FRESHWATER FISHERIES

Management trials to restore dwarf inanga show mosquitofish a threat to native fish

David Rowe

NIWA management trials for the Department of Conservation suggest that mosquitofish rather than trout may have been the main cause of the decline of dwarf inanga in several Northland lakes. Mosquitofish are likely to be a major problem for the conservation of native fish in northern New Zealand.

Department of Conservation staff involved in this research are Ray Pierce, Tom Herbert, Joe Kereopa and Keith Hawkin.

THE DWARF INANGA *(Galaxias gracilis)* is a small, native fish species present in only 13 lakes near Dargaville, Northland. Much of its life cycle is completed in the open-water, central areas of lakes (the limnetic zone). However, its adults depend on the shallow, marginal zone of lakes (the littoral zone) for feeding throughout the year and for spawning in summer.

Dwarf inanga populations have declined over the past 30 years and the species is now threatened. In accordance with a draft species recovery plan prepared for the Department of Conservation, NIWA has conducted management trials in several Northland lakes to try to identify the factors responsible for its decline.

The role of trout

As part of these trials, dwarf inanga populations in Lake Waikere and Lake Taharoa (north of Dargaville) were monitored between 1993 and 1998. The aim was to look for any effects of trout stocking.

Since 1968, both lakes have been regularly stocked with rainbow trout by the Northland Fish and Game Council. When numbers of dwarf inanga declined one year after trout stocking began, trout were blamed for their decline – particularly as there was good evidence that trout prey on inanga. However, when dwarf inanga were introduced into Lake Ototoa (South Kaipara head), which is also stocked with trout, they thrived *despite* the fact that the trout prey on them. This raised the possibility that something other than trout predation may have been affecting the dwarf inanga in lakes Taharoa and Waikere.

Another culprit?

Mosquitofish (see panel) were (illegally) introduced into lakes Waikere and Taharoa in the year after trout stocking began. These fish are known to have had an adverse effect on some native fish species in Australia and the USA. Could they have affected the dwarf inanga? A series of trials was planned to try to establish whether the decline in the dwarf inanga was caused by trout predation, mosquitofish, or some other factor.

Trout stocking was suspended in Lake Waikere after 1994 and trout already present in the lake were removed over the next few years.

If trout predation had been the main problem for dwarf inanga in Lake Waikere then, following the removal of trout, dwarf inanga abundance should have increased. However, if the removal of trout had little or no effect on dwarf inanga numbers, then the possibility that mosquitofish were affecting dwarf inanga would have to be considered.

For comparison, trout stocking continued in Lake Taharoa (our "control" lake) where no change in dwarf inanga numbers was expected.

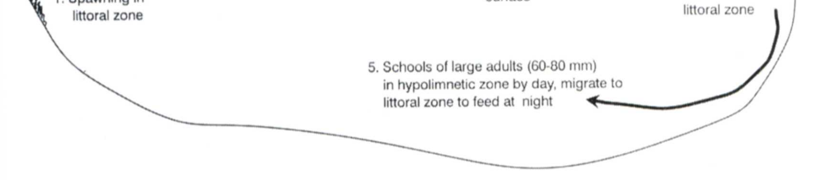
In 1994 the mean abundance of dwarf inanga in both Lake Taharoa and Lake Waikere was less than 2 fish/net/night. In other lakes where this species is common, the usual range is 10–40 fish/net/night. By 1998, the mean abundance of dwarf inanga in Lake Waikere was still no greater than 2 fish/net/night and was not significantly different from that in Lake Taharoa. Thus, the removal of trout in Lake Waikere had had no measurable affect on the abundance of the dwarf inanga. It seemed that something other than trout predation was the main factor limiting dwarf inanga in this lake.

Mosquitofish to blame?

Strong evidence that mosquitofish were responsible came to our attention in autumn 1998. Hundreds of dead and dying dwarf inanga were found floating near the lake surface around much of the shoreline of Lake Waikere. Over 88% of the 160 fish examined exhibited severe physical damage to either the tail or head region. Most fish had no tail fins and could not swim, while others were missing one or more pectoral fins, or had one or more damaged eyes (see Table below). It appeared that mosquitofish had caused the damage.

I saw mosquitofish attacking both the head and tail regions of healthy, active dwarf inanga in the shallows of Lake Waikere. When caught and placed in the shallows, a 50-mm long dwarf inanga was immediately mobbed by mosquitofish and, within a minute or two, was completely immobilised. The mosquitofish then left the dwarf inanga alone to its fate. Although dwarf inanga in the size range 30–40 mm were most vulnerable, it was apparent that 60–70 mm long fish had also been attacked by the much smaller (20–40 mm long) mosquitofish.

below:
Main features of the life history of dwarf inanga in Northland dune lakes.



