Research Article

Effects of Feeding Levels on Production Characteristics of Pond-Raised African Catfish in Pond Culture System of Pakistan

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Abstract | A fish species (African catfish, *Clarias gariepinus*) with high growth and production potential was imported from Thailand and acclimatized in the local environment of Pakistan. For the successful culture of any fish species, the knowledge about the proper feeding regime especially the appropriate amount feed offered, is very important. To determine the optimum feeding level for African catfish culture, an experiment was conducted in earthen ponds of size 0.02 hectare each, for the period of four months at a stocking rate of 10,000 fingerlings per hectare (500 fish/acre). The experiment design was CRD with four treatments (2%, 4%, 6% and 8% feeding level of wet fish body weight daily) having 3 replications. The feeding the fish at higher levels showed higher final weight and weight gain, percent weight gain and specific growth rate. The values of Feed Efficiency (FE) and Food Conversion Ratio (FCR) were best at the lower feeding levels. Although maximum weight gain is 8% feeding level, yet based upon cost benefit analysis, feeding at 4% rate was considered best. The economic profitability for the culture of African catfish in earthen ponds showed that net profit is increased on increasing feeding level from 2 to 4% of wet fish body weight, however, upon further increase in feeding level from 6 and 8%, the feed cost was increased that decreased the net profit. So, it was concluded that the feeding level of 4% wet fish body weight was optimum for economical production of African catfish in earthen pond culture system of Pakistan.

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Introduction

The knowledge about the proper feed is very important because fish feed accounts for 40-50% of the production costs for the fish culture. The development of new balanced commercial diets, the proper feeding regime especially the appropriate amount feed offered is very important to promote optimal fish growth and health. The cost if fish production can be reduced tremendously reduced if fish is fed at the optimum rate. Feeding rate is affect the water quality, survival, health, growth, and fillet composition (Davies *et al.*, 2006). One problem that is faced by fish culturists is to determine a balance

between rapid growth of fish and optimal use of feed (Gokcek *et al*., 2008). The water quality, immunity, fish health as well as fish growth are directly influenced by feeding rates (Lee *et al*., 2000; Dwyer *et al*., 2002; Garcia *et al*., 2010). Due to the return of appetite from gastric evacuation, the optimal feeding rates may enhance growth by improving the intake of food (Riche *et al*., 2004). However, the overloading of fish stomach and intestine due to overfeeding leads to decrease in digestive efficacy and reduced feed consumption and utilization (Du *et al*., 2006). Both over feeding and under feeding affect the cost of fish production (Mihelakakis *et al*., 2002) and physicochemical parameters of water quality (Ng *et al*., 2000). The rate of feeding is affected by many factors like the fish size, its type, the system used to culture it (Chou *et al*., 2003) and the nutrients availability in the feed stuff. Maximum growth rate at reduced cost could be attained by the regulation of the feeding rates (Mihelakakis *et al*., 2002; FAO, 2012).

African catfish *Clarias gariepinus* (Burchell, 1822) is an extremely important fish from commercial point of view and it is widely cultured in different regions of the world other than Pakistan. It is native to Africa and it has been introduced by many Asian and European including Thailand, Malaysia, Indonesia, Germany, Netherlands and Belgium. The characteristics i.e., fast growth rate, high stocking densities, diseases resistance, wider environmental conditions tolerance ranges and profitability makes this one of the favorable fish for aquaculturists (Huisman and Richter, 1987; Hogendoorn, 1980; Goos and Richter, 1996; Haylor, 1992). The feeding habit of African catfish is generally omnivores. This fish feed on plankton, insects, plant matter and snails present in the natural water bodies (Uys, 1989). When significant differences in size occur during its rearing period this species become highly cannibalistic which can be controlled by efficient feed managements and periodic gradings (Baras and Jobling, 2002). The potential of this fish species for the fish culture system of Pakistan was tried to be explored (Basharat *et al*., 2020). The objective of the study was to determine the optimum feeding level to get maximum growth and profitability from its culture which would lead to development of better protocols of rearing African catfish for fish farmers in earthen pond culture of Pakistan.

Materials and Methods

Study site and experimental systems

The present study was one the experiments conducted to develop, African catfish diet from indigenous feed ingredients available in Pakistan. This experiment was conducted to determine the optimum feeding level for African catfish culture. The experimental system was the earthen ponds of size 0.02 hectare each, at a stocking rate of 500 fingerlings per pond, for the period of four months at Aquaculture and Fisheries Program, NARC, Islamabad.

Experimental design and procedure

The experiment design was CRD with four treatments (2, 4, 6 and 8% feeding level of wet fish body weight daily) having 3 replications. The aqua-feed of 35% crude protein was used to conduct this experiment.

