NEW ZEALAND

MUDFISHES

A GUIDE

Nicholas Ling

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New Zealand mudfishes: a guide

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Introduction

New Zealand's mudfishes are unusual fish by any standards. When their wetland habitats dry out in summer, they burrow into the soil and remain there, motionless, breathing air, until the first decent flood of autumn refills the wetland and washes them from their refuge. Few fish species worldwide have such ability to survive for extended periods out of water. Early settlers in New Zealand were surprised to find live fish when digging vegetables from the earth. This ability to survive prolonged periods of drought allows them to colonise habitats that would be unsuitable for conventional fishes, which cannot survive out of water.

These cryptic, nocturnal fish were probably once the most abundant freshwater fish in New Zealand. However, the loss of more than 90% of our wetlands over the past two centuries has confined them to a few refuge habitats still threatened by development of adjacent land. Although mudfish are sometimes encountered by farmers when digging or clearing drains, their existence is not widely known to the general public due to their cryptic or reclusive nature. They are all quite small, averaging around 100 mm in length, and dirty brown or black in colour. This makes them hard to spot in their swampland habitats even when they are active during the day.

Mudfishes are our most specialised group of freshwater fish and a unique component of our natural heritage. Urgent and careful management of their remaining habitat is essential to ensure that they remain with us throughout the twenty-first century.

What are mudfish?

Four species of mudfishes are recognised in New Zealand, with a further species occurring in Tasmania (the Tasmanian mudfish, *Neochanna cleaveri*). Apart from the recently discovered Northland mudfish, whose distribution overlaps with that of the black mudfish, the species have quite disjunct distributions throughout the North and South Islands.

Mudfish belong to the genus *Neochanna* in the family Galaxiidae, our most numerous group of freshwater fish. Including the mudfishes, there are twenty-one galaxiid species represented in New Zealand; more than fifty percent of our native freshwater fish fauna. This ancient family of fishes originated on the prehistoric super-continent of Gondwana and is found throughout the temperate Southern Hemisphere.

Like all galaxiids, mudfish are elongate fish lacking scales, and have a thick leathery skin with a coating of mucus that protects the fish against infection, and also reduces desiccation when out of water. However, mudfish differ from other galaxiids in a number of ways. They have either very reduced or absent pelvic fins and are more eel-like in form. They also have characteristic differences in the bones of the head and in the teeth.

Some of the galaxiid species are diadromous, meaning that their life cycle involves both marine and freshwater stages. Adults migrate down rivers in the spawning season to lay eggs. The hatching young are washed out to sea and subsequently return to freshwater as whitebait. By contrast, mudfish have abandoned the sea and spend their entire life cycle in freshwater.

Mudfish habitats and ecology

Mudfish generally occupy habitats that dry out over summer months, forcing the fish to aestivate during this period (see page 7). This relieves competition, and even predation, from other fish species since these cannot survive such prolonged periods of drought. However, the common name mudfish is somewhat incorrect in that all species actually prefer clear, non-turbid water rather than muddy habitats.

The black mudfish and its relative, the Northland mudfish, seem to have the most specialised habitat requirements of all mudfish species. They are obligate swamp dwellers, mostly confined to infertile or oligotrophic bogs on acidic peaty soils that are dominated by reeds such as *Baumea* or *Schoenus*. They prefer clear rather than turbid water, and are not generally found in eutrophic wetlands characterised by vegetation such as *Typha orientalis* (raupo or bulrush).

Figure 1 Black mudfish habitat - the Kaimaumau wetland near Kaitaia.

The close relationship between the two northern mudfish species and substrate type is illustrated in Figure 2. Mudfish have only been recorded in Northland from wetlands associated with acidic soils. Unfortunately, very little original mudfish habitat remains and what is left is rapidly disappearing. Many sites are such small remnants that their future seems very uncertain, since water levels in small wetlands can be very unstable.

