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Preliminary Rearing Trials of an Australian Native Fish, Silver Perch *(Bidyanus bidyanus)* (Mitchell) with Reference to Growth and Production of Solid Waste in Aquaculture[1]

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Abstract

The native silver perch *Bidyanus bidyanus* has good potential as an aquaculture species in Australia. Juveniles of this species (1.14-2.13 g) were reared in glass aquaria at room temperatures (18-20°C) with aeration. Fish were kept individually in separate aquaria for the study of growth and solid waste production. In the first experiment, three commercial diets referred to as diet 1, diet 2 and diet 3 were offered to fish for four weeks in order to study the gain in weight and food conversion ratio. The gain in weight decreased in the order of fish fed diet 2 > diet 1 > diet 3 ($P>0.05$). In the second experiment, diets 2 and 1 were fed to fish for four weeks in order to study the relationship between growth of fish and production of solid wastes (suspended and dissolved) in the culture system. Diet 2 resulted in slightly better gain in weight ($P>0.05$) and less solids production in comparison to diet 1.

Introduction

The silver perch (*Bidyanus bidyanus*) is an Australian native fish of high aquaculture potential (Rowland et al. 1995). It is one of four principal species of the Murray-Darling River system and is much sought after by commercial and recreational fishers (Cadwallader 1979). Although aquaculture is an infant industry in Australia, interest in the culturing of silver perch is growing both in Australia and in nearby Asia (Gooley and Rowland 1993).

Previous research on *B. bidyanus* has concentrated on its biology (Rowland and Barlow 1991; Allan and Rowland 1992; Rowland and Allan 1994; Rowland et al. 1995) and nutrition (Allan and Rowland 1992; Allan et al. 1994; Allan and Rowland 1995). Until now there have been no attempts to study the

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amount or types of waste entering the environment from the rearing of silver perch or other species in Australia. This information is required since research in Europe and North America demonstrates a strong relationship between water pollution and the discharge of fish farm effluents (Albaster 1982; Ketola 1982; Penczak et al. 1982; Solbe 1982; Bregheim et al. 1984; Phillips 1985; Carr and Goulder 1990; Beveridge et al. 1991; Cowey and Cho 1991; Foy and Rosell 1991a, 1991b; Persson 1991; Pillay 1992; Ketola and Richmond 1994). This is the first in a series of planned experiments to study waste production from rearing of silver perch. These preliminary trials were designed to study growth and waste production at 18-20°C (room temperature) since previous research has demonstrated that silver perch can grow at temperatures as low at 12°C (Barlow and Bock 1981; Rowland 1995). Based on these results, further studies will be conducted on other forms of pollution from aquaculture of silver perch. The objectives of these preliminary rearing trials were:

- To evaluate growth performances (gain in weight and feed conversion) of silver perch fed on three locally available commercial diets;
- To compare the amount of solid waste (uneaten food and feces) load from the feeding of silver perch with reference to growth achieved.

Materials and Methods

The experiments were conducted in the wet laboratory at the Victoria University of Technology. The experimental fish (1,140-2,130 mg) were purchased from a local native fish farm where fish were grown in earthen ponds. They were acclimatized in the laboratory in large holding tanks (46 x 30 x 30 cm) for four weeks before use in experiments. All experiments were conducted at room temperatures of 18-20°C. Domestic tap water was used after dechlorination with an appropriate conditioner (Sera Aquatan). pH was monitored using a pH meter (Orion SA 520), and water temperature and fish health were monitored routinely. The pH of water was maintained at 7.5-8.5 using sodium bicarbonate or sodium bi-phosphate to adjust the pH. Fish were fed silver crumbles/starter (appropriate for fingerlings) at the rate of 3% body weight as recommended. They were fed twice per day (0900 and 1600), 6 d per week. Sampling was conducted once a week to measure gain in weight and to adjust feed amount. The experimental details are given in Table 1. Proximate analysis was done following AOAC (1990) and Chiu (1989). Protein was analyzed by Kjeldahl method (N x 6.25), fat by ether extraction (New 1987), moisture by drying in an oven overnight at 105°C, ashing by burning samples in a muffle furnace at 600°C overnight, and carbohydrate by difference in weight. Gross energy of diets was calculated using kilocaloric values of $5.5 \cdot g^{-1}$ protein, $9.1 \cdot g^{-1}$ lipid and $4.1 \cdot g^{-1}$ carbohydrate (New 1987).

