

Occurrence of Exotic Tropical Fish in the Cooling Pondage of a Power Station in Temperate South-eastern Australia

P. L. Cadwallader,^A G. N. Backhouse^A and R. Fallu^B

^A Fisheries and Wildlife Division, Ministry for Conservation, Snobs Creek Freshwater Fisheries Research Station and Hatchery, Private Bag 20, Alexandra, Vic. 3714.

^B Fisheries and Wildlife Division, Ministry for Conservation, 250 Victoria Parade, East Melbourne, Vic. 3002.

Abstract

Three species of exotic tropical fish, the black mangrove or Niger cichlid, *Tilapia mariae* Boulenger, of West Africa; the convict cichlid, *Cichlasoma nigrofasciatum* (Günther), of Central America; and the Jack Dempsey cichlid, *Cichlasoma octofasciatum* (Regan), of Central and South America, have been recorded from the cooling pondage of a power station in temperate south-eastern Australia. All three species are readily available in the local aquarium fish trade. Black mangrove cichlids and convict cichlids appear to have established self-maintaining populations in the pondage, and also occur in a creek below the pondage.

Introduction

During 1978, specimens of the black mangrove or Niger cichlid, *Tilapia mariae* Boulenger, and the convict cichlid, *Cichlasoma nigrofasciatum* (Günther), were taken in eel nets in the cooling pondage of the Hazelwood power station near Morwell, Victoria. Surveys of the cooling pondage and associated waters were subsequently undertaken in 1979 and in this paper we report the results of these surveys and discuss the significance of the occurrence of feral populations of exotic tropical fish in temperate Victoria. The problems associated with the introduction of tropical fish into Australia have recently been reviewed by McKay (1977).

Study Area

The Hazelwood cooling pondage (38°18'S., 146°23'E.; Fig. 1) was formed in 1962 by damming Eel Hole Creek, an intermittent tributary of the Morwell River, and has a surface area of 480 ha and a maximum depth of about 17 m. Heated water released from the power station raises water temperatures in the pondage to above the ambient temperature throughout the year, from 14 to 27°C in winter, and from 21 to 35°C in summer (data of State Electricity Commission of Victoria, S.E.C.V.). Other physicochemical parameters of pondage water are monitored regularly by the S.E.C.V. and the following mean values are based on four samples taken at the pondage spillway between February 1978 and March 1979: pH 8.5 (range 8.4-8.6), dissolved oxygen 8.0 mg/l (7.0-9.2), total dissolved solids 698 mg/l (625-740), suspended solids 17.5 mg/l (10-35), turbidity 13 Jackson turbidity units (7-21), colour 34 Pt-Co units (25-55), biological oxygen demand 1.3 mg/l (0.6-2.7), chemical oxygen demand 19 mg/l (13-27), total nitrogen 0.62 mg/l (0.39-1.18), total phosphate 0.17 mg/l (0.07-0.22), sulfate 193 mg/l (172-213), chloride 157 mg/l (130-177), silica 17.8 mg/l (14.1-20.0), and oil and grease 1.2 mg/l (0.4-2.1).

Above the pondage, the water in Eel Hole Creek is at ambient temperature, but below the pondage Eel Hole Creek receives warm water from the pondage overflow spillway and, consequently, its water temperatures are higher than the ambient temperature throughout the year. Despite the influx of warm water from Eel Hole Creek, the Morwell River has only slightly elevated water temperatures (Fig. 1).