Before stocking of fishponds, dikes were checked completely for leakages and apparent repairs. Excessive grass was removed from pond bottoms and ponds were dried completely and limed by using quick lime at the rate of 7-10kg/100m^2 for disinfection. Ponds were filled with water from tube well source up to the level of 2.5m and the water level was maintained at this level throughout the experiment. The fish offered feed two times daily in the morning and evening.

Evaluation of fish growth and feed utilization

Before the start of experiments, all fish were acclimated to the experimental condition for a period one week. Prior to the stocking of fish in experimental units, the initial data of fish was recorded. During the experiments period, the data regarding the fish growth were recorded on fortnightly basis and accordingly the amount of feed was adjusted. At end the experiments, all fish were caught with nets, number of fish survived and final weight were recorded. The growth parameters i.e., weight gain, percent weight gain, feed efficiency and specific growth rate (SGR), protein efficiency ratio (PER), feed conversion ratio (FCR) and survival rate was determined by using following formulae:

Weight gain = Mean final weight of fish – Mean initial weight of fish

Percent weight gain= final weight of fish – initial weight of fish/ Initial weight × 100

Protein efficiency ratio= Weight gain (g)/ Protein fed (g)

Feed efficiency= (Wt. gain/feed offered × 100)

Food conversion ratio = (Feed offered/Weight gain)

Specific growth rate (SGR)= {[(ln Wf – ln Wi) × 100]/ days}.

Wf: final weight; Wi: initial weight.

$$\text{Survival rate} = \frac{\text{Total number of fish harvested}}{\text{Total number of fingerlings stocked}} \times 100$$

Proximate analysis of feed and fish

After the preparation of fish diet, the proximate analysis was performed at Fish Nutrition Lab, NARC to determine moisture, dry mater, fat, fiber, percent crude protein and total ash. After the completion of experiment, three fish were sampled randomly from each treatment for whole body proximate analysis. The fish meat was crushed and its moisture and dry matter was determined. The obtained dry meat of fish was subjected to further analysis to find out its ash content, crude fiber, lipid and crude protein by standard methods (AOAC, 2003).

Water quality analysis

To determine suitability of water for fish, the water quality parameters (water temperature, dissolved oxygen, pH, alkalinity and hardness) were analyzed before start of experiment and at weekly intervals. The pH of the water was determined using a pH meter. Water temperature was recorded with digital thermometer. The reading was taken by dipping the sensor of thermometer in water. Other water quality parameters including alkalinity and hardness were determined through titration methods (Boyd *et al.*, 2016).

Data analysis

The significant differences among different parameters were checked by ANOVA (analysis of variance) and Duncan's Multiple Range test by using SPSS software. Relationship among the feeding levels, cost of feed and net profit was determined by MS Excel and correlation analysis.

Results and Discussion

The fortnightly growth trend of the pond raised African catfish under different feeding regimes is shown in Figure 1. This trend showed that the growth of African catfish significantly varied among the fish fed at different feeding levels. The growth of African catfish increased over time by increasing the feeding level. At the end of 4 months experiment the data for growth parameters like mean total weight, mean weight gain (WG), feed conversion ratio (FCR), specific growth rate (SGR) and percent weight gain (PWG) of African catfish are shown Table 1. A significant (P<0.05) difference was recorded in the final weight, weight gain, percent weight gain and specific growth rate among all the treatments. The feeding rate at 8% showed higher final weight and weight gain, percent weight gain and specific growth rate followed by 6% feeding rate, 4% feeding rate and 2% feeding rate, respectively. The values of feed efficiency (FE) and Food Conversion Ratio (FCR) were best at the lower feeding levels. The Food Conversion ratio (FCR) value was increased by increasing the feeding levels; the best FCR was recorded for 2% and 4% feeding level followed by 6% and 8% feeding level, respectively.

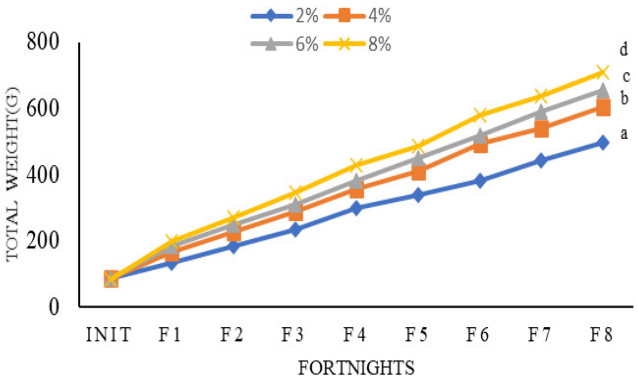

Figure 1: *Fortnightly growth trend of pond raised African catfish at different feeding levels. Different letters differ significantly (P<0.05).*

The data on production characteristics of pond raised African catfish at different feeding levels are summarized in Table 2. The economic profitability of using different feed application levels for the culture of African catfish in earthen ponds is shown in Figure 2. It is observed that net profit is increased on increasing feeding level from 2 to 4% of wet fish body weight. However, upon further increase in feeding level from 6 to 8%, the feed cost was increased that decreased the net profit and vice versa.

