile progeny in a great many different fish stocks, which by all other definitions of the term, we would consider as different species. Even crosses between different genera are possible in a number of cases including some important aquaculture species such as the major carps and tilapias.

The rationale

If we exclude scientific curiosity, hybridization is usually attempted for two reasons. The main reason is the hope of observing heterosis or "hybrid vigour" for one or more commercially important traits. The rationale behind this hypothesis is that different species are likely to have evolved different alleles at common gene loci and thus that there will predictably be high levels of heterozygosity in the hybrid progeny. High levels of heterozygosity are often associated with greater "fitness". If hybrid vigour does result in good characteristics for aquaculture then these should be consistent for all F1 crosses of the species, providing predictable gains in the hybrids.

The other main rationale for carrying out hybridisation is to combine a set of desirable characteristics from two or more different species into a single hybrid with the combination of traits in the hybrid then having significant benefits, in the context of production or marketing, over either of the parental species.

Its popular science!

Perhaps because it's often relatively simple research to carry out there is a very large body of literature on scientific studies in which hybrids have been produced and evaluated for a range of traits. In my own library alone I have several hundred publications that make significant reference to hybrid fish and there are over a thousand and possibly several thousand publications dealing with the issue. It is my impression that in the majority of studies in which viable hybrids are produced, the hybrids have traits that essentially represent an average between the traits of the two parental species. Deviations from this norm, where clear-cut heterosis in which the hybrid out performs both parental species for commercially important traits, are rare

In the US the cross between two Ictaluriid catfish, the channel catfish (female) and the blue catfish (male) produces a fish with superiority for growth rate and several other important traits. Efforts to produce the hybrid on a commercial scale have however failed. In other hybrids, whilst they may not grow faster or have higher production than parental species, the combination of two species may result in fish with other desirable traits. Some hybrids are sterile (common in crosses between species with significantly different chromosome number), whilst others may have enhanced environmental tolerances (e.g. tilapia hybrids), attractive appearance or flesh quality (e.g. Clarias catfish hybrids) or they may be monosex (tilapia or North American bass). These traits can be advantageous under certain circumstances. For example triploid hybrids between grass carp and bighead carp might have benefit from a conservation perspective where the fish might have an application for weed control in a location to which neither species is indigenous.

A poor return

Despite the large body of research on hybridisation, the bulk of it justified in the context of potential applications in aquaculture, there are very few hybrid fish produced in commercial aquaculture worldwide. Probably the best example is the hybrid catfish cultured in South-east Asia, principally in Thailand and, to a lesser extent, Vietnam. This is a hybrid between the indigenous *Clarias macrocephalus*, a small, slow growing species particularly desired for its flesh quality, and the exotic *C. gariepinus*, the African catfish, a larger faster growing catfish but with poorer marketability. The hybrid, which has characteristics that are essentially intermediate between the two species, represents a good compromise as it is faster growing and more robust than the indigenous catfish with a much-improved marketability compared to the pure African catfish. Whilst the parental species used to be cultured as pure species in small quantities the hybrid is now cultured very widely in Thailand where it represents the second most important inland aquaculture species with a production of over 70,000 MT per annum. Another example of significant use of hybrids in aquaculture is the culture of hybrid tilapia, mainly the F1 hybrid between *O. niloticus* and *O. aureus*, which are often near monosex male. Whilst FAO published statistics do not record significant production of this hybrid it is thought that 50-75% of Chinese tilapia production is of this hybrid indicating a very significant contribution to global tilapia production. The exact reason for the preference for this hybrid in China and Taiwan is not clearly understood as it is no longer a popular tilapia for culture in the rest of the world. One of the other well-known examples of hybrids is the hybrid striped bass which is used in aquaculture in North America and Israel although levels of production are relative low. With apparently only three hybrid finfish in significant commercial production, surely it has to be considered that research on hybridisation has not lived up to its potential with regard to commercially valuable outputs. This is of course not to say that that may not be other reasons for carrying out hybridisation, for example as a prelude for inter specific backcrossing which can be used to introgress advantageous genes (e.g. for disease or environmental tolerances) from one species to another.

The downside?

There is a downside to hybridisation, particularly if it is carried out indiscriminately. The main risk lies with a permanent loss of species purity in aquaculture stocks with the prospect of this being passed on to wild stocks in locations where the species are indigenous, resulting in a break down of species barriers. As so many hybrids are fertile they can be used either deliberately or accidentally, as broodstock resulting in segregation of genotypes with some of the subsequent F2 hybrids or backcrosses being indistinguishable from either or both of the parental species. Use of hybrids as broodstock on any kind of scale would thus fairly rapidly lead to widespread introgression.