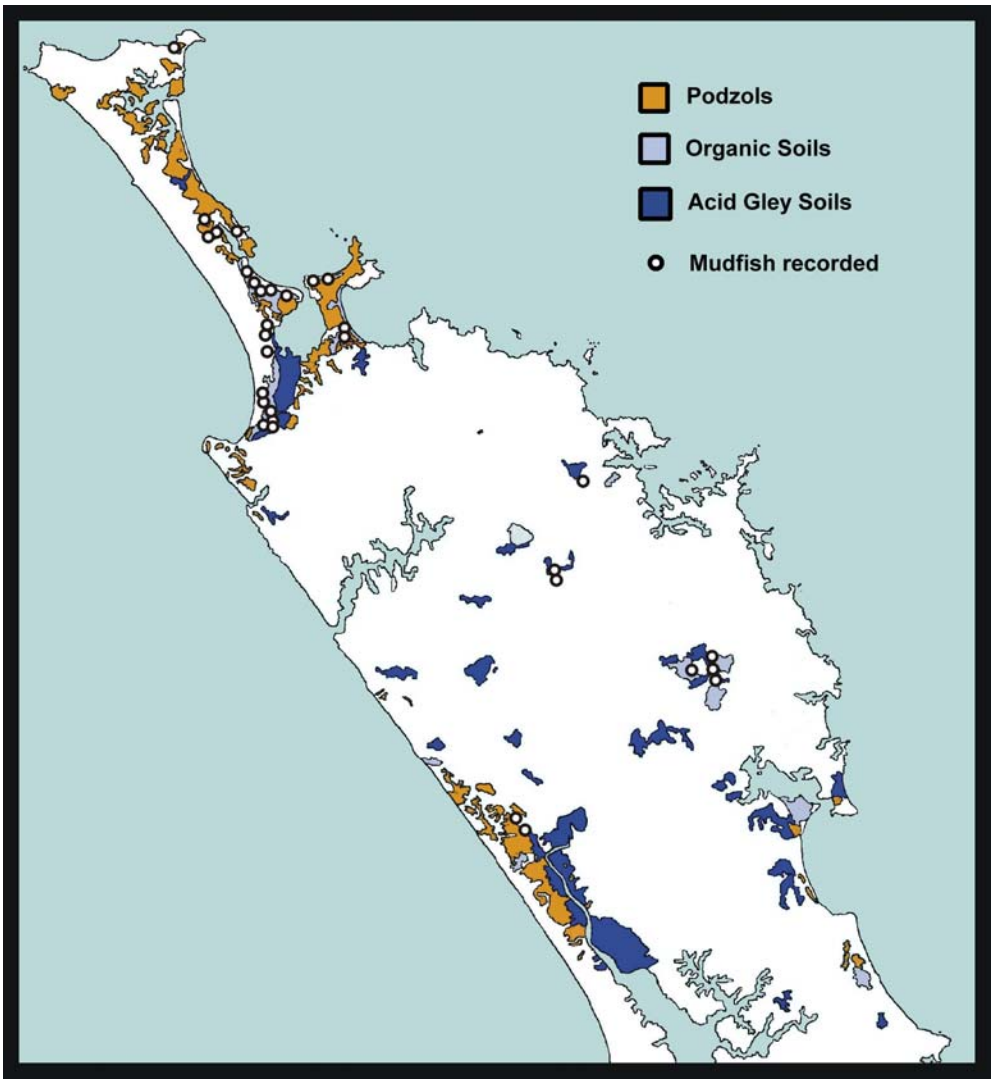


Figure 2 The recorded distribution of the two mudfish species occurring in Northland closely matches wetlands associated with acidic soils.

Unlike both the northern species, brown mudfish tolerate a wide range of habitats from the peaty pakihi bogs of the West Coast, to eutrophic raupo swamps, swampy lake margins, forest pools, and even spring-fed swampy streams.

Figure 3 Brown mudfish habitat – a sphagnum bog (pakihi) in podocarp forest on the West Coast of the South Island.

Brown mudfish, like the other species, become sexually mature during the summer aestivation so that spawning can occur as soon as enough water is available. This gives the offspring the greatest possible time to grow before they, in turn, are forced to undergo their first aestivation the following summer. Because the metabolic rate of animals is inversely related to their size, the bigger a fish is, the longer it is likely to survive these extended periods without feeding.

