Introduction
Two species of tilapia, Mozambique tilapia (*Oreochromis mossambicus*) and the black mangrove cichlid or spotted tilapia (*Tilapia mariae*), are becoming significant pests in many waterways in tropical and sub-tropical Australia. Numbers of both species have increased and they have spread significantly since their introduction during the 1970s and 1980s due to natural and human-assisted (whether deliberate or unintentional) dispersal.

There are a range of control measures currently available for use on tilapia and other pest fish but most are situation specific. For example, screens and filters can be used to prevent movements of pest fish, and poisons may be effective in eradicating small, newly established populations. In the majority of situations, unless the entire population and any possible source of reintroduction are removed, the highly flexible reproductive capacity of tilapia will, in the absence of effective ongoing management, see the population quickly return to original numbers.

There is currently no single overall option for the control of tilapia. The main focus of tilapia management is restricting the range of both species by attempting to minimise their spread by people. Targeted education campaigns actively highlight the potential damage caused by introduced tilapia to the natural environment and educate the public on what the fish look like and what to do if one is found. Community involvement in protecting and conserving local waterways is the most effective control method in stopping the further spread of both tilapia species in Australia.

Current management tools
To minimise the environmental, social and economic impacts of introduced tilapia in Australia, management principles include early detection of new populations, minimising the ability of the species to establish in and/or spread to new environments, protecting native biodiversity, conserving natural resources and associated recreational and commercial fisheries, and implementing a united, practical and effective management strategy.

Management tools available for the control and/or attempted eradication of tilapia in Australian waterbodies include the following:

**Containment/exclusion**
Exclusion screens have been used successfully in Queensland to prevent the movement of tilapia through water supply infrastructure from affected to non-affected areas. Screens are placed at strategic points on waterways, in irrigation channels and in pipelines and are designed to stop the movements of pest fish, and in some cases, their eggs and larvae. Screen types vary in cost, and designs range from electric barriers through to rotating drum filters and fine mesh, self-cleaning barriers. They are generally very expensive and are only suitable in some situations. A number of fish exclusion screens are currently being used in Australia.

**Physical removal**
Netting techniques such as gill and seine netting can remove substantial numbers of fish, particularly in small enclosed waterbodies where fish are unable to escape. These techniques are relatively simple and cost-effective when compared to other techniques and can be undertaken by community management groups. However nets need to be monitored regularly for by-catch of native species.

When done regularly, electrofishing has been shown to be a relatively cost-effective way of controlling tilapia in small impoundments and dams. Electrofishing works by passing an electrical current into the water to stun fish, and enables a person to capture unwanted fish with a net. This can be done with generator powered boat-mounted units or with battery-operated backpacks. This equipment is expensive, potentially hazardous to operators and should only be used by highly trained staff.
Angling has been used to remove relatively small numbers of fish from selected watercourses (eg during fishing competitions). Traditionally these events are carried out over a short period and are not an effective means of population control and/or eradication. However bringing the community together to focus on tilapia removal from local watercourses does help to raise public awareness of the pest fish issue.

**Chemical removal**

The use of poisons for controlling or spot eradication of pest fish is the most commonly used tactical control method. However poisons are usually non-selective and will kill native species as well as the targeted pest fish. More than 30 chemicals have been used worldwide as fish poisons but the most commonly used is rotenone. Rotenone is a natural substance extracted from the root of the tropical derris plant that can also be produced synthetically. Poisoning operations need careful planning and coordination to minimise any possible unintended impacts and to maximise the chances of total eradication.

**Environmental and biological control**

The use of predators to control tilapia numbers has mainly been used in aquaculture ponds in Asia to regulate excessive production of fry. Preliminary evidence from Australia has shown that barramundi prey upon tilapia juveniles in both open river systems and impoundments in northern Queensland. A trial to assess their effectiveness as a control option for Mozambique tilapia is currently underway. Naturally occurring pathogens and parasites can also be used to control introduced fish. Research to investigate the use of koi herpes virus to control carp in Australia is currently underway. To date, no suitable pathogens have been identified for use in controlling introduced tilapia species.

Restoration of degraded aquatic habitats has been proposed as another possible control method. Tilapia are thought to have a competitive advantage over native fishes in highly degraded systems due to their adaptable biological characteristics and their ability to consume a wide variety of foods. Restoring degraded systems by revegetating banks or restoring natural flow regimes may bring back native fishes, thus acting as a natural control for tilapia populations.

**Integrated control**

The use of two or more control methods simultaneously may be a more effective means of controlling introduced tilapia. Preliminary evidence suggests that the strategic placement of gill nets in a waterbody followed by nighttime electrofishing can substantially increase the catch rate of large tilapia in a closed system. Alternatively, the release of a predator such as barramundi to control juvenile fish whilst larger fish are targeted with netting and/or electrofishing, may provide an effective strategy for targeting all age groups in the population. Other possible control options could work to exploit different behavioural aspects of the species, or combine technology to locate natural aggregations of target animals (eg using ‘Judas’ fish - a radio-tagged fish whose movements can be tracked) and breeding ‘hotspots’, which could then be targeted using traditional techniques (eg netting, electrofishing or poisons).

**Effectiveness of control methods**

Mathematical modelling provides a way of demonstrating graphically the effectiveness of some of these control measures on tilapia populations. CARPSIM, a simple age-based simulation model, was developed to simulate the effects of a range of management scenarios for introduced carp in southern Australia. This model has been adapted for use with both tilapia species. It works by starting with a set number of fish (base population) which then naturally builds in numbers before stabilising at equilibrium. Various control methods are then applied over a set period to the simulated population, with the density of fish responding accordingly. Control methods that can be simulated include fishing, poisoning, recruitment sabotage and predation (on juveniles and adults) and combinations thereof.

**Future control and eradication options**

The effectiveness of these control measures depends on a range of external factors including water quality, habitat type, and the size and flow regime of the water bodies being treated. Historically, a single control method has been used to control tilapia infestations. However modelling suggests that simultaneously applying more than one control method may be more successful. In the future, emerging techniques such as habitat restoration or genetic manipulation may offer the potential to more effectively control invasive tilapia populations.

**References**


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