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GROWTH AND YIELD OF ASIAN CATFISH *CLARIAS MACROCEPHALUS* (GUNTHER) FED DIFFERENT GROW-OUT DIETS

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Abstract

Juveniles of the Asian catfish *Clarias macrocephalus* (3.6±0.17 g; 78.0±0.09 mm) were fed one of four diets: a laboratory-formulated diet of 18.9% (Diet 1) or 34.2% (Diet 2) protein, a commercial feed pellet of 28.9% protein (Diet 3) or a diet of 80% blanched chicken entrails and 20% rice bran (31.7% protein; Diet 4). After 120 days of culture, catfish fed Diet 2 grew significantly better ($p<0.05$) than the other groups, reaching 108.9 g and 232.8 mm (daily weight gain 0.88 g; specific growth rate 2.9%), with a condition factor of 0.86 and production of 18.2 kg per 25 m^2 pen. Feed conversion with Diets 2 and 3 (2.5 and 2.3, respectively) was better than with Diets 1 and 4 (3.4 and 5.0). Survival (68-81%) did not differ significantly among treatments ($p>0.05$). Catfish fed Diet 2 had the highest apparent lipid retention (131.7%). The protein efficiency ratio was lowest (1.3) in Diet 2, but did not differ significantly from Diets 1 and 3. Catfish fed Diet 4 were fatty and had a lower crude protein content. Results suggest that *C. macrocephalus* fed 34.2% crude protein have a significantly higher weight and total yield. Further, a taste test showed that odor, flavor and appearance did not differ amongst the diets.

Introduction

The Asian catfish *Clarias macrocephalus* (Gunther) is a highly esteemed food fish in Malaysia (Mollah and Tan, 1983), Thailand (Areerat, 1987) and the Philippines (Guerrero, 1988; Santiago and Gonzal, 1997) because of its tender and delicious meat.

In the Philippines, catfish farming is a growing industry. One native species being cultured is *C. macrocephalus*. This species has been the subject of considerable research in breeding (Mollah and Tan, 1983; Tan-Fermin, 1992, Tan-Fermin and Emata, 1993;

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Tambasen-Cheong et al., 1995; Santiago and Gonzal, 1997; Tan-Fermin et al., 1997), hatchery techniques (Bevan and Kramer, 1987; Fermin et al., 1995) and nursery techniques (Bombeo et al., 2002). Kwei Lin (1990) reported on the culture of *C. macrocephalus* in cages in ponds stocked with *Oreochromis niloticus.* However there is limited information on the grow-out of *C. macrocephalus*.

Earlier *C. macrocephalus* culture in the Philippines did not prosper due to an inefficient diet (Guerrero, 1988). Catfish are carnivores, but can feed on kitchen refuse, benthic organisms, decaying organic matter and formulated feed (Areerat, 1987). Catfish growers in the Philippines commonly use chicken entrails, trash fish, rice bran or any combination of these. However, the supply of chicken entrails and trash fish is limited and seasonal.

The present study was undertaken to evaluate the growth, survival, feed conversion ratio (FCR) and production of Asian catfish fed four diets and, thereby, improve the growth and production of one of the slow-growing clariid catfish (IFFP, 1998).

Materials and Methods

The study was conducted in a freshwater fishpond in Dumangas, Iloilo, Philippines. Twelve pens were installed in a 440 m^2 pond. The pond was prepared by sun-drying the bottom for five days until the soil cracked. Hydrated lime [$Ca(OH)_2$] and chicken manure were then applied at 1 ton/ha each. The pond was filled with water to an initial depth of 10 cm. After seven days, the water depth was increased by 5 cm every two days until it reached 30 cm. Next, urea (45-0-0) was applied at 25 kg and ammonium phosphate (16-20-0) at 50 kg/ha and the water level was raised to 60 cm. The pens were installed in two parallel rows, 1 m apart. Each pen was created by enclosing a 5 x 5 m area with B-net (2 mm mesh) held in place by a bamboo framework and round ipil-ipil wood (10 cm diameter). The bottoms of the nets were buried 30 cm into the pond bottom. To prevent leaching and mixing of feed, the walls were lined with plastic sheet (gauge 2.6). A bamboo catwalk was constructed between the rows for ease of feeding and management.