Canterbury mudfish are seriously threatened by habitat destruction. Although extensive areas of true wetland may once have existed on the Canterbury Plains, these have all but disappeared due to land development and agriculture. Canterbury mudfish are now mostly found in overgrown ephemeral streams, often fed by seasonal springs. These are often gravel-bedded; fish burrow into banks or under vegetation to aestivate.

Figure 4 Canterbury mudfish habitat – a seasonal, spring-fed, gravel-bedded stream on the Canterbury Plains.

All species including the Canterbury mudfish are generalised opportunistic carnivores that will eat almost anything of appropriate size. The tiny newly hatched fry, only 5 to 7 mm long, are active by day, feeding in mid-water on any small aquatic zooplankton. After two months, when they have reached a length of about 35 mm, they become nocturnal like the adults and feed mostly on small crustaceans, earthworms, the larvae of aquatic insects, and forage for trapped insects at the water surface.

Aestivation – a fish out of water

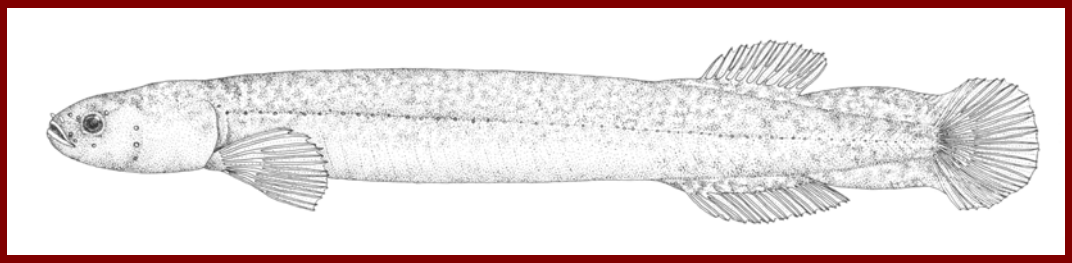
Many galaxiids, including some of our more common species such as the banded kokopu, can survive out of water for short periods, perhaps several days. However, mudfish regularly survive periods of emersion lasting for several months each summer. This process is called aestivation and is the summer equivalent of hibernation. Their survival depends on finding a suitable refuge that provides adequate access to air yet also remains damp to prevent dehydration. Suitable locations include burrows in damp mud, or under dense clumps of vegetation, logs or other litter.

Studies on the black mudfish show that they reduce their metabolic rate by around 60% and remain mostly inactive throughout the period of aestivation. The lungfishes of Africa and South America also undergo aestivation by burrowing into damp mud and can remain in a state of truly suspended animation, or torpor, for a year or more. However, mudfish do not undergo torpor and remain alert throughout the aestivating period. If an aestivating mudfish is returned to water, it will become active immediately.

Figure 5 Black mudfish aestivating in damp mud in a Waikato farm drain.

Black mudfish - *Neochanna diversus*

Figure 6 black mudfish



Black mudfish were discovered in the 1940s and are found in peat swamps throughout the northern half of the North Island. Their distribution has undoubtedly suffered greatly from the destruction of appropriate habitat as wetlands have been drained for pastoral agriculture. In the Waikato Region, at least 75% of wetlands have now been drained and the species is mostly confined to large protected areas such as the Wangamarino wetland and the Kopouatai Peat Dome. Remnant populations still exist in farm drains and small swampy streams but the long-term survival of these seems doubtful.

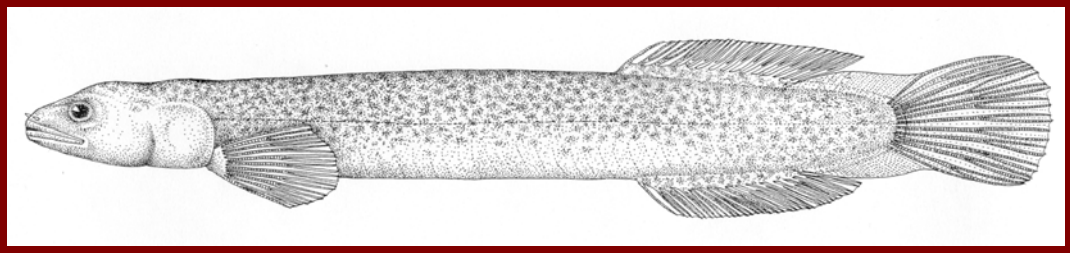
As with other mudfish species, preferring habitats that dry out over summer effectively eliminates competition with other fishes that cannot survive such conditions.

