PESTSMART

Daughterless carp

Introduction: Carp are prolific breeders. A single female carp can produce upward of 1.5 million eggs per year[1]. This means that typical control programs that concentrate on physical removal of the fish or that target individual spawning events are unlikely to have an impact, except on a local scale. Sophisticated modelling exercises support this.

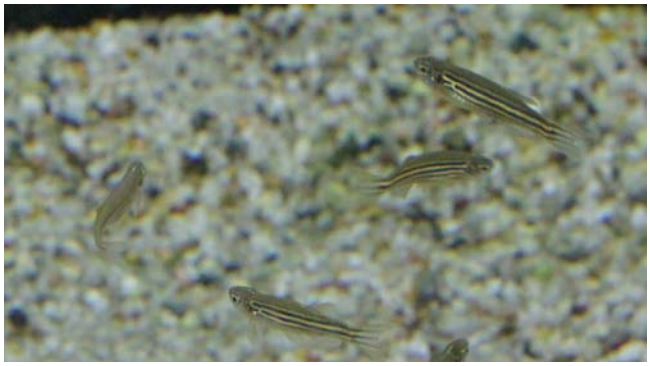
With funding from the Murray-Darling Basin Authority (MDBA) through the Invasive Animals Cooperative Research Centre (IA CRC), CSIRO has been developing alternative and potentially more powerful means of controlling carp, by breeding into a carp population a mechanism that reduces the number of females and so radically reduces carp numbers within a few generations. This is the basis for 'daughterless technology'[2].

Technology summary: The basic idea is to alter the genes of carp so that they only produce male offspring. The altered 'female lethal' genes become part of the genetic make-up of offspring. With fewer females produced with every generation the population becomes almost entirely male, and logically, the population would eventually crash.

> *"The idea is to alter the genes of carp so that they can still reproduce, but the offspring are all males"*

Invasive Animals CRC research: Developing this daughterless 'gene' requires cutting-edge genetic technology. CSIRO has successfully tested a mechanism in zebrafish (*Danio rerio*), a laboratory fish species which is closely related to carp.

An enhanced version of the gene appears to be lethal to females in zebrafish – it occurs only in females and reduces egg production by 70–90%.



Fourth generation daughterless zebrafish. All are male. Image: Ron Thresher, CSIRO, Hobart

Pond trials of daughterless zebrafish carriers. Image: Ron Thresher, CSIRO Hobart

In collaboration with Auburn University (USA), preliminary trials have started on carp that have had their genetic make-up changed. Testing to determine if the technology works in the field requires the gene construct to be properly built into carp chromosomes. This process takes several generations in any species, and at least four years in carp as they only reach sexual maturity at two years of age. This means that only initial testing of some constructs were possible before the end of the IA CRC-funded project in June 2012. One-year extension funding to June 2013 from the Lower Murray-Darling CMA has been secured to carry out further testing.

Partnerships: This project has involved close cooperation between the MDBA, IA CRC and CSIRO. It has also been generally supported by the community across the Murray–Darling Basin (MDB). The Lower Murray-Darling CMA is supporting the project into 2013.

Juvenile carp containing the daughterless genetic construct. Image: Ron Thresher, CSIRO Hobart

Pond facilities at Auburn University (USA) where preliminary trials of daughterless genes are being done on carp. Image: Ron Thresher, CSIRO Hobart

Future proposed research: If the constructs work as predicted and **funding and government support is secured**, the next stage will be to seek release approval from the Office of the Gene Technology Regulator (OGTR). Brood stock would need to be developed and further trials carried out.

With approval for release and additional funding, field trials could then start:

- predictive models and operational issues will be tested in the field, by stocking male carp that can mate but not reproduce (called 'triploids') and exploring options, such as selective removal of wild males. Impacts will be compared against the model predictions. Models indicate that stocking triploids is ineffective as a control option, compared to a daughterless carrier, but the underlying population dynamics should be similar.
- a field trial of the 'daughterless' technology in tilapia, a species likely to invade the MDB in the near future, will occur in northern Australia. Tilapia have a much shorter life-cycle than carp and so will provide results faster that can help us understand how daughterless carp technology will work.
- prototype daughterless carp will be produced in the USA and transferred to a breeding facility in Australia.

Implications for pest fish management: Additional modelling, combined with detailed studies of carp biology in the MDB by the IA CRC, indicates that it is possible to release enough carriers into the MDB to effectively control carp. However, the stocking program will need to be long-term, because carp can live for up to 30 years. Application of daughterless technology to control carp would require a long-term commitment.

Significantly, once the technology has been developed for one species, it can be readily and inexpensively adapted to target other pest fish species, such as tilapia and gambusia. A population-level response to daughterless technology would take much less time in these pest fish species because of their shorter generation times.

This world-first genetic technology offers the genuine option of effective control of invasive pest fish species, especially if combined with other population reduction techniques. The use of daughterless technology in combination with another method of population reduction will enhance its effectiveness and greatly reduce the time required for a detectable impact. The reduction technique would need to be widespread to have the greatest impact.

Best options would appear to be a daughterless stocking program in combination with the use of a virus, such as Koi herpesvirus (KHV), or a daughterless stocking program when populations are at a natural low, such as after prolonged drought.

Further information:

1. Brown P, Sivakumaran KP, Stoessel D, and Giles A (2005). Population biology of carp (*Cyprinus carpio* L.) in the mid-Murray River and Barmah Forest Wetlands, Australia. *Marine and Freshwater Research* 56:1151–1164.
2. Fisher N and Cribb J (2005). Monitoring Community Attitudes to Using Gene Technology Methods (Daughterless Carp) for Managing Common Carp. Pest Animal Control CRC, Canberra.
3. Thresher R (2008). Autocidal technology for the control of invasive fish. *Fisheries* 33:114–121.
4. *Koi herpesvirus as a biological control for carp*. PestSmart Toolkit factsheet Invasive Animals CRC, Canberra.