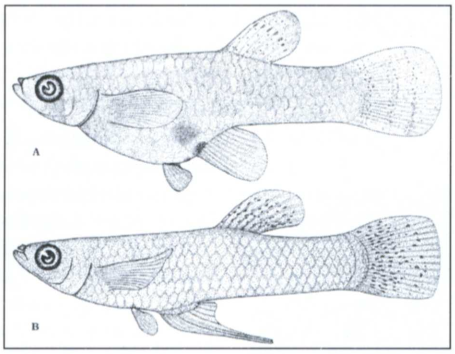
Mosquitofish facts

THE MOSQUITOFISH (*Gambusia affinis*) is a native of waters in the Gulf of Mexico drainage basins of the USA. Its reputation (some say undeserved) for eating large numbers of mosquito larvae has lead to its introduction into warm-to-temperate mosquito-infested waters throughout the world.

Mosquitofish were imported to New Zealand from Hawaii in 1931 and a population established in a pond in the Auckland Botanical Gardens. In 1933, a liberation was made into Lake Ngatu (Northland). The species seemed to be restricted to Northland waters until about 20 years ago. Since then, their range has expanded considerably to include anywhere north of Waikato and Bay of Plenty and other locations such as Hawke's Bay.

Mosquitofish are tiny, reaching maximum lengths of 60 mm and 35 mm for females and males respectively. The body is olive green on top and silvery white underneath; the fins are a translucent pale amber, with black markings on the dorsal and caudal fins. The eyes are very large and greyish to olive. The head is large with an upward-turning mouth.

The species is tolerant of demanding habitat conditions, including very low oxygen levels, high salinities and temperatures ranging from 44°C down to freezing level (though temperatures of over 15°C are required for reproduction). Their preference is for still or very slow-flowing waters and extensive weed beds seem to be favourable.



Mosquitofish (Gambusia affinis)*: A female, 28 mm long.; B male, 16 mm long.*

It is known that mosquitofish can be quite aggressive: documented behaviour includes eating fish eggs and young and attacking much larger fish than itself by nipping the fins. The extinctions or severe reductions of several species of fish in Southeast Asia and Africa have been attributed to the introduction of mosquitofish and the subsequent competition and predation.

This description, including the illustrations, is based on information from: McDowall, R.M. 1990. "New Zealand Freshwater Fishes: a natural history and guide". Heinemann Reid/MAF Publishing Group.

Table 1. Injuries found on dwarf inanga from Lake Waikere, autumn 1998

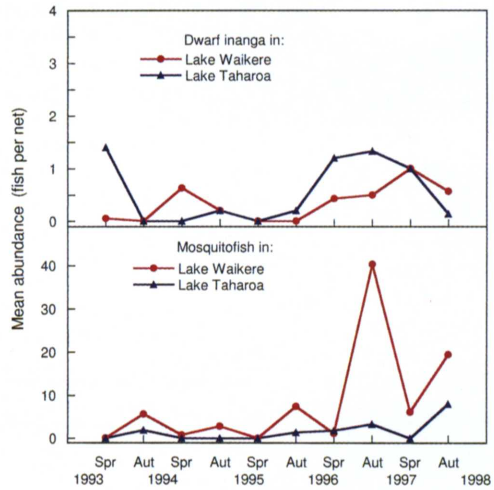
Type of injury	Percent of fish affected
Tail fin missing	52.0
One or more pectoral fin missing	40.3
One or more eye damaged	34.2
Anal or dorsal fin damaged	41.5

This kind of physical damage would prevent dwarf inanga from swimming properly, from seeing and hence from feeding. If dwarf inanga survived the mosquitofish attack, they would soon die from starvation.

If mosquitofish could cause the deaths of approximately 200 dwarf inanga over a couple of days, then, over a period of several months they could potentially wipe out thousands of adult dwarf inanga. In addition, it is possible that mosquitofish could further reduce dwarf inanga numbers by reducing their fertility (inhibiting spawning), eating eggs laid in the littoral zone, or by preying on dwarf inanga larvae. Such impacts have occurred on other small fish overseas.

Trout predation helps?

Such widespread mortality of dwarf inanga had never been observed in other lakes, including Lake Taharoa and the scale of the damage in Lake Waikere was unprecedented. So the question arises: had there been an increase in mosquitofish numbers following the removal of trout from the lake?



Mean abundance (as catch per unit effort) of dwarf inanga (top) and mosquitofish (bottom) in Lake Waikere and Lake Tahahoa.

