COMMERCIAL EXTENSIVE LARVAL REARING OF AUSTRALIAN FRESHWATER NATIVE FISH

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Introduction

The establishment of Australian native fish hatcheries was made possible with the development of efficient hormone-induced breeding and extensive pond rearing techniques for Murray cod (*Maccullochella peeli*), golden perch (*Macquaria ambigua*),and silver perch (*Bidyanus bidyanus*) in the late 1970's (Rowland *et al.* 1983; Rowland 1986a; Rowland 1989).

Extensive larval rearing involves fertilizing large earthen ponds to promote a plankton bloom which becomes the food supply for the fish larvae. The conditions in the ponds imitate the plankton rich environment of inundated floodplains, thought to be important nursery grounds for young fish (Geddes and Puckridge 1989).

Many key factors play an important part in the survival and growth of fish larvae in the rearing ponds. An understanding of fish growth and development, behaviour, diet, plankton ecology, fish diseases, predators and critical water quality parameters, enable pond management practices that will ensure good growth and survival rates essential for viable commercial production. This paper outlines how these factors relate to rearing Murray cod, golden perch and silver perch.

Larval growth, development, behaviour and diet

There are some important differences between the larvae of Murray cod, golden perch and silver perch that warrant different rearing conditions.

Murray cod larvae are large, 12mm total length (T.L.), and well developed when they commence feeding 9 to 11 days after hatching (Lake 1967; Rowland 1989). At this early stage they are capable swimmers, easily capturing small zooplankton and showing a preference for crustaceans and chironomid larvae (Lake 1967; Rowland 1985).

Rowland (1985) showed that first feed larvae were able to withstand a delay of over 10 days without food, without a significant increase in mortality (mortality was always less than 20%) as long as the larvae were then offered food at high concentrations. He also showed that survival in aquaria was over 80% for Murray cod larvae fed on a low level of zooplankton of 250 organisms/litre. Survival for larvae fed at higher food concentrations was not significantly higher. The highest value was 89%.

These features of large size, efficient prey capture and ability to survive at low food levels ensure that survival of Murray cod in the rearing ponds is consistently high (Figure 1).

Golden perch and silver perch larvae are similar to many species of marine fish larvae, being small and poorly developed at first feed. The concept of a "critical period" is described for this type of fish larvae when sufficient prey must be encountered or heavy mortality results (May 1974; Pitcher and Hart 1982; Leggett 1986). At the commencement of feeding, golden perch and silver perch larvae are only 5mm total length.

At this stage they are poorly developed, weak swimmers that are inefficient at capturing food (Lake 1967; Arumugam and Geddes 1987). Rowland (1989) describes the importance of having dense blooms of suitable zooplankton in the rearing ponds for the first few days of feeding as being vital for obtaining high survival rates.

The type of plankton suitable for high survival rates in the rearing ponds differs for golden perch and silver perch. First feed silver perch larvae are limited to smaller prey having a smaller mouth gape of 0.4mm compared with 0.5mm in golden perch (Arumugam and Geddes 1987). Gut analysis of early feeding larvae shows that silver perch start feeding on small rotifers, algae, chironomid larvae and small crustaceans.

In contrast, golden perch larvae feed mainly on small crustaceans and insect larvae, rarely ingesting rotifers or algae (Lake 1967; Arumugam 1986b). The highest survival rates for silver perch larvae at Inland Fisheries Research Station (IFRS) have occurred when they were released into ponds with a dense bloom of rotifers, *Brachionus sp.* For golden perch, high rates of survival have occurred in ponds with blooms of cladocerans, *Moina sp.* (S.J. Thurstan, unpublished data).

Visual stimuli are important for golden perch larvae and fry for locating their prey and initiating an attack (Arumugam 1986b). This helps explain why they rarely eat algae or slow moving rotifers and are attracted to larger, more obvious prey as found for bluegill (*Lepomis macrochirus*) (Wetterer 1989). Golden perch of less than 20mm in length tend to select the largest prey available, and often attack prey that is too large to ingest (Arumugam and Geddes in press). As golden perch increase in size, their impact on larger species of zooplankton also increases. Arumugam and Geddes (1987) describe the relationship between mouth gape and fish length for golden perch as linear, which gives an indication of the size of prey, fish of different lengths are able to consume.

