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Original Article

Development of low-cost feeds for fattening of native catfish, *Clarias macrocephalus*

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Abstract: Growth performance, survival, and feed efficiency in native catfish, *Clarias microcephalus*, fed chicken entrails, earthworm meal, and low-value fish meal were investigated. A simple cost-benefit analysis using this fattening approach was done to evaluate the profitability of using these low-value feed ingredients. Nine 30L aquaria were stocked with native catfish juveniles (about 20 cm in total length and 80 g in weight) at a density of 1 fish per liter. The catfish were fed cooked chicken entrails (Treatment 1), earthworm meal (Treatment 2) and low-value fish meal (Treatment 3) at 3% body weight for 60 days. At the end of the feeding trial, the growth of the fish fed various low-cost feeds was not significantly different. Survival was better in fish fed cooked chicken entrails than with either earthworm meal or low-value fish meal. Feed conversion efficiency (FCE) was relatively similar among the three types of feeds. A simple cost-benefit analysis using these low-cost feeds showed a return of investment (ROI) of 68-79%, indicating the feasibility of using these feeds for fattening of catfish. These preliminary results show that utilizing low value feed ingredients or food wastes as sources of feeds during fattening of native catfish are feasible. In addition, food wastage is reduced by bringing these food sources back to the food chain during aquaculture operations.

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Introduction

The rapid global expansion of freshwater aquaculture in recent years has resulted increasing the industry and number of fish species that are being utilized (Mather and de Bruyn, 2003). Fishing production has reached its limit, which calls for an increase of fish supply from aquaculture (FAO, 2012). Aquaculture currently produces about 50% of the world supply of fisheries products for direct human consumption (Boyd, 2012). It is envisioned that aquaculture production will increase fish supply and bridge the gap between fish supply and demand.

One potential area for aquaculture development is tapping the rich freshwater resources. In the Philippines, there are at least 10,000 hectares of freshwater ponds and 250,000 hectares of inland freshwater resources that can be developed for freshwater aquaculture (PSA, 2018). However, very few species are being utilized for aquaculture. The freshwater Asian catfish, *Clarias macrocephalus* is one of the most important but declining fishes in the Philippines (Tan-Fermin, 2003). World production of catfish had been dominated by the hybrid species of *C. gariepinus* x *C. macrocephalus* (FAO, 2003). Though native catfish i.e. *C. macrocephalus* has been overtaken by the African catfish, *C. gariepinus* as a preferred catfish species in aquaculture, there is still high demand for native catfish because of its superior meat quality and flavour (Coniza et al., 2008). Hence, there is a huge potential to develop native catfish as an aquaculture species.

Catfish culture requires the formulation of efficient food to meet the protein requirements of fish during grow-out period. Protein is the most expensive macronutrient in the fish diet (Pillay, 1990) and amount of the protein in the diet should be just enough for fish growth. Although native catfish is an omnivorous species, fish meal is still considered as

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main animal protein source when developing formulated diets for this species. Alternatively, the use of cheap and locally available resources could provide a way to reduce the total production costs (Edwards and Allan, 2004; Munguti et al., 2012). One approach that can reduce the cost of animal feeds is the use of farm and food wastes, agro-industrial by-products or household wastes, either as direct feeds or incorporated as components of feeds along with other ingredients that will meet the nutritional requirements of native catfish (Aletor, 1986; Fagbenro and Arowosoge, 1991).

Current estimates revealed that about 40–50% of catfish farmers still use wet farm-made feeds from locally available feedstuffs that have wide variations in their composition and nutritional value (Edwards et al., 2004). The lack of efficient diets remains one of the bottlenecks in the development of native catfish culture in the Philippines (Coniza et al., 2003), therefore, there is a need to explore some of these alternative feed ingredients that are suitable for catfish culture. Once these feed ingredients are identified, these can be further developed into commercial diets for native catfish. Hence, this study aimed to assess the efficiency of selected locally available feed sources that can be used in the grow-out culture or fattening of native catfish. The feasibility of using these feed ingredients was also determined using a simple cost-benefit analysis.

Materials and Methods

Experimental procedure: The study was conducted in Aquatic Science Laboratory (ASL) at Western Philippines University-Puerto Princesa Campus, Palawan, Philippines. The native catfish were obtained from the local suppliers in the municipalities of Quezon and Roxas, Palawan. A total of 27 fish with average body weight of 81.9±10.6 g were used as experimental animals. The fish were placed in glass aquaria and acclimated to experimental conditions for 2 weeks.