Experiment 1: Effects of Feed on Growth and Feed Conversion

The experiment ran for four weeks and tested three commercial diets, referred to as diet 1, diet 2 and diet 3 with protein content of 53, 45 and 36%, respectively. Table 2 shows the proximate composition of the diets. Fish (1.14-1.54 g) were kept individually in separate aquaria (30 x 16 x 17 cm) to study individual growth performance with respect to gain in weight, food conversion ratio (FCR) and specific growth rate (SGR). Unfed fish (control) were kept in separate aquaria to compare growth performance of fed fish. A biological filter was used in each tank to enhance the culture environment.

Table 1. Experimental details of feeding trials 1 and 2 conducted at room temperatures (18-20°C) with silver perch juveniles. Trial 1 tested three diets, while trial 2 tested two diets. Both experiments ran for 28 d.

Trial no.	Temperature (°C)	Tank size (cm)	Diet no.	No. tanks/diet	No. fish/tank	No. fish/treatment	Average initial size (mg)
1	18-20	30 x 16 x 17	1	10	1	10	1,540
1	18-20	30 x 16 x 17	2	10	1	10	1,140
1	18-20	30 x 16 x 17	3	10	1	10	1,440
2	18-20	30 x 16 x 17	1	10	1	10	2,000
2	18-20	30 x 16 x 17	2	10	1	10	2,130

Table 2. Proximate composition and other information of the three diets fed to silver perch juveniles in trials 1 and 2. Trial 1 used all three diets while trial 2 used diets 1 and 2 only.

	Diet 1	Diet 2	Diet 3
Protein	53.00	45.00	35.89
Fat (%)	06.92	08.50	4.96
Carbohydrate (%)	27.02	36.66	46.15
Ash (%)	13.06	09.84	13.00
Nitrogen (%)	08.48	07.20	05.74
Phosphorus (%)	01.31	01.16	01.28
Fiber (%)	01.42	03.00	02.00
Dry matter (%)	91.80	90.12	88.99
Moisture (%)	08.20	09.88	11.01
Digestible energy ($Kcal \cdot kg^{-1}$)	5,027	5,273	4,851
DE/P ($Kcal \cdot kg^{-1}$)	95	117	135

Experiment 2 : Effects of Feeding on Suspended and Dissolved Solids Production

Here, as above, individual fish were kept in separate aquaria but fed diets 1 and 2 which sustained the best gain in weight in experiment 1. This experiment was designed to study the amount of suspended and dissolved solids produced over a 4-week growth period. No biological filter was used in the aquaria, however aeration was provided and dissolved oxygen level was more than 6 $mg \cdot l^{-1}$. One-third of the water was exchanged daily. Each aquarium was siphoned once every morning to collect uneaten food and feces (solid waste) using a 5-mm hose. Collected solids were filtered first through a fast filter (Whatman 512) and later through a standard 0.45-μm glass fiber filter (APHA 1989). The residue retained on both filters was dried in an oven at 105°C for 1 h, cooled in a desiccator and weighed using an analytical balance. The increase in weight was considered as total suspended solids and was determined as suspended solids/fish. The filtrate from the total suspended solids was used for total dissolved solids determination following APHA (1989).

The following formulae were used:

Weight gain (g) :Final weight of fish - Initial weight of fish (Chiu 1989)

Feed conversion ratio (FCR) : $\frac{\text{Weight of feed fed}}{\text{Weight gained by the fish}}$ (Laird and Needham 1988: Chiu 1989)

Specific growth rate (SGR) : $\frac{\ln w_t - \ln w_0 \times 100}{d}$ (Laird and Needham 1988; Chiu 1989)

where, ln = natural logarithm; wt = average final weight; w_0 = average initial weight; d = total days of experiment;

Protein efficiency ratio (PER) :Wet fish weight gain/Dietary protein intake (EIFAC 1980)

Total dissolved solids (mg/l) : $\frac{(A - B) \times 1{,}000}{\text{sample volume, ml}}$ (APHA 1989)
where A = weight of dry residue + dish,(mg);
B = weight of dish, mg

Results were analyzed by one-way analysis of variance (ANOVA) or a 2-sample student t-test using an IBM-compatible MS Excel program. The level of significance was set at 0.05 for all statistical tests performed.

