FEEDING AND GROWTH OF GOLDEN PERCH (*MACQUARIA AMBIGUA*), AND ASSESSMENT OF ITS POTENTIAL FOR AQUACULTURE

Thesis submitted by
Brett Herbert

For the Degree of Doctor of Philosophy in the School of Marine Biology and Aquaculture
James Cook University
September 2005

ELECTRONIC COPY

I, the undersigned, the author of this work, declare that the electronic copy of this thesis provided to the James Cook University Library, is an accurate copy of the print thesis submitted, within the limits of the technology available.

______________________________ _______________

Signature Date

STATEMENT OF ACCESS

I, the undersigned, the author of this thesis, understand that James Cook University will make it available for use within the University Library and, by microfilm or other means, allow access to other users in other approved libraries. All users consulting this thesis will have to sign the following statement:

> In consulting this thesis, I agree not to copy or closely paraphrase it in whole or in part without the written consent of the author; and to make proper public written acknowledgement for any assistance which I have obtained from it.

Beyond this, I do not wish to place any restriction on access to this thesis.

-- ---------------------------------

Brett Herbert

STATEMENT OF SOURCES

DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

-- ----------------------------------

Brett Herbert

ACKNOWLEDGEMENTS

I acknowledge the support and assistance of my colleagues at the Freshwater Fisheries and Aquaculture Centre, Walkamin, for their assistance with sampling and running experiments. In particular, Peter Graham, Neil Harris, Ben Hockings, Dave Bull and Bevan O'Grady assisted with all aspects of day to day running and monitoring of experiments (particularly feeding and water quality monitoring), maintenance of equipment, assistance with measuring and grading fish, and support when things went wrong. I also acknowledge the assistance of DPI&F biometricians Scott Foster, Bob Mayer and Joanne de Faveri for guidance and advice on statistical analysis. Peter Graham is a co-author of the papers due to his dedication and input into experiments, and input into material prepared for publication separately to this thesis. I also thank the veterinary staff at Oonoonba veterinary laboratory for assistance and advice with disease issues, and for providing histological material for me to examine.

This work was conducted as an element of my employment by the Queensland Department of Primary Industries, which provided facilities, infrastructure and administrative support to enable this work to be conducted.

I wish to acknowledge the input of Chris Barlow, my initial co-supervisor who suggested that this study be undertaken. I also acknowledge the input of my supervisory team, Peter Appleford, Paul Southgate, and Rocky de Nys who assisted with commencement and finalisation of the thesis, and provided valuable comments and criticisms of the drafts. Stuart Rowland, Mike Rimmer, Jeff Gooley and Brett Ingram also provided input and suggestions on draft material for publications, and advised on experimental design and direction. Members of the Aquaculture Association of Queensland provided input into the direction of the research (for example focus on weaning fingerlings rather than larvae), and also advised me of requirements for further research when they started farming golden perch.

I also thank my family for their unfailing support during the course of this study.

Abstract

Golden perch (*Macquaria ambigua*) is a valuable freshwater fish native to south eastern Australia. The fishery for this species is diminishing and there exists an opportunity to develop aquaculture techniques for commercial production. Mass production techniques for fingerlings have been developed, but the paradigm that weaning of golden perch onto artificial foods essential for aquaculture development was difficult or impossible, impeded investigations into optimising aquaculture techniques for the species. The aims of this study were to develop aquaculture techniques for golden perch, focussing on three major issues: (1) weaning fingerlings on to artificial foods; (2) the nursery phase of production; and (3) growout of the fish to market size. Additional investigation of a destructive epizootic in aquaculture golden perch was also undertaken to develop control techniques for mixed motile aeromonad/ciliate protozoan infections.

