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Use of *Artemia*, Frozen Zooplankton and Artificial Food for Weaning Fingerlings of the Freshwater Fish Golden Perch *Macquaria ambigua ambigua* (Percichthyidae)

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Abstract

Juvenile golden perch *Macquaria ambigua ambigua* (Percichthyidae) (mean weight 0.16g, mean total length 23.9mm) were weaned onto a commercial crumble diet over ten days by co-feeding frozen *Artemia* or frozen zooplankton, harvested from plankton ponds. Crumble was used to replace plankton slurry, in 10% by volume daily increments. An additional treatment of abrupt weaning from frozen zooplankton to crumble diet, and a control of frozen zooplankton, was maintained. Weaning using zooplankton produced better growth and survival over 56 days (1.57 g, 78.0%) than *Artemia* (1.11 g, 62.4%), and survival was significantly better than abrupt weaning from zooplankton on to crumble diet (1.57 g, 13.3%). Co-feeding produced better survival rates but poorer growth when non-boosted *Artemia* was used in co-feeding. Frozen zooplankton is a cheap and readily available alternative to *Artemia* as a co-feeding weaning diet.

Introduction

A weaning method suitable for golden perch (*Macquaria ambigua ambigua*: Percichthyidae) fingerlings has been developed using *Artemia salina* nauplii as a transition food between zooplankton from rearing ponds and artificial food. However, *Artemia* is relatively expensive compared to zooplankton. In the tropics, plankton is readily and easily cultured in quantity, at any time of the year. Production of native freshwater fish fingerlings in Australia is largely dependent upon use of fertilised plankton ponds, stocked with larval fish which feed on zooplankton, reaching size suitable for stocking in impoundments for recreational fishery enhancement (about 50 mm) in 6-8 weeks (Rowland 1996).

Frozen plankton has potential as an alternative to *Artemia*, as it is readily available, cheap, and can be stored ready for immediate use when required. Sieving to select the appropriate-sized plankton for particular fish fingerlings can be done, as most ponds produce a variety of species in a succession (Arumugam 1986). Using frozen plankton to replace *Artemia* in the weaning process would appear desirable, as fish reared in plankton ponds are already familiar with this food.

This aim of this trial was to determine whether frozen freshwater zooplankton would be an acceptable alternative to newly hatched *Artemia* nauplii as a weaning transition food for golden perch.

Materials and Methods

Experimental facilities

Pond-reared golden perch were obtained from a commercial hatchery in southern Queensland, and transported to the Freshwater Fisheries and Aquaculture Centre (FFAC), Walkamin. They were quarantined in 200 l tanks, treated with a 70 $mg \cdot l^{-1}$ formalin and $10 g \cdot l^{-1}$ salt for one hour as a prophylactic treatment against disease and parasites. The fish were graded using a bar grader and then 75 graded fish of mean total length 23.9±3.4 mm, mean weight 0.16±0.06 g, were stocked in each of 16 experimental tanks. Experimental tanks were 160 l round plastic tanks, equipped with a central standpipe with bottom outlet, and an external standpipe to maintain water level at 100 l. Each tank had one air stone, and flow-through bore water at 5 $l \cdot minute^{-1}$. Water temperature was maintained at 24 to 27.8°C, mean of 25.7°C. Temperature was continuously monitored in three tanks using a calibrated temperature logger, and pH and oxygen monitored three times per week using a TPS FL90 water checker. Oxygen was maintained above 6.3 $mg \cdot l^{-1}$ at all times, and pH was constant at 6.8.

For feeding, a plastic mesh bag (70mm x 50mm, mesh size 2mm) containing a 5 ml block of frozen zooplankton or *Artemia* was suspended near the water surface, where it melted, producing a stream of food falling to the bottom. Each 5 ml block took approximately 7 minutes to dissolve, and the bag was left in the tank for 30 minutes. All tanks were fed three times daily, at approximately 8:00, 12:00 and 16:00. After an eight-day acclimation period when fish were fed frozen *Artemia* or zooplankton, weaning was commenced. The experiment ran for 56 days after the acclimation period.