Results

Of the three diets, diet 2 resulted in the best growth rate (Fig. 1.). However, statistical analysis did not reveal any significant difference ($P>0.05$) in weight gain among the fish fed the three different diets. Better FCR and SGR were achieved in diet 2 ($P<0.05$) than in the other diets (Table 3.). Diet 3 had the poorest FCR and SGR, and was not used in trial 2. The survival rate in experiment 1 was 100%.

Table 3. Weight gain, specific growth rate and food conversion of individual silver perch fed three diets and reared at room temperatures for 28 d in trial 1.

	Diet 1	Diet 2	Diet 3
Average initial weight (mg)	1,540	1,140	1,440
Average final weight (mg)	1,980	1,600	1,830
Gain in weight (mg)	440±19[1]	460±22[1]	390±50[1]
Percentage gain in weight	29±1.40[1]	40±2.2[2]	27±1.70[1]
Specific growth rate (SGR)	1.05±0.07[1]	1.41±0.03[2]	0.99±0.04[1]
Food conversion ratio (FCR)	2.97±0.06[1]	2.24±0.10[2]	3.20±0.04[1]
Protein efficiency ratio (PER)	0.69±0.02[1]	0.99±0.07[2]	0.89±0.06[2]
Survival	100	100	100

[1] Values are mean±SE; n=10.
[2] Values in the same row with common superscripts are not significantly different (P>0.05).

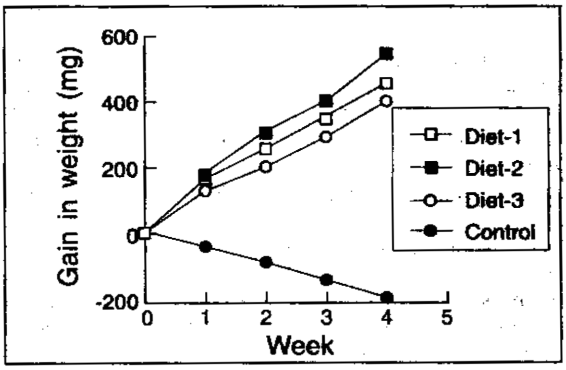

Fig. 1. Gain in weight/fish (mean±SE; n=10) of silver perch juveniles reared for four weeks and fed three diets @ 6 d•week^{-1} at room temperatures (18-20°C). There were no significant differences in weight gain of fish fed three diets (P>0.05). The control group was unfed.

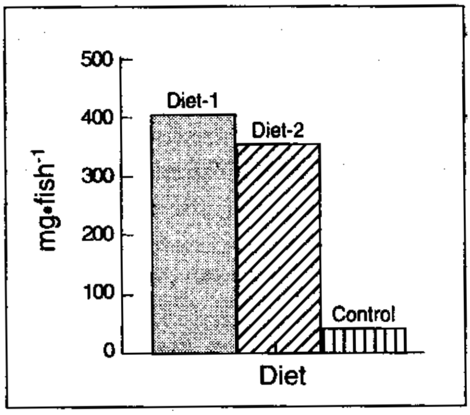

Fig. 2. Mean suspended solids produced by silver perch (2.00-2.13 g) fed two diets in experiment 2 and reared for four weeks at 18-20°C (n=10). The control group was unfed.

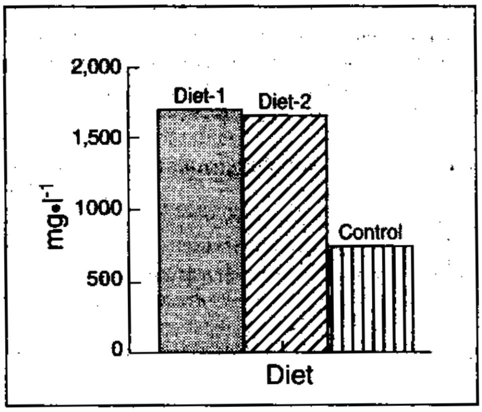

Fig. 3. Mean dissolved solids (±SE) produced by silver perch (2.00-2.13 g) fed two diets in experiment 2 and reared for four weeks at 18-20°C (n=10). The control group was unfed.