Weaning of fingerling golden perch was investigated after discussions with industry indicated that reliable, cheap, mass production of fingerlings was regularly undertaken and there was no real need to wean larvae or fry. Fingerlings used in weaning experiments (18-31 mm TL, 0.1-0.5 g) are produced by commercial hatcheries for recreational fishery enhancement. A weaning technique using frozen *Artemia* nauplii and formulated crumble food ice blocks was developed, in which the frozen *Artemia* was gradually replaced by crumble food particles. *Artemia* nauplii slurry was replaced with crumble food particles, with the proportion of crumble increasing by ten percent each day until 100% crumble food was being fed to the fingerlings after ten days. Iceblocks of pure *Artemia* slurry, presented in a mesh bag, were fed over an acclimation period to habituate fish. Subsequently prepared co-feeding (*Artemia*/crumble) iceblocks were fed using the same method. This method was successful resulting in 77% weaning success.

Due to the relatively high cost of *Artemia*, frozen zooplankton was tested as an alternative and produced better weaning results than the control *Artemia* weaning treatment in terms of survival (16% better) and growth (1.57 g ± 0.55 g on zooplankton against 1.11 ± 1.07 g on *Artemia*). This was adopted as the control treatment and the method of choice for mass weaning of fingerlings for nursery and

growout trials. After requests from industry for alternatives to plankton or *Artemi*a in weaning fingerlings, commercially available seafood products were tested as co-feeding diets in the weaning process. Squid, fish roe, prawn, mussel, scallop, and fish were tested against a zooplankton control. The seafood materials were processed to be a similar size to the plankton control (500 µm – 1.5 mm) and co-fed with crumble as iceblocks in 10% increasing increments and compared to a zooplankton control. Weaning using zooplankton as a co-feeding diet was far superior to other treatments tested in terms of both survival and growth. The best survival rates of the seafood treatments (the fish roe co-feeding treatment) was 39% and the poorest survival rate of zooplankton co-fed controls was 87% in the first trial. End weights of golden perch on all weaning treatments were significantly different ($P<0.05$) to the control. The olfactory and organoleptic properties of the co-feeding weaning diets were suggested to be of great importance in success of weaning.

Weaning techniques were further refined by investigating the effect of the duration of the transition period, the size of fingerlings, and light intensity on weaning success in fingerling golden perch. Attempts to reduce the co-feeding period or alter the ten-day transition period reduced weaning success significantly, from 62% feeding fish in the control treatment to between 36 and 46% for abbreviated treatments, suggesting that a minimum ten day transition period was essential for golden perch fingerlings. Mean weights at the end of the trial were also significantly different ($P<0.05$) (2.1 ± 0.97 g for controls, and 1.6 ± 0.83 g to 1.8 ± 0.99 g for treatments). The effect of size of fingerlings at weaning was tested (using fingerlings of the same age but different sizes), and no significant differences in weaning success were found between sizes from 0.1–0.24 g, suggesting that early weaning may provide significant benefits through a rapid transition to artificial diets.

The effect of light intensity on weaning of golden perch fingerlings was tested, with bright light, low light level and no light treatments. Golden perch weaned best in low light (1.79 ± 0.081 lux) and bright light (73.64 ± 0.55 lux), but over 6% of those in the dark treatment (0.00965 ± 0.00275 lux) were weaned successfully. The low light treatment produced significantly better results in terms of condition (3.45 ± 0.01 compared to the bright treatment (2.9 ± 0.01) ($P<0.05$), but was not significantly different in terms of survival or growth.

Two experiments were conducted on weaned golden perch to determine effects of density and diet on growth of golden perch in tanks. Firstly, in order to test the effect of density on growth of fingerlings, and to determine if density used in the weaning trials was suitable, golden perch fingerlings were grown in tanks at densities of 1000, 2000,7500 and 10000/m^3 for 82 days. At high stocking density there was less heterogeneity in growth than at low density, but overall growth was slower. Fish in the highest density treatment weighed significantly less (5.9 ± 0.3 g) than other groups (7.1± 0.3 g to 7.9 ± 0.4 g). Secondly, due to perceptions in industry that pellet texture was an impediment to golden perch feeding, a soft pellet was prepared using gelatine as a binding and moistening agent, and tested against the three commercially available dry pelleted feeds. Growth of golden perch fed on moist pellets (2.44 ± 0.07 g to 2.6 ± 0.07 g) was significantly less than that of fish fed dry pellets (3.4 ± 0.09 g and 3.83± 0.09 g).