Two days before stocking, 2 kg (wet weight) swamp cabbage *Ipomea aquatica* and 4 kg water hyacinth *Eichornia crassipes* were put into each pen to serve as shelter for the catfish. The plants were limited to 20-30% of the pen area throughout the experiment to allow space for feed input.

Hatchery-bred *C. macrocephalus* juveniles (weight 3.6±0.17 g, total length 78.0±0.09 mm) were stocked at 10 fish per m^2. Four diets (Table 1) were tested in a completely randomized design with three replicates per treatment for 120 days. Diets 1-3 were given at 5.0, 4.5, 4.0 and 3.5% of the fish biomass per day for the four months, respectively. They were fed in crumble form for the first two months and pellet form (2.5 mm diameter) in the third and fourth. Diet 4 was fed following industry practice: 10% of the biomass per day for the first two months and 8% thereafter. Chicken entrails in Diet 4 were blanched in a nylon screen bag in boiling water for a few seconds, then chopped finely and mixed with rice bran (sieved through a 1-mm mesh). Feeds were given twice daily at 08:00 and 16:00.

The water level was maintained at 60 cm for the first 15 days of culture and raised to 90-105 cm for the remainder of the experiment. During the first two months, 30-40% of the pond water volume was drained and replenished by pumping water from the reservoir pond once a week. From the third month, the same amount of water was exchanged twice weekly.

Soil samples from the pond bottom were collected before and after the experiment to analyze the levels of organic matter, pH, available iron, phosphate and sulfate. Water quality was monitored twice weekly. Water temperature and dissolved oxygen (YSI model 57) were determined between 08:00 and 09:00, turbidity with a Secchi disc, and pH with a portable pH meter (Accumet Basic, Fisher Scientific). Water samples were analyzed for nitrite-nitrogen (NO_2-N) and ammonia-nitrogen (NH_3-N) following the methods of Strickland and Parsons (1972).

Twenty-five fish were sampled for weight using a seine net every 15 days to monitor

Table 1. Composition (%)and proximate analysis (% dry matter basis) of experimental diets for *Clarias macrocephalus* juveniles.

	Diet 1[a]	*Diet 2*[a]	*Diet 3*[b]	*Diet 4*
Composition				
Chilean fishmeal	6	20		–
Soybean meal	5	30		–
Rice bran	70	31		20
Bread flour	9	9		–
Soybean oil	5	5		–
Mineral mix[c]	1	1		–
V-22[c]	1	1		–
Dicalcium phosphate	3	3		–
Chicken entrails	–	–		80
Proximate analysis				
Moisture	10.4	8.5	8.8	72.7
Crude protein	19.0	34.2	28.9	31.7
Crude fat	12.8	9.5	11.1	29.7
Nitrogen-free extract	53.0	36.4	48.4	24.6
Crude fiber	5.8	5.8	4.7	7.2
Ash	9.4	14.2	8.4	6.8
Gross ME (kcal/kg)[d]	4032	3679	4091	4910
Protein to energy ratio (P/E)[e]	47	93	71	64

Analyses according to AOAC (1990)
[a] SEAFDEC/AQD-formulated diets
[b] Commercial feed pellet
[c] Commercial pre-mix
[d] Metabolizable energy values (kcal/kg): protein 4; fat 9; nitrogen-free extracts 4
[e] P/E = mg protein/kcal energy

growth and adjust the feed ration. During sampling, fish were anesthetized with 400-500 ppm ethylene glycol monophenyl ether. After harvest, fish were sampled and graded according to body weight.

The proximate compositions of the experimental diets and fish carcasses before and after the experiment were determined according to AOAC (1990). Moisture was determined using a moisture balance. Crude protein was determined by the semi-micro Kjeldahl method, crude fat by the Soxhlet extraction method, and crude fiber in a fat-free material sample by dilute acid and alkali treatment. Ash content was determined in a muffle furnace at 550˚C while nitrogen free extract (NFE) was calculated as the remainder of the dry ingredients.