Black mudfish reach a maximum size of around 160 mm total length and probably live for up to ten years.

Northland mudfish – *Neochanna heleios*

Barry O'Brien

Figure 7 Northland mudfish



The Northland mudfish was discovered in 1998 and is one of our rarest native freshwater fishes. Its distribution overlaps with that of the black mudfish and is restricted to just a few small wetland sites on the Kerikeri volcanic plateau. Its habitat requirements are the same as those of the black mudfish, preferring clean-water wetlands on acid soils. All known habitats of the Northland mudfish are quite restricted in area and threatened by development of adjacent land. At the most extensive site at Kerikeri, fish survive in holes left by the gum-digging activities of the early 20th century.

Urgent conservation management of this species' remaining habitat is required to maintain appropriate water levels at each site, and restrict nutrient inputs that may cause these wetlands to gradually become more eutrophic.

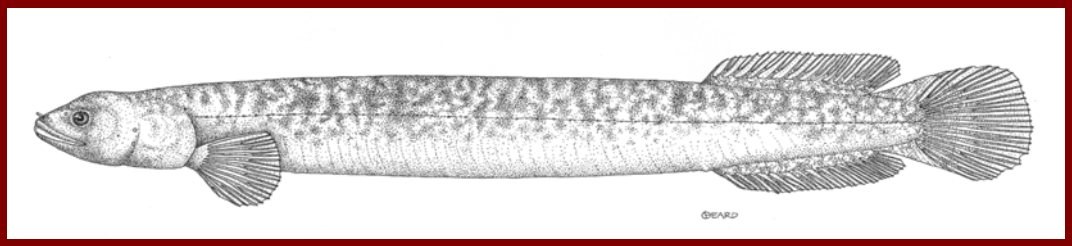
Almost nothing is known of the biology of this species.

Northland mudfish reach a maximum size of at least 135 mm total length and probably live for about eight years.

Brown mudfish – *Neochanna apoda*

Barry O'Brien

Figure 8 brown mudfish



The brown mudfish was the first mudfish to be discovered in New Zealand and was formally described in the 1860s. It is found in both the North and South Islands in a surprisingly wide range of habitats compared to the other mudfish species. Suitable habitats range from Pakihi peat swamps of the West Coast to forest pools, swampy lake margins, and even spring-fed streams. The brown mudfish is the most eel-like of the four species, with the dorsal and anal fins being almost confluent with the caudal fin.

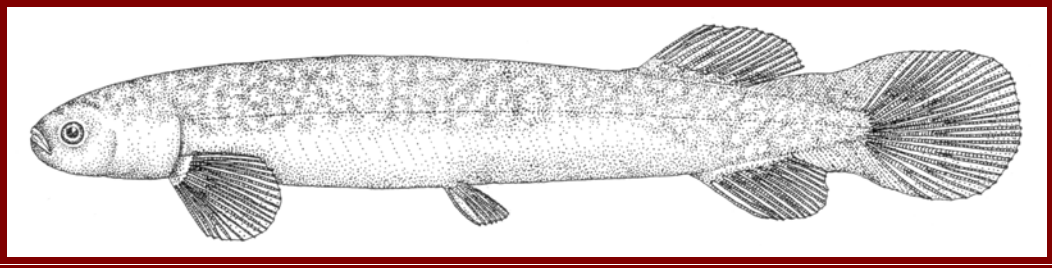
The brown mudfish is the largest mudfish species in New Zealand reaching a maximum length of up to 175 mm. Fry spawned in autumn or early winter grow rapidly to about 70 mm by their first aestivation the following summer. Although locally abundant at some sites, it is now quite rare in some parts of its former range.

The brown mudfish is well known for its ability to aestivate. It is often encountered at considerable depths when digging farm drains in swampy ground.