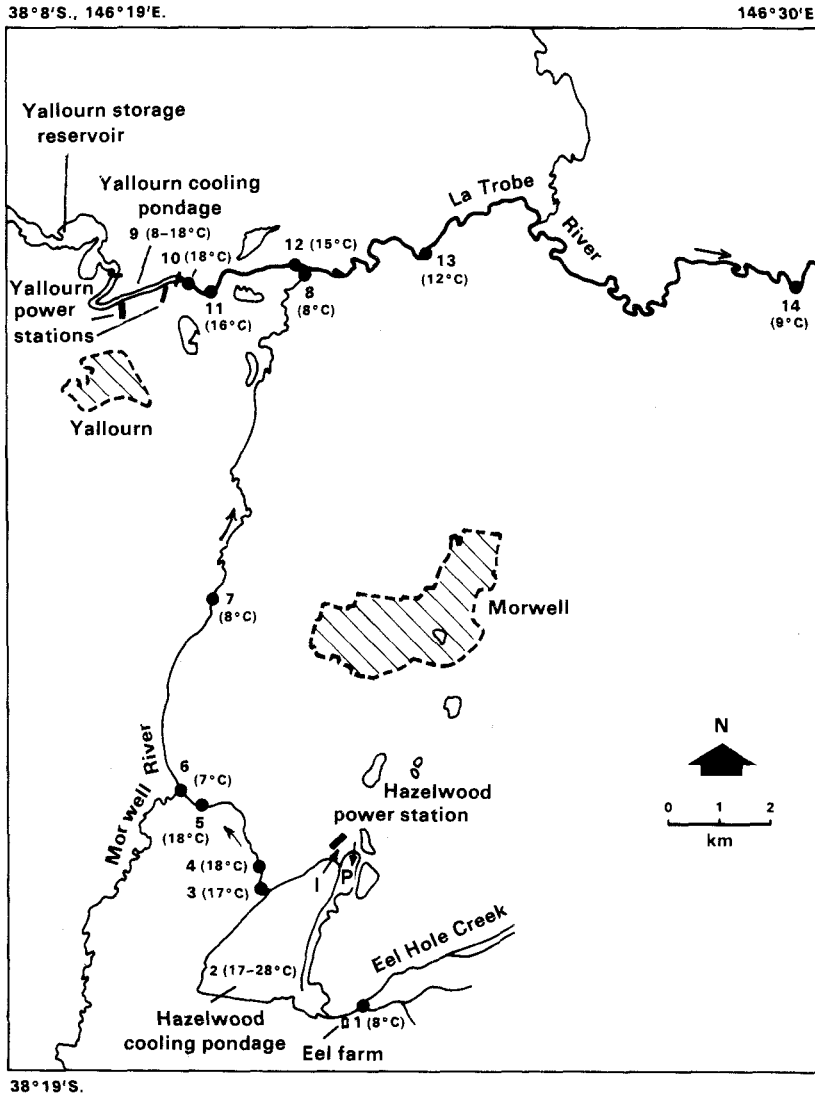


Fig. 1. Hazelwood cooling pondage and associated waters. 1-14, Fish survey stations, with water temperature (as recorded in the July and August 1979 surveys) in parentheses; I, inlet to Hazelwood power station; P, outlet from power station.

The Yallourn cooling pondage is situated immediately below the Yallourn storage reservoir and was formed by construction of a weir across the La Trobe River. It supplies cooling water for, and receives heated effluent from, the Yallourn power stations. Water temperatures in the pondage vary considerably and, for some distance down-stream of the pondage, the La Trobe River has water temperatures higher than the ambient temperature (Anon. 1978; Fig. 1).

Methods

Preliminary surveys were made on 5 April and 9–10 June 1979 when fish were collected in the Hazelwood cooling pondage and Eel Hole Creek. A seine net (100 m long; 2 m deep; mesh size 40 mm in wings, 25 mm in bunt) was used to collect fish in the pondage, and dip nets (mesh size 0.5 mm) were used along the margins of the pondage and in Eel Hole Creek. In more extensive surveys conducted during the periods 9–13 July and 30 July–2 August 1979, fish were collected in the Hazelwood cooling pondage, Eel Hole Creek, Morwell River, Yallourn cooling pondage and La Trobe River with gill nets (mesh sizes 50–125 mm), baited trap nets (mesh size 13 mm; liver and bread baits), dip nets (mesh size 2 mm), a seine net (30 m long; 2.4 m deep; mesh size 20 mm) and a 240 V pulsed d.c. electrofishing unit.

Most captured tropical fish were anaesthetized in quinaldine and preserved in 10% formalin. Total length (TL, length from tip of snout to tip of caudal fin) was measured to the nearest millimetre on a measuring board.

Water temperature at each survey station was recorded to 0.1 °C with a Digitron thermometer (model 1751-K).

Results

Fish species recorded during the surveys of the Hazelwood cooling pondage and associated waters are listed in Table 1. Black mangrove cichlids were widespread and abundant in Hazelwood pondage and in Eel Hole Creek below the pondage. They were taken in both still and flowing waters, in rocky and debris-strewn areas, beneath overhanging banks and in shallow mud-bottomed bays where there was little or no cover. Convict cichlids also were found in Hazelwood pondage and in Eel Hole Creek below the pondage, but they were far less common than black mangrove cichlids. They appeared to be restricted to areas where cover was provided by rocks, debris and overhanging vegetation. The presence of the Jack Dempsey cichlid in the Hazelwood cooling pondage was indicated by the capture of one specimen in an eel net in March 1979. This specimen (~ 70 mm TL) was kept alive in an aquarium at the local eel farm and was inspected by the authors in July 1979. No tropical fish were found in the Morwell River, the Yallourn cooling pondage or the La Trobe River.