A total of nine (9) rectangular glass aquaria (0.65x0.25x0.31 m) were used. The following low-cost feeds were assigned into three treatments, viz. cooked chicken's entrails (Treatment 1), earthworm meal (Treatment 2), and low-value fish meal (Treatment 3). The tank replicates were assigned using complete randomized design in triplicate. Each aquarium was filled with 30L and aerated 24 hours before stocking. Fish were stocked in each aquarium at a density of 3 fish per aquarium. All aquaria were covered with black plastic sheet to simulate the natural habitat.

Water quality was monitored for pH and temperature weekly at 09.00 a.m. using appropriate water kits. Dissolved oxygen was monitored using an oxygen meter (HI 9143 Microprocessor Oxygen meter HANNA, USA). Debris at the bottom of the tanks was siphoned out daily while total water exchange was done every two weeks after sampling.

Feeding and sampling: All diets were divided into small portions and stored in the freezer. On the day of feeding, each portion was thawed and fish fed twice a day (09.00 and 17.00) at 3% body weight for 60 days. Fish mortality was monitored daily. Individual fish in each tank was weighed at the start and every 15 days to monitor growth and feed utilization. For the purpose of measuring growth parameters, all fish were taken from each aquarium replicate and measured for total length and weight. The length was measured using 30 cm ruler; while weight was measured using a weighing balance. After each sampling, survival (%), specific growth rate (SGR), feed conversion efficiency (FCE) and growth rate (GR) was calculated using the formula given by Aderolu et al. (2010). At the end of the study, a simple cost benefit analysis was done by computing the return of investment (ROI) in a 500 m^2 earthen pond using the data of the present study.

Statistical analysis: Means and standard error (SE) of each zootechnical parameter were computed. All statistical computations were performed at the 0.05 probability level. Data for all zootechnical parameters of treatments were analysed using One-Way Analysis of Variance (ANOVA). When ANOVA revealed significant differences, then Duncan's multiple-range test (Zar, 1999) was applied to characterize and quantify the differences between treatments. Analyses

Table 1. Zootechnical parameters of catfish fed various low-cost feeds.

Growth Parameters	Chicken entrails (Treatment 1)	Earthworm meal (Treatment 2)	Low-value fish meal (Treatment 3)
Initial Weight (g)	86.81±7.93	82.12	76.92
Final Weight (g)	108.26±6.94	92.44	110.59
Weight gain (g)	21.45±2.00	10.32	33.67
Initial Length (cm)	23.04±0.59	22.00	22.33
Final Length (cm)	24.5±0.67[c]	22.88[a]	23.75[b]
Length gain (cm)	1.46±0.3[c]	0.88[a]	1.42[b]
Specific Growth Rate %/day	0.37±0.03	0.20	0.61
Feed Conversion Efficiency (%)	12.3±0.38	6.73	20.33
Survival rate (%)	100±0.00[a]	77.78b	77.78[b]

Values in each row with different superscripts indicate significant difference at $P<0.05$. N= 3 tank replicates per treatment.

were performed using Microsoft Excel 2010.

Results and Discussions

The zootechnical parameters of native catfish fed different low-cost feeds are shown in Table 1. After a 60-day fattening period, catfish fed three different types of feeds had increased in weight ranging 10 to 34 g. In terms of the weight gain and final weight, no significant differences were observed among treatments, demonstrating that these low-cost feed ingredients had similar effects in the growth of the fish. However, in terms of average final length, significant differences ($P<0.05$) were obtained among treatments, with catfish fed chicken entrails contributed to the highest average length of the fish.

Survival rates of catfish were significantly different ($P<0.05$) among the treatments, with highest survival in fish fed chicken entrails (100%). The groups fed earthworm meal and low-value fish meal had similar survival rates (77.78%). The mean feed conversion efficiency (FCE) ranged from 12 to 20%; however, no significant differences ($P>0.05$) were observed between the treatments.

Proximate analyses of the feed ingredients were within the values in previous published studies. Chicken entrails had moisture content of 76-83%; crude protein content of 56%; ash content of 11% and fat content of 2.5% (Seong et al., 2015; Kwikiriza et al., 2016). Low-value fish meal had the following proximate composition: moisture content of 77-80%, crude protein content of 70%; ash content of 2.5-4% and fat content of 0.5-3% (Emre et al., 2003; Ramalingam et al., 2014; Kwikiriza et al., 2016). Earthworm meal contained 57-64% moisture; 18-24% crude protein; 0.9-1.2% ash and 0.5-1.8% fat (Finke, 2002).

A simple cost and return analysis is shown in Table 2. The return of investment (ROI) for rearing native catfish in a 500 m^2 pond using the zootechnical data from the small-scale study were 68.37, 71.18 and 79.47% for low-value fish meal, chicken entrails, and earthworm meal, respectively.