A relatively large (>80 mm long) dwarf inanga from Lake Kanono.

Mosquitofish thrive in warm waters, and their abundance in Lake Waikere was always highest in autumn and lowest in spring. Our sampling shows that in 1997 and 1998, the autumnal abundance of mosquitofish in Lake Waikere was 100–300% higher than in previous years when trout were present (see graph). Such a big increase in mosquitofish numbers could well have increased the mortality rate of the dwarf inanga in Lake Waikere.

The graph shows that no such marked increase in mosquitofish numbers was recorded for Lake Taharoa where trout stocking had continued. This indicates that the absence of trout in Lake Waikere allowed mosquitofish numbers to increase there.

So, ironically, the annual trout stocking may actually have helped to maintain small populations of dwarf inanga in both Lake Waikere and Lake Taharoa by restricting the numbers of mosquitofish. Although trout are not known to prey extensively on mosquitofish, the scarcity of plant cover around the shorelines of both lakes means that mosquitofish would be highly vulnerable to trout. Therefore it is quite possible that the presence of trout in both lakes could have kept mosquitofish numbers in check.

Extinction in Lake Kai Iwi

Although high densities of mosquitofish occurred in Lake Waikere in 1997 and 1998, even higher densities (>50 fish/net/night) were recorded in Lake Kai Iwi in 1993. This small lake adjacent to Lake Taharoa is also stocked with trout every year, but differs from Lakes Waikere and Taharoa in the much denser beds of rushes which fringe most of the lake and provide large amounts of cover for small fish. Although this cover would protect both mosquitofish and dwarf inanga from predation by trout, high densities of mosquitofish could have provided an even greater threat to dwarf inanga than the trout.

The survey of this lake in 1993 failed to record any dwarf inanga there, but fish sampling was limited to fyke netting for adults. A more comprehensive survey was therefore carried out by the Department of Conservation in April 1998. Densities of mosquitofish were still high (over 40 fish/net/night), and no dwarf inanga were caught or seen in Lake Kai Iwi despite exhaustive fyke netting for adults, beach seining for juveniles and tow netting for larvae. Thus, the dwarf inanga is now probably extinct in Lake Kai Iwi and it is likely that the relatively high densities of mosquitofish are responsible.

Management implications

It is highly likely that mosquitofish will be a threat to other native fish. For example, common bullies were prevented from occupying waters less than 1 m deep in Lake Waikere and Lake Kai Iwi by the high densities of mosquitofish there. Bullies were absent from the shallows (up to 1 m deep) in both these lakes, but hundreds were present in Lake Taharoa, and occur in the shallows of other lakes lacking mosquitofish. Recent studies at Waikato University indicate that mosquitofish could also affect mudfish.

We are therefore concerned that recent liberations of mosquitofish for the control of mosquitos (e.g., in Tauranga and Coromandel) could place native fish species at risk. Alternative controls for mosquito larvae are needed (e.g., native fish such as inanga or banded kokopu). Research is also needed to develop appropriate controls for mosquitofish in lakes where native fish populations are endangered. This will need to include a study to establish beyond doubt the apparent controlling effect of trout on mosquitofish populations, and the consequent benefit to some native fish species (e.g., dwarf inanga), when populations of all three types of fish inhabit the same water body. ■

David Rowe is based at NIWA Hamilton.

Further reading

McDowall, R.M. and Rowe, D.K. 1996. Threatened fishes of the world: Galaxias gracilis McDowall, 1967 (Galaxiidae). Environmental Biology of Fishes 46: 280.

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NATIVE FRESHWATER FISH

Eels and cover

Don Jellyman

Gordon Glova

The amount of cover available in a stream may be critical in determining how many young eels reach maturity.

THERE IS CONSIDERABLE CONCERN overseas that recruitment (i.e., the number reaching a given size) of each of the three most economically important freshwater eel species – European, North American and Japanese eels – is diminishing. Supporting evidence is based on commercial catch databases which often go back as far as 30 years.

In the absence of similar data for the two New Zealand eel species, it is not known whether declines are also occurring in the recruitment of glass-eels (young stages) of either or both species. However, there is some concern about the status of longfinned eels and some aspects of recruitment of both species are currently being investigated (see *Water & Atmosphere* 5(3): 11).

Part of NIWA's research programme "Sustainability of Freshwater Eel Fisheries" is investigating whether there might be a density-dependent "bottleneck" into the adult fishery. We have hypothesised that recruitment into the adult eel phase may not be determined by the net number of glass-eels arriving into that catchment, but by some other vulnerable stage in the eels' life history. More specifically, the main factor could be the amount