Canterbury mudfish – *Neochanna burrowsius*

Tony Eldon

Figure 9 Canterbury mudfish



The Canterbury mudfish was formally described in the 1920s but has only recently been classified as a true mudfish species. Its distribution is restricted to northern and central Canterbury and, like the other mudfish species, is threatened by the destruction of suitable habitat. Until discovery of the Northland species, it was regarded as possibly our rarest native fish. Unlike the other species that prefer still water, the Canterbury mudfish is usually found in slow flowing, overgrown, swampy streams of the Canterbury Plains. Like the other mudfishes, they can aestivate during the regular summer droughts that afflict the region. The have been reported to construct small flask shaped burrows to retain water over these dry periods. Although they can tolerate low oxygen concentrations in water, like other mudfish species they do so by gulping air at the surface, which they hold against their gills to extract oxygen.

Canterbury mudfish grow to around 165 mm and probably live for five to six years. This species is easily distinguished from the other New Zealand species by having small pelvic fins.

Studying mudfishes

First, catch your mudfish! The scientific study of mudfish species has been greatly impeded both by misconceptions as to their rarity, and by perceived difficulties in capturing these shy nocturnal fishes. Their habitats restrict the use of normal fishing equipment such as set nets or electric fishing machines. However, in recent years, the use of fine-mesh Gee minnow traps has proved to be extremely successful. These traps are double-ended wire baskets that clip together as shown below.

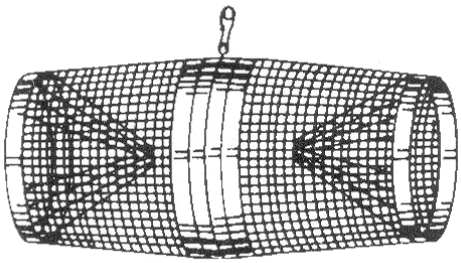


Figure 10 Gee minnow trap

Figure 11 Minnow traps set in a wetland

The traps should be set with the openings of the entry cones just below the water surface; the rationale is that, when the fish are feeding at the water surface at night, they are directed into the trap. Setting the trap at this level also provides an air space to allow the trapped fish to gulp air at the surface. If an air space is not provided, the fish will drown if the water oxygen concentration is too low, as is often the case in swampy environments. Traps do not need to be baited. While some researchers swear by the use of vegemite or bread as bait, unbaited traps catch just as many fish.

Other traps can be used to catch mudfish but they should have a small entrance hole to prevent escape and be set in the same manner.

Keeping mudfishes

Permission to keep mudfish in captivity should be obtained from the local Department of Conservation office. A permit is required to transport any native fish from one area to another and to keep native fish in captivity. Many mudfish habitats are on land administered by the Department and a permit is also required to catch fish and, in some cases, even to allow access to these sites.

Aquaria

Mudfish are relatively undemanding as aquarium subjects but also unspectacular since they will spend most of the daylight hours hiding. They prefer a low pH, soft water, and of course plenty of places to hide. Suitable hiding places can be provided with waterlogged driftwood or rocks, or even cut lengths of opaque plastic pipe. Care should be taken in the choice of a substrate. Aquarium gravel is suitable so long as it is not of a type that will cause the water to become alkaline. Other suitable substrates are peat or dried sphagnum moss. These will help keep the water slightly acidic and the fish will burrow into them.

Mudfish do not require a period of aestivation each year and will happily live in almost any permanent water body so long as they do not have to compete with, or face predation by, other fish species. Some captive populations have been maintained under such conditions for at least fifteen years.

Feeding

Mudfish will readily accept dead food such as frozen bloodworms. These are available from most aquarium suppliers. More aquarium fish die from overfeeding than from any other single cause. Mudfish should only be fed

every three or four days, and then only as much as they will readily eat in about 15 minutes. Any uneaten food should be siphoned from the aquarium. Some substrates such as sphagnum make this difficult and therefore care should be taken not to overfeed in the first place.

Temperature

Mudfish cannot tolerate high temperatures, which can present problems keeping them over the summer months. The fish will suffer if the water temperature exceeds about 22°C. The aquarium should be situated out of direct sunlight where it can remain as cool as possible.

Water

Tapwater is suitable for use but only if it is completely chlorine-free. This can be achieved by using commercial chlorine removers that contain sodium thiosulphate, or by aerating the water for at least 24 hours to drive off the chlorine. The pH of the water can be adjusted to be slightly acidic using commercially available aquarium products designed for acid-loving fishes such as discus.