The native catfish is one of the important aquaculture commodities in the Philippines. According to Coniza et al. (2008), it is valued as a food fish in most Southeast Asian countries due to its tender and delicious flesh. Small-scale fish farmers consider this species to have a good potential for aquaculture. Due to the abundance of these low-value sources of feeds for catfish, the present study determined the growth, survival, feed efficiency and simple cost and return analysis of native catfish using these locally available feeds (chicken entrails, earthworm meal and low-value fish meal). Based on the results, the growth performance of catfish in terms of weight gain was similar when fed either of the chicken entrails, earthworm meal or low-value fish meal. Marketability of the fish is influenced by its weight and native catfish are usually sold in 80-200 g (SEAFDEC/AQD, 2009). The catfish were of harvestable sizes during the

Table 1. Simple cost-benefit analysis of catfish fattening using low-cost feeds.

Technical basis	Chicken entrails (Treatment 1)	Earthworm meal (Treatment 2)	Low-value fish meal (Treatment 3)
Stocking rate (fish/m^2)	3.00	3.00	3.00
Total stock (fish/500 m^2)	1500.00	1500.00	1500.00
ABW (g) @ stocking	82.00	82.00	82.00
Culture period (days)	60.00	60.00	60.00
Growth increment (g/month)	13.13	5.22	14.29
ABW (g) @ harvest	108.26	92.44	110.59
Survival (%)	100.00	78.00	78.00
Yield (kg)	162.39	108.15	129.39
Feed conversion rate	1.37	0.75	2.26
Total feed consumed (kg)	53.90	9.16	75.60
Operational Cost (Philippine Peso, PhP)			
Labor @ Php 275.00/day	6000.00	6000.00	6000.00
Native catfish @ Php40/kl	731.71	731.71	731.71
Feeds	4652.00	500.00	2490.00
Total operational cost	11384.00	7232.00	9222.00
Return (Philippine Peso, PhP)			
Sales @ Php 120	19487.00	12979.00	15527.00
Profit	8103.00	5747.00	6305.00
Return on Investment (%)	71.18	79.47	68.37

N = 3 tank replicates per treatment.

fattening experiment, but since the fish were thin, they were further reared in the aquaria for two months to increase their weight and selling price.

In terms of growth performance, the locally available feed ingredients can be used as feeds for the fattening of native catfish, however, only chicken entrails resulted in 100% survival of the fish stock in this study. The survival of catfish fed chicken entrails was higher than those of Nahar et al. (2000) and Coniza et al. (2008), which was 83 and 81%, respectively. Among the low-cost feeds for catfish culture, the use of chicken entrails is popular based on earlier studies of Nahar et al. (2000) in African catfish fry and Coniza et al. (2008) in native catfish fingerlings. In fact, use of the chicken entrails has been recommended by Yaakob and Ali (1994) for the canvass tank culture of hybrid catfish in Malaysia. The authors stressed that catfish farmers still prefer to use this feed than commercial feed pellets because the former is cheap and readily available. The culture of catfish using earthworm as a replacement for fish meal was done by Omeru et al. (2016) and demonstrated the potential of earthworm as an alternative ingredient in formulating feeds. The survival (75%) recorded by Omeru et al. (2016) was comparable with our result (78%). Based on literature review, most of the studies conducted on catfish are Thai catfish and African catfish (Nahar et al., 2000; Akegbejo-Samsons and Fasakin, 2008; Adewumi, 2015; Tunde et al., 2016). Further, these previous studies focused on fry and fingerlings using commercial and formulated feeds as well as natural feeds.

The feed conversion efficiency (FCE) of 6.73% for native catfish fed earthworm meal was lower than the FCE of 12.83% that was obtained by Omeru et al. (2016) in African catfish fed formulated feeds containing earthworm ingredients (50% earthworm and 50% fishmeal). The differences in the ages of the fish during the experiment could have contributed in disparity of the results.

The economic potential of native catfish for fattening is promising because based on the simple cost analysis, the ROIs were in the range of 68-79%. The fish readily accept these locally available and cheap feed sources. Small-scale farmers can easily adapt this technique of fattening catfish in portable canvass tanks (Yaakob and Ali, 1994) for 1-2 months resulting in better profits. In general, catfish aquaculture technology is simple and easily adaptable. The fish can be marketed live or profits can be enhanced through selling cooked products.

In conclusion, the three types of feeds can be used for the culture of catfish because they have same growth and feed efficiency. Survival is best attained when catfish fed chicken entrails and in terms of profitability, both chicken entrails and low-value fish meals are recommended for fattening or commercial production. Future studies needs to be done to develop proper formulations for development of artificial feeds to enhance growth, nutrient absorption and minimize wastage of raw materials.

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