Data on growth collected from fry rearing ponds at IFRS over six years show a linear increase in length for Murray cod, golden perch and silver perch during the rearing period (Figure 2). In contrast, Arumugam and Geddes (1987) found that golden perch length and weight increased exponentially with respect to time in a single rearing pond. The different results are best explained by the greater variability in conditions affecting fish growth experienced in the many ponds comprising the IFRS data.

The presence of structures that provide some form of cover or shelter have been shown to be important for the growth and wellbeing of golden perch reared in laboratory conditions. Once the larvae reach 10mm in length they seek cover and defend a territory from other fish. Fish that have cover competed more successfully for food, grow faster and are able to withstand longer periods of starvation (Arumugam and Geddes 1987). Similar cover seeking behaviour has been observed for Murray cod. Silver perch, however, rarely use cover, spending more time actively swimming, usually in groups. The importance of cover in rearing ponds has not been studied, but it may play an important role in fry production.

Plankton ecology and insect predation

The plankton blooms that develop in rearing ponds normally follow a predictable succession of dominant species with a tendency for the average size of the zooplankton to increase over time (Arumugam 1986b). Detailed descriptions of plankton succession in IFRS rearing ponds are given by Arumugam (1986b); Arumugam and Geddes (1986); Geddes and Puckridge (1989).

A typical succession of dominant zooplankton species in a newly filled rearing pond at IFRS starts with rotifers such as *Brachionus* sp , followed by cyclopoid copepods and *Moina* sp, then calanoid copepods and finally *Daphnia carinata* (Arumugam 1989). The length of time before the start of the rotifer bloom and the period which each species dominates depends upon pond water temperature. Pond temperature can vary more than 10^{0}C over the breeding season, and may change dramatically overnight. At 18^{0}C the first rotifer bloom will take ten to fourteen days to develop and may last for one week. At 28^{0}C the rotifer bloom may occur after four days and last for only two days.

The unpredictable nature of the weather which influences the temperature of rearing ponds presents a problem of coordinating the release of golden perch and silver perch larvae into a rearing pond with an ideal zooplankton bloom. Artificially bred golden and silver perch larvae require feeding seven days after the broodstock are induced to spawn and there can be no guarantee that the zooplankton species abundance will be ideal. This uncertainty may account for the high variability of golden perch and silver perch survival in rearing ponds , shown for golden perch in Figure 1.

To reduce the high rates of golden perch mortality caused by unsuitable zooplankton in the rearing ponds, Arumugam (1986a) proposed feeding golden perch in the hatchery on *Artemia salina* nauplii for a few days until pond conditions are suitable. This practice has been tried at IFRS with some success (Author, unpublished data).

Post and McQueen (1987);Arumugam and Geddes (1986); and Arumugam and Geddes (1988) showed that as fish grow they have an increasing effect on the size, composition and biomass of the zooplankton populations in enclosures, resulting in marked reductions in the abundance of preferred prey species and blooms of non-prey species of zooplankton. Rearing ponds are harvested when predation pressure reduces the food organisms to levels that can no longer support fish growth. The mass of fish normally harvested from the 0.4 ha rearing ponds at IFRS normally ranges between 20 and 40 kg,with a maximum recorded value of 160 kg.

Many species of aquatic insects inhabit the rearing ponds,and often develop large populations. Several species have the potential to be serious predators of fish larvae (Arumugam 1986b) but they pose a greater problem in the later stages of rearing fry when they compete for the limited resource of plankton for food (Geddes 1986; Arumugam and Geddes 1986). Routine control of aquatic insects takes place in fish rearing ponds in Malaysia (Arumugum 1989) but as yet it is not common practice for rearing Australian native fish.