The composition of carcass of African catfish fed at different feeding levels in earthen ponds has been shown in Table 3. The body composition specifically crude protein contents of African catfish meat were non-significant (P<0.05) at variable feeding levels. High in lipids contents were found in the meat of fish fed at 6 and 8% body weight per day than that of the fish fed at 2 and 4% body weight per day. Ash contents was high and lipid content was lower in the fish offered with feed at 2% feeding rate as compared to fish fed at 4, 6 and 8% feeding rate.

Table 1: *Effects of feeding levels on growth parameters of pond-raised African catfish.*

Parameters	Feeding levels			
	2%	4%	6%	8%
Initial weight (g)	84.2±0.10a	84.7±0.12a	86.62±0.08a	84.4±0.15a
Final weight (g)	498.3±0.52d	603.2±0.32c	655.3±0.27b	708.6±0.43a
Weight gain (g)	414.1±0.34d	518.5±0.24c	568.6±0.19b	624.2±0.37a
Feed conversion ratio	2.0±0.01d	3.3±0.04c	4.4±0.03b	5.7±0.02a
Feed efficiency (%)	49.29±0.07a	32.97±0.05b	22.52±0.09c	17.30±0.06d
Specific growth rate	1.48±0.05b	1.63±0.08a	1.68±0.04b	1.77±0.09a
Percent weight gain (%)	491.8±0.14d	612.1±0.43c	656.6±0.56b	739.5±0.72a
Survival rate (%)	70.0±0.24b	91.4±0.15a	92.0±0.22a	94.0±0.26a

Means±SD/SE with different letters differ significantly (P<0.05).

Table 2: *Production characteristics of pond raised African catfish at different feeding levels.*

Parameters	Feeding levels			
	2%	4%	6%	8%
No of fish stocked	500	500	500	500
No of fish harvested	350	457	460	470
Total harvest (kg)	174.4	275.6	301.4	333.0
Total feed consumed (kg)	293.5	718.6	1161.5	1695.3
Cost of feed (PRs)	11743.02	28747.63	46462.82	67815.57
Income from fish (PRs)	43601.25	68920.17	75362.95	83269.9
*Net profit (PRs)	31858.16	40172.54	28900.13	15454.33

**Net profit= Income from fish-Cost of feed.*

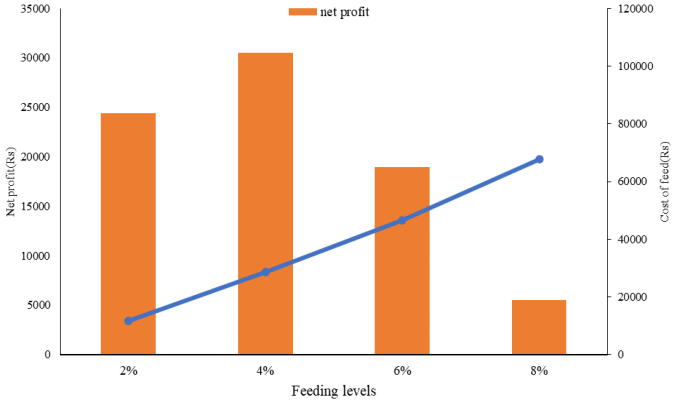

Figure 2: *Relationship between cost and profit at different feeding levels.*

Table 3: *Carcass composition of African catfish fed at different feeding levels in earthen ponds.*

Parameters	Units	Feeding levels			
		2%	4%	6%	8%
Dry matter (%)		10.20a	12.43a	12.30a	11.03a
Moisture (%)		89.80a	87.57a	87.70a	88.97a
Crude protein*		51.25a	54.18a	52.82a	53.23a
Crude lipid*		4.10b	4.63b	8.92a	9.38a
Ash*		21.02a	11.53b	13.05b	11.0b

*Means with different letters differ significantly (P<0.05). * Percentage of dry matter.*

Data regarding to various water quality parameters is summarized in Table 4. In the present study water quality does not seem to be influenced by the increased rate of feed application. Various physicochemical parameters including dissolved oxygen, temperature, and pH were within the appropriate ranges for culturing catfish and it was noted that apparently these parameters did not have any impact on the growth of catfish, as these remained optimal for all treatment groups.