Commonly, aquaculture systems in Asia have developed to exploit the particular feeding habits or ecological niche of distinct species. This is very much so in the case of multi-species polyculture where the species used occupy complementary, non-competitive niches, enhancing the overall productivity of the systems. With the use of hybrids or with hybrid introgression the integrity of the behavioural patterns breaks down. One example where this appears to be occurring is in Bangladesh (and some other Asian countries) where the introduced Chinese carps are widely used in polyculture. A common practice in some Bangladesh hatcheries is to use the sperm of one species to cross with females of the other, typically using silver carp sperm to fertilize eggs from bighead carp when males of the latter species are in short supply at the end of the breeding season. The hybrid is difficult to distinguish from the parental species and is quite likely to enter the broodstock. As might be expected, the hybrid has traits intermediate between the two species making it fairly omnivorous given that silver carp are primarily phytoplankton feeders and with bighead mainly feeding on zooplankton. Culture of hybrids or widespread introgression of the species thus removes the advantage of complementarity of feeding behaviour in the two pure species. Based on morphological investigations, it has been suggested (Rajts, pers. comm.) that introgression has reached the point in Bangladesh that the current "silver carp" stocks are widely introgressed and as a result tend to compete with more omnivorous Catla in carp polyculture

Figure 1: Illustration of differences between silver and bighead carp and the properties of their hybrids. In silver carp (top left) it is thought that the pectoral and pelvic fins do not overlap whilst in bighead carp (bottom left) an overlap is clear. A range of intermediate types can be seen among cultured stocks in Bangladesh (right) probably representing hybrid or introgressed stock. In the intermediate types the gill rakers also vary between the fine dense rakers of the bacteria and phytoplankton feeding silver carp and the coarser rakers of the zooplankton feeding bighead carp. Gut length is also intermediate between the longer gut of the silver carp and the shorter one of the bighead. (Photo and accompanying information provided by F. Rajts)

systems. However, genetic analysis using DNA markers being carried out under an on-going DFID funded project involving the University of Stirling, demonstrated that introgression is present in less than 10% of broodstock in hatcheries surveyed, indicating that the problem may not yet be very widespread.

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Introgression was also found to be widespread in Philippine tilapia stocks in the 1980s, with the majority of stocks considered at the time to be pure *O. niloticus* found to be introgressed with the previously introduced and slower growing *O. mossambicus*. This resulted in the fresh introduction of tilapia stocks from several sources and it has taken over a decade to effectively replace the introgressed stocks. Given the almost ubiquitous presence of feral tilapia through much of Asia, introgression of cultured stocks is commonplace, although it often goes undetected.

In summary

It is debatable whether the potential risk-benefit ratios of hybridisation warrant continued experimentation and certainly efforts to raise awareness of the risks of indiscriminate hybridisation should be made. Even the relative success story of the hybrid catfish in Thailand is not without its risks. Wild stocks of *C. macrocephalus* are threatened not only by collection of females for use as broodstock but also by introgression with hybrids escaping from commercial farms. The only reason that this had yet to happen on a wide scale would appear to be down to the good fortune that the hybrid has reduced reproductive capacity.

What's New on the Web

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Technology assistance for non-profit organizations

A few days ago I stumbled across the 'Techsoup' website completely by accident. Techsoup is a US-based organization that calls itself a 'comprehensive source of technology information just for nonprofit organizations', and this would seem to be a fairly accurate claim - Techsoup does a number of things. If you or your organization is involved in use of technology for development, community work or education then I recommend that you take a careful look at the resources available through this website. The site has a very impressive list of sponsors and partners including Microsoft and AOL Time Warner, BP, Adobe Systems, VodaFone, Lotus and Cisco Systems. It is also partnered with an organization called Computer Mentor and…CNET…ok guilty, so I was enviously reading reviews of a great new handheld computer that is available pretty much everywhere but Thailand (grumble…why, Dell, why ?).

Free and discounted technology for non-profit organizations

Firstly, Techsoup partners with the philanthropic groups of leading technology companies to provide centralized access to technology products that have been donated (ie. are available for free) or discounted for non-profit organizations. There is some quite good equipment available here – for example virus protection software from Symantech, Office XP from Microsoft and switches from Cisco Systems. Some things are available directly through the Techsoup website (they charge relatively small administrative fees) and for others you have to apply directly to the providing company. There are application procedures (of course) and the vendors also impose varying restrictions in line with their company policies.

Grants, funding and resource links

You'll find lists of free and discounted software distributors. There is also a comprehensive list of links to technology-related funding and grants providers – Adobe, Dell, the Gates Foundation, the Hewlett Foundation, Mitsubishi, the Packard Foundation and the list goes on. Application details are provided along with comments and ratings from people who have already applied so you can find out which grants schemes have user-friendly procedures and which would be a waste of your time.

User-friendly technology guides

At last a technology organization that actually provides user-friendly information. A wide range of easy-to-understand articles are provided through the site that to help laypersons understand technology, and to use it effectively and appropriately. No computer background is assumed. Subjects covered include technology planning and hardware, using the internet and email effectively, options for online discussions and making technology accessible to people. There's a lot of other useful stuff that you might need to know if you're going to get involved in using technology for development – how to find appropriate volunteers, dealing with consultants, and What To Do When Your Techie Leaves You !

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