THE EFFECT OF TEMPERATURE IN THE EXTENSIVE REARING OF AUSTRALIAN BASS, *MACQUARIA NOVEMACULEATA* (STEINDACHNER)

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Introduction

The Australian bass (*Macquaria novemaculeata*) is a catadromous percichthyid fish native to the coastal drainages of south-eastern Australia (MacDonald 1978). Its renowned angling and eating qualities have created a demand for the commercial production of bass fingerlings for stocking into farm dams and public impoundments. In comparison to other commercially important native freshwater fish (Rowland *et al.* 1983), only relatively small and irregular numbers of Australian bass have been produced to date.

Two major problems have limited the success of large scale breeding of Australian bass. In early research, a high proportion of larvae failed to develop functional swim bladders, resulting in slow growth and increasing mortality over the latter stages of intensive larval rearing. Similar difficulties have also been reported in the intensive culture of several species of marine fish (Spectorova and Doroshev 1976; Al-Abdul-Elah *et al.* 1983; Chatain 1987). Australian bass are physoclistous, inflating their swim bladders 6-11 days after hatch at a temperature of 19_1°C (Figure 1). Some of the factors affecting the development of swim bladders in cultured Australian bass larvae were experimentally determined by Battaglene and Talbot (1990). A high percentage (>70%) of larvae with functional swim bladders can now be produced by culturing larvae for the first ten days after hatch, in conditions of darkness, salinities above 25 ppt and low to zero aeration.

The second major constraint to the large scale breeding of Australian bass is an apparently nutritionally based metabolic disorder (Battaglene *et al.* 1989a). This disorder has been particularly troublesome, causing high mortality of intensively reared larvae at around 30 days of age. Affected larvae exhibit symptoms such as erratic swimming, fainting, constipation, failure to digest food, pale colour and copious mucous production. Possible causes of this disorder include hepatic and renal dysfunction due to nutritional deficiencies in fatty acids and/ or vitamins (Battaglene *et al.* in press).

The low survival of bass larvae in intensive systems prompted the initiation of experimental work on extensive pond culture based on the methods used to rear the closely related golden perch *Macquaria ambigua* (Rowland *et al.* 1983). In the period 1987-91 more than 30 pond stockings have been undertaken during experiments designed to appraise and improve extensive rearing techniques. Ponds at the Brackish Water Fish Culture Research Station (BWFCRS) and freshwater and saltwater ponds in the Clarence River region of NSW have been used.

The experimental stocking of freshwater ponds with 21-day-old larvae resulted in low and variable survival (0-17%) to metamorphosis (Battaglene *et al.* 1989b). This was possibly due to the restricted ability of larvae to tolerate transfer from saltwater to freshwater. Survival of 21-day-old larvae in saltwater ponds was more consistent (3-15%) but yolk-sac larvae did not survive (Battaglene and Allan 1990). Poor food availability appeared to cause low survival in some extensive rearing experiments run at ambient temperatures. Supplementation of wild zooplankton in ponds with newly hatched brine shrimp substantially increased survival to 12.3±8.8%, n=8 (Battaglene *et al.* in press).

Australian bass spawn in winter, when ambient temperatures in some experimental ponds drop as low as 9°C. Van der Wal (1985) reported an optimum temperature range of 16-20°C for survival of seven-day-old bass larvae, with significantly reduced survival and growth at 12°C. This range of 16-20°C corresponds with the September/October water temperatures in most NSW estuaries (Wolf and Collins 1979). Temperature is considered the major growth rate-controlling force for fish fed a suitable ration (Brett 1979; Shepherd and Bromage 1988). At ambient winter pond temperatures bass larvae are slow growing in comparison with many other extensively reared fish. Ponds covered by greenhouses store solar heat (Ogle 1980) and have been used to increase winter pond temperatures (Parker 1989) and subsequent growth rates of prawns and fish (Juan *et al.* 1988; Seidman and Issar 1988; Paessun and Allison 1984).