The TL range of the black mangrove cichlids taken in April was 22–211 mm ($n = 288$) and of those taken in early July 19–205 mm ($n = 918$). The TL range of six convict cichlids taken and preserved in early July was 28–78 mm; several other convict cichlids of about 70 mm TL were kept alive.

Discussion

Cichlid fishes are native to the warm temperate and tropical waters of Africa, Asia (southern India and Sri-Lanka) and America (from Texas in the north, through Central America, to Uruguay in the south) (Legge 1970). Members of the African genus *Tilapia* are cultured as food fishes in many African and Asian countries. Their rapid growth rate and maturation time, high fecundity, simple food requirements (most species are predominantly herbivorous) and wide tolerance range to environmental variables, such as temperature, salinity and pollution levels (Goldstein 1971), render them suitable for aquaculture as a protein source. These characteristics enable *Tilapia* spp. to rapidly populate waters providing suitable habitat, often to the detriment of native species, as reported by McKay (1977). The black mangrove cichlid is native to West Africa, from the Ivory Coast to the Cameroons (Whitehead 1962). Fish of this species reach a maximum TL of about 300 mm and spawn when they are about 150 mm long. Up to 1800 eggs are laid, usually on submerged logs, rocks or plants. The eggs hatch after about 3 days and the newly hatched fry are guarded by the parents (Whitehead 1962; Axelrod and Burgess 1973). Black mangrove cichlids have

Table 1. Fish species recorded in the Hazelwood cooling pondage and associated waters
 Numbers in parentheses are survey station numbers (see Fig. 1). *N*, native species; *E*, exotic species; *P*, fish recorded during the survey; *A*, fish taken by angler; *F*, fish taken by eel farmer. Fish capture methods: *d*, dip net; *e*, electrofishing; *f*, fyke net; *g*, gill net; *r*, rod and line; *s*, seine net; *t*, baited trap net; — not recorded

Species	Eel Hole Creek above Hazelwood pondage (1)	Hazelwood cooling pondage (2)	Eel Hole Creek below Hazelwood pondage (3-5)	Morwell River (6-8)	Yallourn cooling pondage (9)	La Trobe River (10-14)	Collecting method(s)
<i>Anguilla australis</i> Richardson (N) (Short-finned eel)	—	P	P	—	P	P	e, s, t
<i>Retropinna semoni</i> (Weber) (N) (Australian smelt)	—	—	P	—	—	P	d, c
<i>Pseudaphritis urvilli</i> (Cuvier & Valenciennes) (N) (Tupong)	—	—	—	P	P	P	e, g
<i>Gadopsis marmoratus</i> Richardson (N) (River blackfish)	—	A	—	P	—	P	e, r
<i>Phlyppodon grandiceps</i> (Kreffl) (N) (Big-headed gudgeon)	—	—	—	P	—	—	e
<i>Nannoperca australis</i> Gunther (N) (Southern pigmy perch)	P	—	—	P	P	P	d, e
<i>Carassius auratus</i> (Linnaeus) (E) (Goldfish)	P	P	P	—	—	—	d, e, g, s, t
<i>Cyprinus carpio</i> Linnaeus (E) (European carp)	—	P	P	P	P	P	d, e, g, s, t
<i>Salmo trutta</i> Linnaeus (E) (Brown trout)	—	—	—	—	P	—	g
<i>Gambusia affinis</i> (Baird & Girard) (E) (Mosquito fish)	—	—	—	P	P	—	e
<i>Tilapia mariae</i> Boulenger (E) (Black mangrove cichlid)	—	P	P	—	—	—	d, e, g, s, t
<i>Cichlasoma nigrofasciatum</i> (Gunther) (E) (Convict cichlid)	—	P	P	—	—	—	d, e, s
<i>Cichlasoma octofasciatum</i> (Regan) (E) (Jack Dempsey cichlid)	—	F	—	—	—	—	f

been recorded feeding on algae and diatoms (Fagade 1971). The convict cichlid, a native of the Central American countries of Guatemala, El Salvador, Costa Rica and Panama, is a small species, reaching a length of about 150 mm and becoming sexually mature at 80 mm (Sterba 1962). It lays up to 400 eggs which hatch after 3–4 days. Both parents are extremely territorial and aggressive (Axelrod and Shaw 1967). The pugnacious Jack Dempsey cichlid, a native of Costa Rica, the Rio Negro and the Amazon basin (Central and South America), grows to about 200 mm in length and is sexually mature at 75 mm (Legge 1970).