Transporting mudfish

Mudfish can be transported in water or in air. In either case, the primary consideration is to avoid overheating. This can be achieved by keeping transport containers in a cooler. Fish transported in water should have minimal water and plenty of airspace or aeration. Fish transported in air can be wrapped loosely in wet sphagnum moss. In experimental studies of aestivation, mudfish have been kept successfully for several weeks wrapped in wet sphagnum.

Mudfish identification

Most mudfish species are easily identified simply by their allopatric (non-overlapping) distributions. For instance, any mudfish caught on the West Coast or in the Wairarapa would undoubtedly be a brown mudfish. However, the distributions of the Northland and black mudfishes are sympatric (overlapping). The following key gives combinations of characters that will unequivocally identify individual species. Most characters can be identified easily using a hand-held magnifying lens.

Key to species

1 Pelvic (ventral) fins present ……. **2**
Pelvic (ventral) fins absent ……. **3**

2 Pelvic fins with 6 or 7 rays; pelvic fins long, more than 1/3 distance from pelvic fin base to origin of anal fin …….. ……. species of the genus *Galaxias*

Pelvic fins with 4 or 5 rays; pelvic fins short, less than 1/3 distance from Pelvic fin base to origin of anal fin ……. ……. *Neochanna burrowsius* **Canterbury mudfish**

3 Mouth short, extending only as far as the anterior edge of the eye; eye diameter greater than 15% of head length; dorsal fin with 10 to 14 rays; anal fin with 12 to 17 rays; head not bulbous behind eyes ……. ……. *Neochanna diversus* **black mudfish**

Mouth long, extending to the middle or posterior edge of the eye; eye diameter less than 15% of head length; head bulbous behind eyes ……. **4**

4 Caudal fin with less than13 principal fin rays; caudal peduncle depth equal to or less than length; dorsal fin with 12 to 16 rays ……. ……. *Neochanna heleios* **Northland mudfish**

Caudal fin with more than 14 principal fin rays; caudal peduncle depth 1.5 to 2 times length; dorsal fin with 16 to 19 rays ……. ……. *Neochanna apoda* **brown mudfish**

Mudfish conservation

All of our mudfish species face an uncertain future, although none of them can be considered endangered in the same way as kakapo or the giant panda. These latter species are endangered because there are only very few individuals left. But even our rarest mudfish, the Northland mudfish, can be very abundant at the few sites where it is found.

Figure 12 Mudfish can be locally abundant – a single night's catch of Northland mudfish from 15 minnow traps.

By far the greatest threat facing all New Zealand's mudfish species is the continuing destruction of appropriate habitat. Many people regard swamps as either wasteland or potentially valuable pasture. Many remaining habitats are such fragmented or tiny remnants of once larger wetland areas that their future is very uncertain.

One of the most important environmental factors affecting mudfish is the availability of water. The rapid fluctuations in water level that occur in small swamps are prevented in larger wetlands, which act like giant sponges, smoothing out these hydrodynamic oscillations into a more predictable seasonal pattern.

Where wetlands are surrounded by pasture, they often receive run-off loaded with sediment and nutrients causing increases in turbidity and a state of gradual eutrophication. Management of remaining mudfish habitats should aim to reduce such impacts on wetlands and try to retain large wetland reserves. Larger habitats also help to maintain greater genetic diversity in fish populations, whereas small or fragmented habitats act as genetic bottlenecks. Without sufficient genetic diversity, animals do not have the range of genetic variation required to adapt to changing environments.

In some areas such as the Waikato, where wetlands have been drained for pasture, quite significant mudfish populations still exist in drains. Although less than ideal, mudfish seem to cope well in such habitats so long as they are left relatively undisturbed. Fish require plenty of emergent vegetation to provide food and shelter. Regular clearing of drains degrades this habitat for fish and eventually leads to their elimination.