The following summarises the results of experiments carried out in passively-heated greenhouse covered ponds and uncovered ponds, to observe the effect of increased pond temperatures on the growth and survival of Australian bass larvae.

Methods

Experiments were conducted during the winters of 1989 and 1990 using eight saltwater prawn nursery ponds (250 m^2, 1 m deep), located at Palmers Island on the Clarence River. Four of these ponds were enclosed within a plastic greenhouse. An uncovered saltwater pond at BWFCRS (1000 m^2, 1 m deep) was also used. Eight experimental stockings were carried out in the uncovered Palmers Island ponds, eight in the greenhouse covered ponds and one in the pond at BWFCRS (Table 1).

Temperature, salinity, pH and dissolved oxygen (DO) were measured every 1-7 days. The larvae, obtained from hormonally induced broodstock, were intensively reared at BWFCRS using techniques described by Battaglene *et al.* (1989a). Larvae were stocked into the ponds at 2-3 weeks of age at a density of one million per hectare. At stocking, the larvae had developed swim bladders, absorbed their yolk-sac and oil globule, and started exogenous feeding. The extensive culture methods used are described by Battaglene and Allan (1990). In addition, 1 hp paddle wheel aerators were used to increase morning dissolved oxygen levels. For all ponds, natural zooplankton was supplemented by adding newly hatched brine shrimp as described by Battaglene *et al.* (in press). Larvae were sampled every 1-7 days and ponds harvested when the larvae were fully metamorphosed at approximately 20 mm total length. Results are given as mean±SD.

Results and discussion

Temperatures during the experimental trials in the passively heated greenhouse ponds ranged from 18-23°C. Under these conditions larvae took from 48-59 days to reach metamorphosis from hatch with an average survival of 51-23.4% (Table 1). In contrast, temperatures in the uncovered ponds in the Clarence River and at BWFRCS ranged from 9-24°C with metamorphosis occurring at 88-118 days of age and survival averaging 14.7-11.3%. Survival among ponds for all trials was highly variable ranging from 0-80.8%. Salinities in and among ponds ranged from 7-25 ppt, dissolved oxygen from 5.2-16.9 ppm and pH from 6.7-9.8.

The average daily larval growth rates (to metamorphosis) in the passively heated greenhouse ponds were markedly higher (194-231%) than the uncovered ponds (Table 1 and Figure 2). They are also equal to, or greater than, those recorded for intensively reared larvae (Battaglene *et al.* 1989a), with more than twice the average survival rate.

The high degree of variability experienced in survival among pond trials was, in part, due to mortality caused by protozoan parasite epizootics. In some ponds ciliates of the genus *Trichodina* were found on moribund fish. Formalin (15 ppm) or malachite green (0.5 ppm) were used to treat ponds with infected fish. Both treatments reduced parasitic ciliates to undetectably low levels. Regular prophylactic treatments for protozoans in the latter stages of rearing may further increase survival.

Another problem that can reduce survival in fish ponds is water quality deterioration due to sudden mortality of phytoplankton blooms (Boyd *et al.* 1975). The shorter rearing period achievable in greenhouse ponds may reduce the number of disease epizootics and water quality problems.

The ponds at Palmers Island used during these trials are prawn farm nursery ponds. Prawn farms in NSW and South East Queensland usually only produce one prawn crop per year, making them comparatively less profitable than those in tropical climates (Hardman *et al.* 1991). Bass fingerlings were suggested as a potential winter crop for prawn farmers by Battaglene and Allan (1990). The use of passively heated greenhouse nursery ponds can allow the production of two prawn crops in temperate climates (Juan *et al.* 1988). In addition, the faster growth rates achieved in the greenhouse ponds during this study indicate that two crops of bass could be produced before post larval prawns become available in spring.