A taste test was conducted using the Hedonic scale (Land, 1985) on odor, flavor and general appearance or texture of steamed, saltless fish samples taken from each replicate and pooled for each treatment. The fish samples were held in 60-l fiberglass tanks with aeration for about 36 h and then cleaned and steamed for 15 min before testing. A score sheet was provided to each assessor with the Hedonic scale scoring: 9 - like extremely, 8 - like very much, 7 - like moderately, 6 - like slightly, 5 - neither like nor dislike, 4 - dislike slightly, 3 - dislike moderately, 2 - dislike very much and 1 - dislike extremely. The panel was composed of seventeen assessors who were non-smokers and washed their mouths after tasting each sample.

Mean values of body weight, total length, specific growth weight, daily weight gain, FCR, survival, condition factor, production, apparent lipid retention and protein efficiency ratio were compared by analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (SAS, 1988). Differences between means were considered significant at $p<0.05$.

Results

The mean weight, total length, daily weight gain, specific growth rate, condition factor and production of fish fed Diet 2 were significantly higher than those of fish fed Diets 1, 3, or 4 (Table 2). The FCR of Diet 3 was better but not significantly different from than of Diet 2.

Table 2. Growth, survival, feed conversion ratio (FCR), condition factor, apparent lipid retention (ALR) and protein retention ratio (PER) of *C. macrocephalus* fed four diets for 120 days (±SEM). Initial mean body weight 3.6±0.1 g and total length 78.0±0.1 mm.

	Diet 1[a]	*Diet 2*[a]	*Diet 3*[b]	*Diet 4*
Mean body weight (g)	30.2±0.9^{c}	108.9±2.7^{a}	58.3±2.7^{b}	67.4±2.4^{b}
Mean total length (mm)	154.3±0.0^{c}	232.8±0.7^{a}	190.8±0.6^{b}	203.2±0.3^{b}
Daily weight gain (g/day)	0.2±0.0^{c}	0.9±0.1^{a}	0.5±0.1^{b}	0.5±0.1^{b}
SGR (%/day)[1]	1.8±0.0^{c}	2.9±0.1^{a}	2.3±0.1^{b}	2.4±0.1^{b}
Survival (%)[2]	73.1±3.1^{a}	67.7±8.4^{a}	81.2±4.0^{a}	72.4±6.3^{a}
Production (kg/25 m^2 pen)	4.86±0.3^{c}	17.82±1.1^{a}	11.10±1.1^{b}	11.55±0.3^{b}
FCR (feed given/weight gain)	3.4±0.3^{b}	2.5±0.2^{a}	2.3±0.1^{a}	5.0±0.3^{c}
Condition factor[3]	0.8±0.0^{ab}	0.9±0.0^{a}	0.8±0.0^{ab}	0.8±0.0^{b}
ALR (%)[4]	78.0±6.4^{b}	131.7±14.5^{a}	95.0±4.3^{b}	89.6±5.3^{b}
PER[5]	1.7±0.2^{a}	1.3±0.2^{a}	1.6±0.1^{a}	2.4±0.1^{b}

Means within a row with different superscripts are significantly different ($p<0.05$).
[1]Specific growth rate = (ln final wt - ln initial wt)/days x 100
[2]Arcsin transformed
[3]Condition factor = weight in g/(length in cm)^3 x 100
[4]Apparent lipid retention = (final body lipid - initial body lipid)/total lipid fed x 100
[5]Protein efficiency ratio = weight gain/protein fed

Survival rates were similar in all treatments. Catfish fed Diet 2 had the highest apparent lipid retention but their protein efficiency ratio did not differ from those of fish fed Diets 1 or 3.

In catfish fed Diet 1, all of the fish were less than 81 g (Fig. 1). In catfish fed Diet 2, 93.3% of the fish weighed above 80 g. In catfish fed Diet 3, 91.7% weighed less than 81 g and in catfish fed Diet 4, 81.7% were below 81 g and 18.3% were above 80 g.

Crude protein was higher in fish fed Diets 2 or 3 than in fish fed Diets 1 or 4 (Table 3). Catfish in all treatments became fatty at the end of the experiment; crude fat was highest in fish fed Diet 4 and lowest in Diet 3. Ash content was highest in fish fed Diets 1 or 2, NFE was highest in fish fed Diet 3.