Black mangrove cichlids and convict cichlids appear to have established self-maintaining populations in the Hazelwood cooling pondage, but to date there is no evidence to suggest that a self-maintaining population of Jack Dempsey cichlids has become established. Several other tropical fish common in the aquarium hobby in Victoria have apparently been released into Hazelwood pondage, including some barbs (Cyprinidae), live-bearing tooth carps (Poeciliidae) and characins (Characidae), but to date no specimens of these fish have been seen in, or recovered from, the pondage. In addition, about 56 000 rainbow trout, *Salmo gairdneri* Richardson, were released into the pondage soon after it was completed in 1962 and a further 5000 were released in 1968 (Fisheries and Wildlife Division records). Tunbridge and Rogan (1976) also reported the presence of European perch, *Perca fluviatilis* Linnaeus, in the Hazelwood pondage, but no rainbow trout or European perch were taken during the present study.

The presence of populations of black mangrove cichlids and convict cichlids in Eel Hole Creek down-stream of the Hazelwood cooling pondage provides cause for concern. Most of the lower reaches of Eel Hole Creek are channelled, so the absence of cichlids from these areas may be due to the lack of suitable habitat. Water temperature is substantially reduced at the junction of Eel Hole Creek and the Morwell River, but the temperature of the La Trobe River at its junction with the Morwell River is increased by the effluent from the Yallourn power stations (Fig. 1). The water temperature of the La Trobe River is above the ambient temperature for about 15 km down-stream of the Yallourn cooling pondage, so that if the cichlids can survive the normal water temperatures in the Morwell River, particularly in summer, it is possible that they may become established in sections of the La Trobe River. However, no tropical fish were recorded in the La Trobe River during the present study. Although conditions in the Hazelwood cooling pondage appear to be suitable for the survival of self-maintaining populations of the black mangrove cichlid and the convict cichlid, it is unlikely that these two species will be able to withstand the much cooler temperature regimes of most Victorian waters.

Acknowledgments

We thank Mr W. Gardin for bringing the cichlids in Hazelwood pondage to our attention; the staff of the S.E.C.V., particularly Messrs R. Greenwood, J. Flatley and A. Oxley, for providing background data and for their cooperation throughout the project; Messrs R. K. Donald and J. Power (both of the Fisheries and Wildlife Division), J. Campbell, S. D. McCallum and Dr B. C. Chessman (all of the Latrobe Valley Water and Sewerage Board) for assistance in the field; Dr M. Gomon (National Museum of Victoria) for checking the identity of *T. mariae* and *C. nigrofasciatum*; and Mr R. J. McKay (Queensland Museum) and Drs D. D. Evans (Fisheries and Wildlife Division) and B. C. Chessman for their comments on the manuscript.

References

- Anon. (1978). 'Annual Report 1977-78.' Appendix C. (Latrobe Valley Water and Sewerage Board: Traralgon.)
- Axelrod, H. R., and Burgess, L. (1973). 'Breeding Aquarium Fishes: Book 3.' (T.F.H. Pubs: New Jersey.)
- Axelrod, H. R., and Shaw, S. R. (1967). 'Breeding Aquarium Fishes: Book 1.' (T.F.H. Pubs: New Jersey.)
- Fagade, S. O. (1971). The food and feeding habits of *Tilapia* species in the Lagos Lagoon. *J. Fish Biol.* **3**, 151-6.
- Goldstein, R. J. (1971). 'Introduction to the Cichlids.' (T.F.H. Pubs: New Jersey.)
- Legge, R. (1970). 'The Complete Aquarist's Guide to Freshwater Tropical Fishes.' (Eurobook: London.)
- McKay, R. J. (1977). The Australian aquarium fish industry and the possibility of the introduction of exotic fish species and diseases. Department of Primary Industry, Fisheries Division, Fisheries Paper No. 25.
- Sterba, G. (1962). 'Freshwater Fishes of the World.' (Vista: London.)
- Tunbridge, B. R., and Rogan, P. L. (1976). 'A Guide to the Inland Angling Waters of Victoria.' (Government Printer: Melbourne.)
- Whitehead, R. A. (1962). The life history and breeding habits of the West African cichlid fish *Tilapia mariae* and the status of *T. meeki*. *Proc. Zool. Soc. London* **139**, 535-43.

Manuscript received 4 December 1979, accepted 9 April 1980