Diets and feeding regimes

Plankton was collected from a plankton pond at FFAC using an airlift, washed, and sieved between 250mm and 1.18 mm size aperture, and frozen immediately in 5 ml blocks. Plankton consisted of *Moina micrura* (20-70% by count), juvenile *Daphnia carinata*(10-30%), and cyclopoid and calanoid copepods (20-70%). *Artemia* were hatched and harvested as nauplii, rinsed in fresh water, and frozen in 5ml blocks.

Weaning diets were made by mixing fresh food slurry (either plankton or *Artemia*) with 0.6mm salmon crumble (Gibson's Limited, Glenorchy, Tasmania), then freezing it in blocks. The crumble diet was a commercial fish starter crumble, 55% protein, 15.4% fat, 4.1% fibre, 11.8% ash and 13.7% carbohydrate. During the transition, the slurry was gradually replaced with crumble over 9 days, in 10% increments by volume. When the feeding regime was 100% crumble, the empty bag was placed in the tank as normal and 5ml of crumble sprinkled on the water surface above it. Three days after transition was complete, the bag was no longer used and food was sprinkled on the surface at feeding times. The experiment ran for 56 days, excluding the acclimation period. At feeding times, water flow was turned off for 30 minutes to avoid food being washed away. Behaviour during feeding was observed. A minimum of one hour after the morning feed, each tank was scrubbed clean and partly drained by lowering the external standpipe, allowing accumulated debris to be sucked out via the internal standpipe.

Treatments were: plankton fed control, plankton fed then gradually weaned on to salmon crumble, *Artemia* fed then gradually weaned on to salmon crumble, and plankton fed, then abruptly transferred to salmon crumble.

There were four replicate tanks of each treatment. A random sample of 40 of the graded fish were weighed and measured (standard and total length) when the trial began. During the acclimation period, mortalities were replaced from an identical tank to experimental tanks. After that, mortalities were recorded daily. The experiment was terminated after 56 days, when all fish in each tank were measured and weighed. Condition was assessed, fish with sunken or flat abdomens were rated as runts, and those that had rounded abdomens were rated as racers.

Data were analysed using ANOVA. Residuals were checked for departures from the assumptions, and any outliers were removed if discovered. Percentage data (mortalities, runts and feeders) were arcsine transformed before analysis. All ANOVAs were then checked for accuracy using GLM analysis.

Results

Fingerling behavior at weaning

Undisturbed golden perch fingerlings remained relatively motionless, distributed around the tank edges. Within three days of using the basket to deliver food, fingerling golden perch rose under the basket immediately after introduction into the tank, and began feeding on the plankton or *Artemia* as it thawed and sank. After five days, most fingerlings actively swam into or around the basket immediately after it was placed in the tank. After the basket was empty, the fingerlings picked at the bottom of the tank.

When the weaning diets were introduced, the same behaviour continued even when 100% crumble was used. After use of the bag was stopped, and crumble sprinkled over the water surface, fingerlings rose in the water column from near the bottom of the tank. A small percentage of fingerlings started feeding on floating crumble particles after about 20 days, but most ate the food as it sank. All fish fed off the bottom after crumbles were offered.

Fingerling growth performance

Both the ANOVA and GLM analyses showed that the percentage of racers in each diet treatment were significantly different ($p<0.001$ in all cases). The outcome for percentage runts also showed significant differences among the diets. The percentages of runts and racers for the various dietary regimes are presented in Table 1.

The results in Table 1 indicate that the plankton weaning treatment was superior to the *Artemia* weaning treatment , producing more racers and fewer runts, promoting higher survival, and giving a higher mean weight. The control treatment produced a high survival rate, but a very high percentage of runts and a low mean weight. When weights and condition factors were compared, all runts were found to be < 0.8 g, and racers >1g. The abrupt weaning treatment produced a more racers (97.2%) than any other treatment. The plankton/crumble treatment, and abrupt crumble treatments, were not significantly different except in survival. Survival was significantly higher in the two gradual weaning treatments and the control. The end weights were also significantly different between other treatments, with the control treatment weighing significantly less than any of the other treatments.