Extensive larval rearing experiments with barramundi (*Lates calcarifer*) have recently been carried out in tropical Queensland. These demonstrated that compared with established intensive rearing techniques, equivalent numbers of barramundi can be produced more quickly and far more cheaply (Rimmer and Rutledge 1991). During the experiments summarised in this paper over 161,000 juvenile Australian bass were produced from 17 pond stockings. The results of this study indicate that commercially important advantages can be gained by extensively rearing Australian bass larvae in greenhouse ponds rather than by conventional intensive hatchery techniques.

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Table 1. Results of Australian bass (*Macquaria novemaculeata*) extensive rearing experiments in greenhouse covered and uncovered ponds

All larvae were intensively reared at BWFCRS for 10-20 days post hatch (average length 4.5-5.8 mm) and stocked into ponds at a density of 1 million per hectare

Site *	No. of ponds stocked	Average % survival	Age at harvest (days)	Growth/day (mm)	Temperate range (^{0}C)
I	8	51-32.4	48-59	0.37-0.44	18-23
II	8	12-9.0	88-118	0.17-0.30	12-24
III	1	35	103	0.19	9-24

*I = Palmers Island greenhouse ponds

II = Palmers Island uncovered ponds

III = BWFCRS uncovered pond

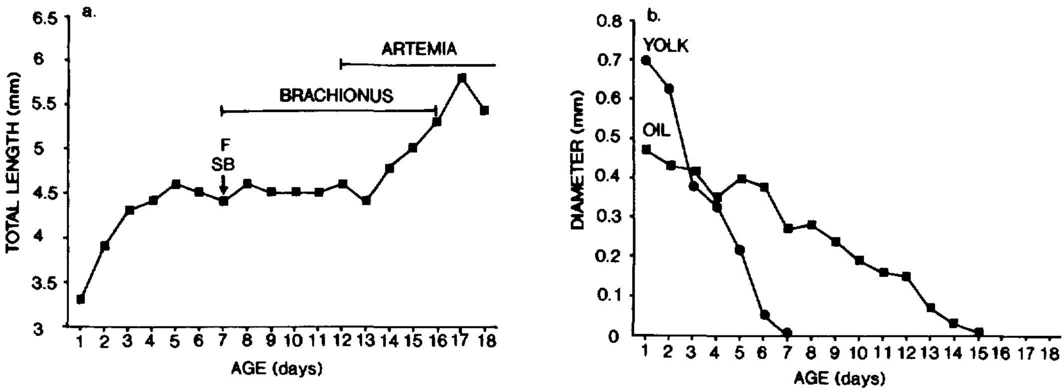

Figure 1. a. The growth of Australian bass (*Macquaria novemaculeata*) during the first 18 days of intensive rearing showing the time of exogenous feeding (F) and swim bladder inflation (SB). Larvae were fed on *Brachionus* (7th-16th day) and *Artemia* (from 12th day). **b.** Absorption of the ●yolk-sac and ■oil globule.

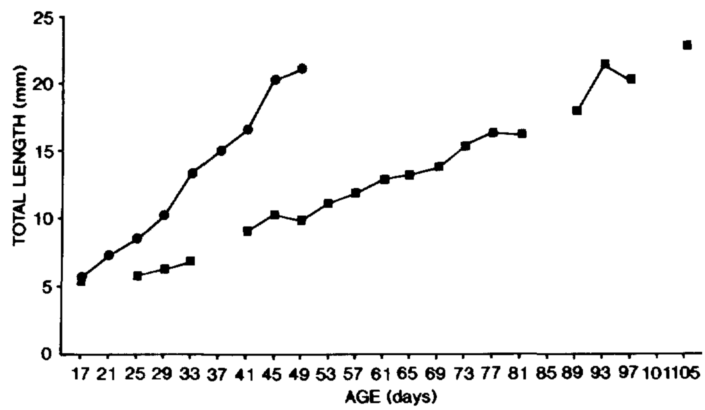

Figure 2. The growth to metamorphosis of extensively reared Australian bass (*Macquaria novemaculeata*) under two individual temperature regimes, ■9-24°C and ●18-22°C. Each point represents the mean length (TL) of 3-10 fish at that age.