In the second experiment with two diets, diet 2 again resulted in slightly better SGR and FCR than diet 1, though the results were not significantly different (P>0.05). Slightly less suspended and dissolved solid waste was produced by fish fed diet 2 (Figs. 2 and 3). Solid waste production from diets 2 and 1 was 350 mg.fish^{-1} and 400 mg.fish^{-1}, respectively, and was not significantly different (P>0.05). The dissolved solids produced was 1,647 mg.l^{-1} with diet 2, and 1,711 $mg \cdot l^{-1}$ with diet 1. Unfed fish (control) produced the least amount of suspended and dissolved solids and this was significantly different from that produced by fed fish ($P<0.05$) (Figs. 2 and 3).

Discussion

In both experiments, fish fed diet 2 (45% protein) showed better gain in weight compared to diet 1 (53%) or diet 3 (35%) although statistical analysis did not show consistent differences across the two experiments. This may indicate that omnivorous silver perch do not require the higher levels of protein tested in this experiment. Allan and Rowland (1991) found that silver perch gained similar weight with 35.7% and 49% protein fed diets ($P>0.05$) but gained less weight with 20.7% protein ($P<0.05$). In our experiment, FCR was better with a 45% protein diet. However, Allan and Rowland (1991) reported better FCR with a 35.7% protein diet. The optimum protein requirements of silver perch juveniles is reported to be closer to 32-35% (Allan and Rowland 1991). From studies made on other freshwater species, it appears that the protein requirement of omnivorous silver perch could be closer to those of channel catfish (Allan and Rowland 1992) or common carp (Cadwallader 1979) and therefore lower than that used in diets 1 and 2.

The growth rate achieved in our experiments was low compared to commercial situations. This could be due to the effect of lower rearing temperatures (18-20°C) or culture methods. Slow growth of silver perch juveniles was reported by Allan and Rowland (1991) at 18.3-22.8°C. It appears that growth of silver perch in aquaria is much slower, which may indicate that artificial tanks may not be an ideal culture system for achieving maximum growth of silver perch. Rowland (1995) obtained a significantly slower growth rate of silver perch in tanks compared to earthen ponds. Similarly, crayfish have shown poor growth in concrete and plastic-lined ponds whereas earthen ponds were very effective in crayfish rearing (Tredwell et al. 1992). Moreover, the objectives of these preliminary trials was to measure the production of solid wastes in a laboratory culture situation, and was not meant to achieve maximum growth of *B. bidyanus*.

In experiment 2, diet 2 produced less suspended and dissolved solid waste (Fig. 2) in comparison to diet 1. This may be related to the slightly better gain in weight and FCR achieved in diet 2 with experiment 2. Lall (1991) reported that ingredients containing a high concentration of fiber, chitin and undigestible carbohydrate may increase the excretion of suspended solids. Total solid production from cages was estimated to be 290-655 kg dry $weight \cdot tonne^{-1}$ of rainbow trout (Phillips et al. 1990). The typical annual figure for solid discharge as effluents from Danish trout farms is reported to be 550 $kg \cdot tonne^{-1}$ (Warren-Hansen 1982). Though caution must be exercised when extrapolating our laboratory results to field aquaculture situations, the estimated solid waste production (dry-weight basis) in diets 1 and 2 were 600 and 551 $kg \cdot tonne^{-1}$ fish produced, respectively ($P>0.05$). The estimated solid waste production was based on rearing of silver perch at 18-20°C and feeding at the rate of 3% body weight. It is reported that even in balanced feed, 15-20% of eaten food is undigestible (Asgard et al. 1986). The present experiment was carried out at lower temperatures (18-20°C·), and at this temperature fish must be less active resulting in poor food intake, and consequently produced more solid waste. Rearing silver perch at a higher growth temperature could be a means of reducing solid waste discharge into the environment.

Minimization of solid discharge from fish farms is important because solids increase the turbidity in receiving waters. Waters high in suspended solids are unsatisfactory for bathing, and waters with high dissolved solids are of inferior palatability and may induce an unfavorable physiological reaction in the transient consumer (APHA 1989). It is therefore essential that further research be conducted on solids production at the higher temperature optimum for growth of silver perch which is probably in the range of 23-28°C (Rowland et al. 1995). Investigations are also necessary on the chemistry of solid wastes produced, since research in other countries (Albaster 1982; Persson 1988; Beveridge et al. 1991; Foy and Rosell 1991a, 1991b) demonstrates a direct relationship between phosphorus and nitrogen levels in solid wastes from aquaculture and algal blooms or eutrophication in lakes or rivers. Our further experiments will be a more detailed study on solid waste, separating uneaten food from feces, and on aspects of phosphorus and nitrogen pollution from rearing of silver perch.

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