Discussion

The behaviour of golden perch fingerlings indicates that they are benthic feeders. Battaglene (1991) found that the diet of juvenile fish (mean TL 57.7mm) was benthic organisms, primarily small atyid shrimp and eleotrid fish. The benthic feeding behaviour has important implications in pond rearing of this species, as artificial foods must sink to be available to the fish.

Zooplankton was a better weaning diet than *Artemia*. *Artemia* nauplii are nutritionally incomplete unless nutritionally boosted prior to use (eg Sheikh-Eldin 1997). Zooplankton harvested from ponds feed on algae and bacteria, which may provide nutrients absent in newly hatched *Artemia*. Colour can be

Table 1. Condition (as represented by the proportion of runts and racers in experimental tanks), survival and weight of golden perch on different weaning treatments. Data are means of four replicates. Mean starting weight was 0.16 ± 0.06 g.

Diet	Racers (%)	Runts (%)	Survival (%)	Weight (g)
Plankton (control)	7.3a	92.7c	82.0a	0.43 ± 0.23a
Artemia and crumble	40.6b	59.5b	62.4a	1.11± 1.07b
Plankton and crumble	93.0c	7.0a	78.0a	1.57± 0.55c
Abrupt crumble	97.2c	2.8a	13.3b	1.57± 0.62c

Means with the same subscript are not significantly different ($P<0.001$)

important in diet acceptance by fish (eg Masterson and Garling 1986). The high proportion of runts in the *Artemia* weaning treatment compared to plankton weaned fish could be explained by a longer time to accept the crumble diet, possibly due to the colour difference. Further experiments measuring growth at intervals after weaning would be necessary to confirm this.

The control treatment, fed exclusively on plankton, had high survival but also a high proportion of runts. This suggests that they were malnourished, but that they were eating enough to survive. As a food item, zooplankton is susceptible to variations in nutritional value (Kubitza and Lovshin 1999), and it is possible that the zooplankton supplied was nutritionally inadequate when harvested from the ponds, or that freezing and thawing reduced the nutritional value of the plankton. In the pond environment, golden perch fingerlings change diet over time, due to changes in plankton composition in the pond and increasing gape size (Arumugam 1986; Herbert, unpublished observations). The restriction in food type available may have contributed to the reduced growth observed in fish fingerlings fed on plankton.

There was no significant difference between the end size of fingerling golden perch weaned abruptly and the plankton weaning treatment, although the survival differential was marked. This suggests that those fish which did wean in the abrupt treatment did so immediately. This result also suggests that a proportion of fish in a population are more opportunistic than others, therefore a small proportion could be expected to grow well in all weaning treatments. The survival results suggest that this proportion was around 13%. Golden perch have been described as opportunistic, macrophagic carnivores (Battaglene, 1991). However, only a small percentage accepted inert food when preceded by training, in the absence of alternative food sources. Our results indicate that gradual weaning is essential for large-scale production of a large proportion of golden perch that feed and grow well.

While the gradual weaning process had high survival (78%) (See Table 1), this could probably be improved by refinements in technique and methodology. For example, determining optimal density, temperature, tank cleaning and light regimes could improve weaning success. Size of fingerlings at weaning may also be important. Larger fingerlings may be more amenable to weaning and handling. Weaning golden perch does not require labour intensive grading and sorting necessary for some carnivorous species (eg barramundi, *Lates calcarifer*) due to cannibalism problems (eg Maneewong, 1987). A gradual weaning process was also adopted for the barramundi culture industry in Australia (MacKinnon, 1987). Improved survival of fingerlings, and managing nursery ponds to retain juvenile golden perch on artificial food, will be essential for development of a viable golden perch grow out industry. The data presented in this study will help achieve this objective.

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