After the issues in weaning golden perch on to artificial foods were resolved, trials to assess growth rates of golden perch in pond culture conditions were undertaken . The initial trial was conducted at two densities (105, 000 and 31, 250 fish/ha) for 220 days, with two replicates for each treatment. There were differences between the treatments in terms of growth (low densities 96.86 ± 9.62 g and 121.92 ± 10.61 g; and high densities 83.75 ± 10.01 g and 89.02 ± 10.65 g), but only the heaviest high density treatment was significantly different to the others. The size frequency distribution of high density treatment was skewed to the left (i.e. a high proportion of small fish) and bimodal, whereas in low density treatments it was more normal. To determine the reason for the skewed distribution the density experiment was repeated with greater replication (3 replicates of each treatment) and fish were sampled regularly to determine the role of diet in growth patterns. The results showed that a large proportion (67-70%) of fish reverted back to eating natural foods and that these were generally much smaller (mean weight about 10g) than those which retained pellet eating behaviour (mean weight around 80g). For every percentage point of pellet in the gut the weight was on average increased by 0.6423%. Analysis of natural diets determined that golden perch are more selective feeders than previously thought with smaller fish selecting *Moina* as prey over copepods, and larger fish feeding on chironomids or Trichoptera but not on Ephemeroptera or Odonata.

In order to test whether exposure to formulated food had a major influence on retention of weaned golden perch on pellets, a further experiment was run to test the effect of broadcast feeding. The results indicated that broadcast feeding significantly enhanced retention of fingerlings on pellets (42.5% retention in broadcast fed treatments against 25% in point feed treatments) and overall growth rates were therefore improved. Broadcast fed fish (15.639 ± 1.07 g) were significantly larger than point fed fish (10.74 ± 0.52 g and 10.899± 1.14 g) at the end of a four month nursery period. In addition, a commercial probiotic product was concurrently trialed to determine whether probiotics had positive effects on water quality or health of fish. The results were too variable to permit meaningful analysis, due to the inherent variability of pond based production systems.

Growout of golden perch to market size after nursery phase was also conducted. To determine whether the smallest golden perch did have growth potential in a commercial setting, the entire contents of six ponds of fish were graded after nursery phase into the smallest 50% and the remainder. The different groups were then restocked into separate ponds. Ungraded controls (at the original density of 1265 fish/pond, approximately 4 fish /m^2) were maintained as a control group. Sex ratios of the respective populations suggested that there was selective mortality of the fastest growing females due to grading (70% males in graded treatments compared to 62% males in the ungraded treatments**)**. The majority of the small size class of fish did not reach market size in the six months after grading. Small fish started at 6.2 ± 0.4 g finished at mean weight of 107.6 ± 10.83 g, compared to large fish stocked at 15.7 ± 0.2 g which grew to a mean weight of 235.1 ± 20.56 g. Ungraded fish averaged 10.9 ± 1.14 g at the start of the experiment and averaged 165.7 ± 22.43 g at the end. Small fish did not appear to grow rapidly when separated from potentially dominant, larger fish, suggesting that factors other than behaviour influenced the size frequency distribution of golden perch cultured in ponds

Finally, when a mixed motile Aeromonad and hymenostome ciliate infection destroyed fish in early growout trials during this study, the aetiology and pathology of the disease was documented and an effective treatment devised. It was determined that *Tetrahymena corlissii* is a primary pathogen to naïve golden perch, and that motile aeromonad bacteria were probably secondary invaders. An effective treatment using a systemic protozooicide was administered which halted mortalities. Previously, *Tetrahymena* had not been reported in Australia, or in food fish, as a primary pathogen of fish in well managed ponds.

In summary, the results of this study indicate that golden perch can be weaned on to artificial foods and do have potential for aquaculture, although there are still issues regarding feeds and feeding (particularly retention of artificial foods), and handling of fish (and subsequent losses due to infections), which require further research for the industry to develop rapidly. However, their potential rapid growth, high market price, and tolerance of poor water quality engender them to profitable aquaculture production systems.

Table of Contents

List of tables

List of Figures