Figure 13 Good mudfish habitat – an unmanaged drain

Bad mudfish habitat – a “managed” drain

Another threat to mudfish, especially in the North Island, is predation by the introduced mosquitofish, *Gambusia affinis*. Mosquitofish are small, aggressive fish, native to south-eastern parts of the United States, and were introduced to many countries during the early part of the twentieth century in the mistaken belief that they were effective in controlling mosquitoes. They have been implicated in the decline or extinction of native species of aquatic invertebrates, fishes and amphibians, in many of the countries where they were introduced.

Mosquitofish were introduced to New Zealand in the1930s. From their original site of release at the Auckland Botanical Gardens, they have been spread throughout most of the North Island and were recently discovered near Nelson in the South Island. Mosquitofish eat mudfish fry and will also attack adults, although the nocturnal habits of the latter will help to protect them from attack by the day-active mosquitofish. Mosquitofish can tolerate a wide range of temperatures and salinities, and thrive in swampy shallow lake margins and drains. Although they cannot survive in mudfish habitats that completely dry out over summer, they can re-invade wetlands from adjacent permanent water bodies during winter when mudfish fry are present.

Mosquitofish are now classified as unwanted organisms in New Zealand, meaning that it is illegal to release, spread, breed or sell them.

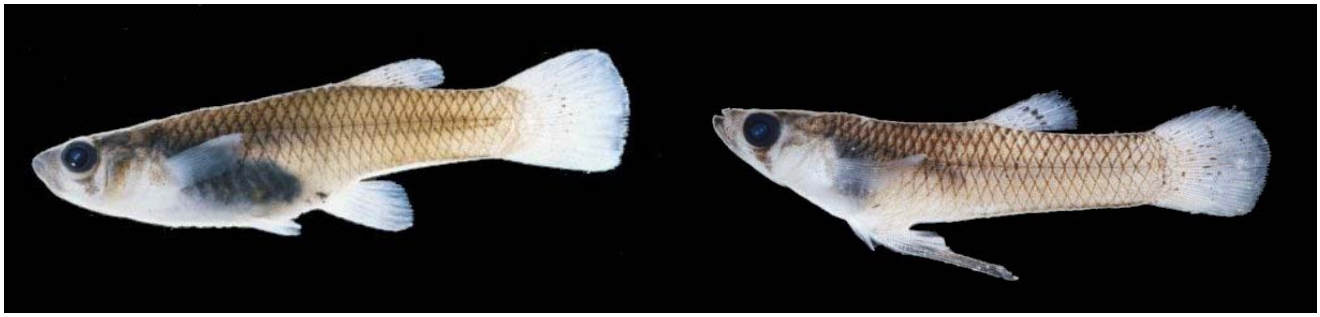


Figure 14 Mosquitofish, *Gambusia affinis* – 50 mm adult female (left) and 30 mm adult male (right)

Glossary

aestivation	a period of torpor or inactivity during a dry or summer season – summer equivalent of hibernation
anal fin	a central unpaired ventral fin posterior to the anus but before the tail
caudal fin	the tail fin
caudal peduncle	the slender posterior end of the body supporting the caudal fin – bordered by fleshy edges in most galaxiids
dorsal fin	any central unpaired fin on the back
eutrophic	aquatic habitats that are nutrient enriched
gley soils	soils saturated with water for prolonged periods and with pale greyish subsoils.
oligotrophic	aquatic habitats that are nutrient poor
organic soils	soils formed from the partly decomposed remains of wetland peat or thick forest litter
pectoral fins	paired fins occurring either side of the fish immediately behind the gills
pelvic fins	paired fins occurring on the belly of the fish between the gills and anus
podzols	strongly acid soils with a hard accumulated substratum of iron, aluminium and silicon rich materials leached from surface layers
principal fin ray count	the number of all branched and segmented fin rays in the caudal fin plus the two longest unbranched rays being the ray immediately above and below the branched rays

Further Reading

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Dr Nick Ling is a senior lecturer in the Department of Biological Sciences at the University of Waikato, and teaches in the areas of animal physiology and comparative zoology. He has been interested in fish since an early age and has spent nearly twenty years researching aspects of their physiology and ecology. Mudfish are perhaps our least well-known and most cryptic freshwater fishes. Nick has spent the past eight years studying the black mudfish in swamps of the northern North Island, and was involved in the discovery of the Northland mudfish in 1998.