Soil quality after harvest did not differ among treatments. pH was 7.5, organic matter was 0.74%, available phosphate was 481 ppm, available iron was 0.02 ppm and available sulfate was 0.28 ppm. Compared to the initial values, organic matter and available phosphate increased, while available iron and sulfate decreased.

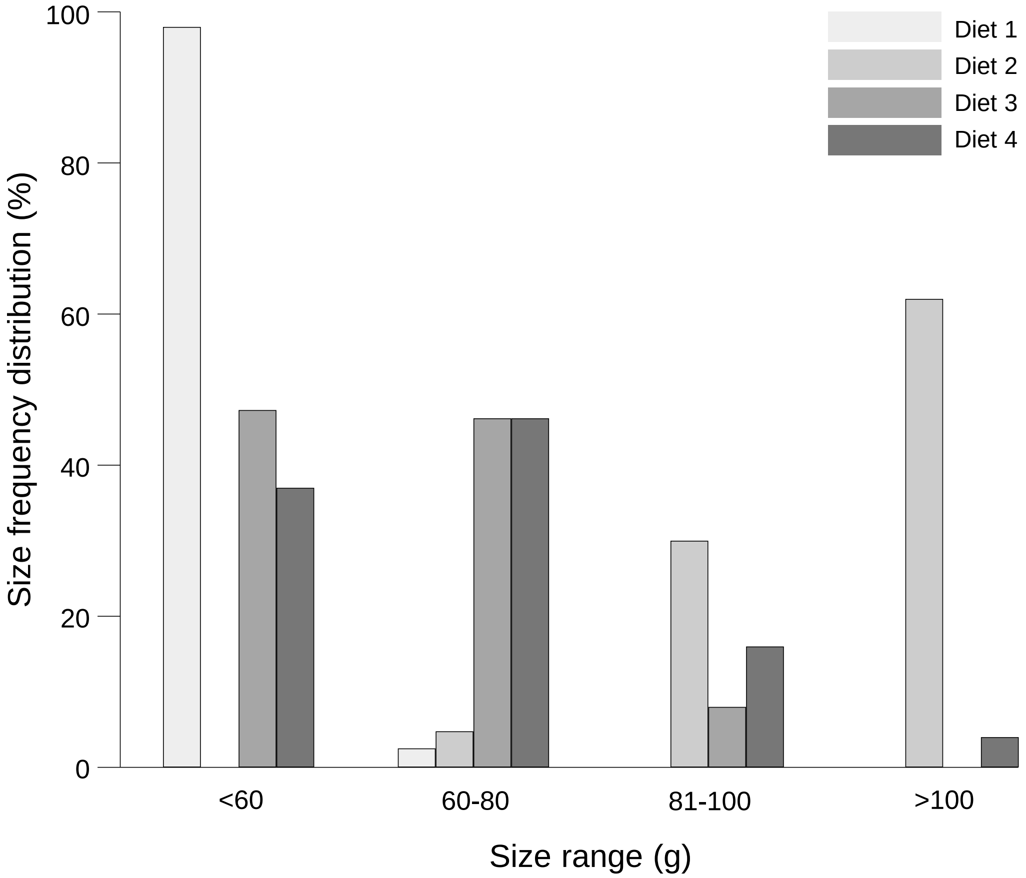

Fig. 1. Size distribution of Asian catfish *Clarias macrocephalus* fed four different diets for 120 days.

Table 3. Proximate whole body composition* (% on dry matter basis ±SEM) of *C. macrocephalus* fed four diets for 120 days (means of three replicates).

	Initial	*Values at harvest*			
		Diet 1	*Diet 2*	*Diet 3*	*Diet 4*
Moisture	91.1	70.9±0.9[a]	71.0±0.5[a]	73.7±0.5[a]	60.7±1.5[b]
Crude protein	65.4	51.8±1.0[b]	54.5±0.6[a]	56.1±0.4[a]	49.8±1.5[b]
Crude fat	9.7	27.8±0.5[b]	28.3±0.3[b]	22.0±0.2[c]	34.5±1.5[a]
Ash	14.7	14.5±0.2[a]	14.2±0.3[a]	12.4±0.1[b]	10.6±0.3[c]
Nitrogen-free extract	10.0	5.8±0.9[b]	3.0±1.2[b]	9.4±0.6[a]	5.1±1.2[b]

Means within a row with different superscripts are significantly different ($p<0.05$).
*Crude fiber was 0.14% at the start of the experiment; levels were lower than 0.05% in all treatments at the end.