Water quality and disease

The eutrophic conditions of rearing ponds lead to considerable variations in water quality factors such as dissolved oxygen, pH and ammonia which affect fish growth and survival. Routine monitoring of water quality is required to maintain favourable conditions (Rowland 1986b).

Thermal stratification commonly occurs in rearing ponds, forming a cooler, oxygen deficient (concentrations less than 2ppm) layer up to 1 m deep on the bottom of the pond. These conditions may retard fish growth by:

1. reducing the bottom cover available to Murray cod or golden perch:
2. concentrating the fish and zooplankton into a smaller volume, which subjects the plankton to heavier grazing pressure (Arumugam 1989):
3. reducing the availability of benthic food organisms that are important prey items to the fish (Arumugam 1989):
4. the production of toxic metabolites such as ammonia and sulphides in anaerobic conditions (Avnimelech and Zohar 1986).

Low oxygen conditions in ponds can be remedied with aeration equipment or by exchanging water.

Protozoan parasites, such as *Chilodonella* sp., *Ichthyophthirius multifiliis, Trichodina* sp. and *Ichthyobodo necator*, are the only disease organisms that have been recognized as causing significant mortality of native fish in rearing ponds (Rowland and Ingram 1991). Regular inspections of fish must be carried out to identify the onset of the diseases, which can then be treated by applying malachite green to the pond.

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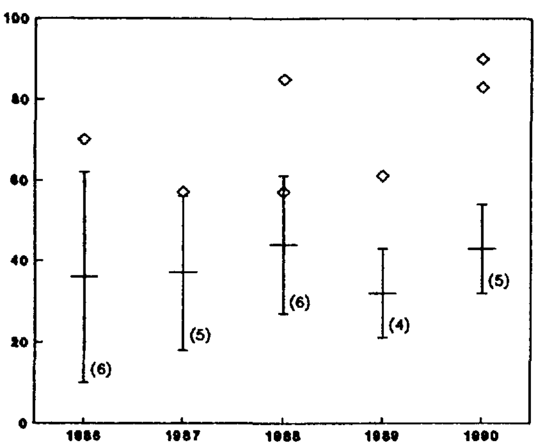

Figure 1. Survival rates of golden perch (Ī) ± s.d. and Murray cod (◊, points represent single points). Sample numbers of golden perch in parenthesis.

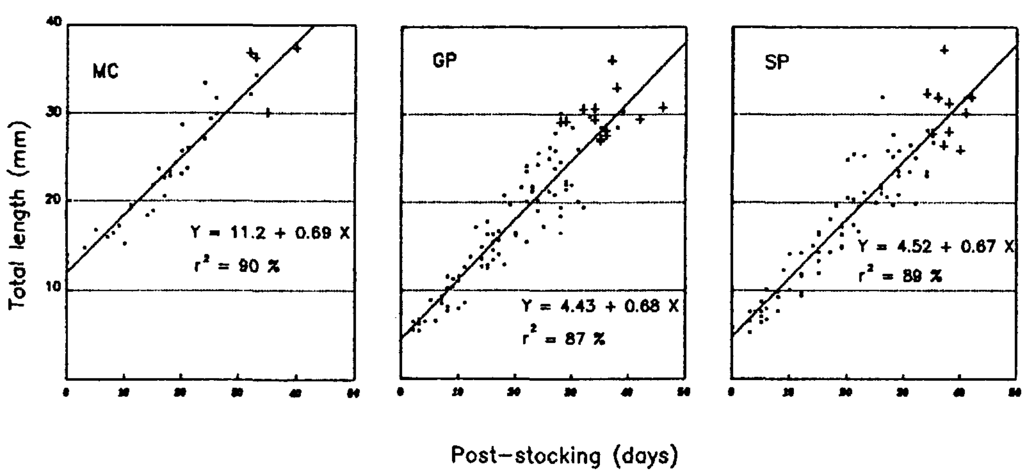

Figure 2. Growth of Murray cod (MC), golden perch (GP), and silver perch (SP) in rearing ponds. Each point (.) is a mean length from 3-5 fish from a pond or 10-20 measured at harvest (+).