The pond water varied little throughout the experiment in all treatments. Physico-chemical parameters were within the optimum ranges reported by Boyd (1990). Turbidity was lower (25 cm) and NH_3-N was higher (1.16 ppm) in the fourth month of culture in some Diet 2 pens. Water parameters ranged temperature 26-30°C, pH 6.5-7.9, DO 1.3-8.8 ppm, NH_3-N 0-1.16 ppm and turbidity 25-95 cm.

Taste analysis showed that the odor, flavor and appearance of all treatments were "slightly liked" by the panel and did not significantly differ among treatments.

Discussion

C. macrocephalus fed a diet of 34.2% crude protein (Diet 2) attained the best growth and yield, with 63.3% of the harvested catfish weighing more than 100 g. The average body weight was 38%, 46% and 72% higher than that of the catfish fed Diets 1, 3 and 4, respectively. Catfish culture usually takes 5-6 months. By using Diet 2, the desired body weight can be attained within a shorter period.

The significantly higher growth of the catfish fed Diet 2 may be attributed to the composition of the feed, which approximated the nutritional requirements of *C. macrocephalus* juveniles. Among the treatments, Diet 2 had the highest amount of crude protein, the lowest amount of energy and the highest P/E ratio. The P/E in Diet 2 could have explained the good growth and feed efficiency in catfish fed this diet. Catfish are carnivorous and require great amounts of protein for growth. For example, the protein requirement for *C. batrachus* ranges 30-40% and for *C. gariepinus* 40-42% (Van Weerd, 1995). The final harvest weight (109 g) of *C. macrocephalus* in the present study is comparable with the harvest weights of 96-130 g in 4-5 months reported by Kwei Lin (1990) and 100 g in 3-4 months reported by the IFFP (1998). Further, the survival of 68-81% was not influenced by the diet used. Kwei Lin (1990) reported survival of 54-92% when *C. macrocephalus* were reared in polyculture with *O. niloticus* in cages suspended in ponds. One way to increase the survival of catfish is to select bigger uniform-sized fingerlings to minimize cannibalism.

Sumagaysay et al. (1991) suggested that the economical diet for milkfish of 24% protein can be lowered if the amino acid requirements are considered. The amino acid requirements of *C. macrocephalus* were not considered in the formulation of the diets in the present study because these data are not available. Diet 1 was formulated as a protein supplement to the natural food in the pond (Robinson, 1991). The amount of natural food might have been insufficient to compensate for the protein-deficiency of Diet 1, with slow growth and low yield as the result.

The increase in organic matter and phosphate in the soil after harvest may be due to increased organic loading of pens caused by the feeding. The decrease in available mineral components such as iron and sulfate may be due to assimilation by *E. crassipes*, *I. aquatica* or another algae, or by trapping in the pond sediment.

The unacceptable physico-chemical parameters in the water samples of some pens fed Diet 2 may be attributed to the high volume of feed given which increased fish excreta, resulting in high organic loading. This reduced water quality and may have affected survival. The higher protein content of Diet 2 may have affected the ammonia level in the pond water. The lowest recorded DO was 1.3 ppm, but *Clariid* catfishes have an arborescent organ for breathing air that can increase their tolerance to adverse DO conditions.

The catfish fed the commercial fish pellets (Diet 3) had similar growth to those fed chicken entrails and rice bran (Diet 4) but the catfish fed Diet 4 contained a higher amount of crude fat and yielded fattier fish. Robinson and Robinette (1993) reported that fattiness in catfish has been identified as a major problem in the commercial catfish industry. An increased fat content is responsible for the poor keeping quality and decreased yield of processed products. Using chicken entrails as feed has many disadvantages such as storage and availability, difficulty of preparation, and blanching which may not sufficiently eliminate bacteria. Although the taste test analysis showed no off-flavor in fish fed Diet 4, or in any other diet, the use of chicken entrails may be practical for a backyard fishpond operation but not in intensive commercial culture. Under the experimental conditions of this study, a diet of about 34% crude protein resulted in the best growth and yield of *C. macrocephalus* in a relatively short period.

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