The feeding trial was conducted to determine the effect of feeding rate on the growth performance of African catfish. A significant difference of growth and weight gain was recorded for African catfish fed at different feeding rates. The feeding the fish at rate 8% body weight showed higher final weight, weight gain, percent weight gain and specific growth rate followed by 6% feeding rate, 4% feeding rate and 2% feeding rate, respectively. This increase in weight gain may be due to the availability of feed to fish at satiation level. The increase in growth rate has been reported in other fish species like *Ictalurus punctatus* (Channel catfish), *Mystus nemurus* (bagrid catfish juveniles), *Piaractus mesopotamicus* (Pacu) and *Dicentrarchus labrax* (sea bass) with higher feeding rates (Eroldogan *et al.*, 2004;

Ng *et al*., 2000). Positive relationship of feeding rate and weight gain was also documented by (Seenappa and Devareaj, 1991; Sen *et al*., 1980; Cui *et al*., 1992; Tippayadara *et al*., 2016) in fingerling and juvenile Asian redtail catfish (*Hemibagrus wyckioides*) by using four feeding levels, i.e., 2, 3, 4 and 5%. Marimuthu *et al*. (2011) described that *Clarias gariepinus* fingerlings fed at commercial catfish feed under four feeding rates (2, 5, 8 and 12%) yielded significantly different final weights. African catfish fingerlings attained highest growth at 8 and 12% feeding level as compared to 2 and 5% feeding level. Similar results were reported by Sun *et al*. (2006) for cobia (*Rachycentron canadum*) juvenile giving a greater SGR when fed with 7% body weight per day as compared to 3% body weight per day.

Table 4: *Physico-chemical parameters of water in ponds of African catfish at different feeding levels.*

Parameters	Treatments	Ranges	Mean	Standard deviation
Temperature (°C)	2%	22.7.0-32.0	27.3	2.7
	4%	21.0-31.8	26.6	2.0
	6%	25.5-28.0	26.7	2.3
	8%	27.2-28.0	27.6	2.0
Dissolve oxygen (mg L^{-1})	2%	6.0-8.6	7.3	1.4
	4%	7.2-7.5	7.3	1.1
	6%	7.0-8.2	7.6	1.2
	8%	6.5-8.2	7.3	1.0
pH	2%	7.0-8.0	7.5	0.6
	4%	7.5-8.5	8.0	0.3
	6%	7.5-8.0	7.7	0.5
	8%	7.0-8.0	7.5	0.3
Alkalinity (mg L^{-1})	2%	178.4-228.0	203.2	8.0
	4%	170.5-189.5	180.0	9.1
	6%	174.7-208.3	191.3	7.2
	8%	171.4-195.3	183.3	8.4
Hardness (mg L^{-1})	2%	173.0-187.2	180.1	10.7
	4%	167.3-193.7	180.5	16.2
	6%	165.2-188.2	176.7	14.0
	8%	163.7-185.9	174.8	12.3

At lower feeding level, the poor growth for fish suggests that most of the consumed nutrients are used to maintain life and a small portion remained for growth. Same findings had been reported by Khandan *et al*. (2019) on snow trout Khan *et al*. (2004) on *C. mrigala*. The values of feed efficiency (FE) and Food Conversion Ratio (FCR) were best at the lower feeding levels. The food conversion ratio (FCR) was increased by increasing the feeding levels. The poor FCR for higher feeding levels may be due to waste of food and loss of nutrients. Similar results were also reported in *Schizothorax zarudnyi* (Khandan *et al*., 2019) *Heteropneustes fossilis* (Khan and Abidi, 2010).

Although weight gain is maximum at 8% feeding level, yet according to the cost benefit analysis, feeding at 4% rate is considered optimum. Other fish species like Channel catfish (*Ictalurus punctatus*), Bagrid catfish (*Mystus nemurus*) and European Sea Bass (*Dicentrarchus labrax*) also showed similar trend of growth increment at higher feeding rates (Eroldogan *et al*., 2004; Ng *et al*., 2000; Robinson and Li, 1999; Borghetti and Canzi, 1993). The increase in the feed application rate is helpful to survival rate and reduce the cannibalism of cannibalistic fishes. Similar results were obtained in present study as survival rate of African catfish was improved with increasing the feeding level. In several other fish species involving *C. gariepinus,* with increased food accessibility reduction in cannibalism has been described (Hecht and Pienaar, 1993; Polis, 1981).

The body composition African catfish especially moisture, ash and protein content were not affected by the different feed application rate. These results are in disagreement with the results of Khandan *et al*. (2019) in snow trout and Khan *et al*. (2004) in *C. mrigala*. These researchers observed the highest protein contents at 4%-6% feeding levels. Whereas body lipid content of fish was higher fed at higher levels than that of the fish fed at lower feeding rate. It has been established that, low lipid contents in body of fish are a consequence of fish fed with less than optimum feeding rate (Bureau *et al*., 2006; Chua and Teng, 1982) and low frequency of feeding (Lee *et al*., 2000; Dwyer *et al*., 2002; Ruohonen *et al*., 1998).

For the catfish farming, water quality is very important factor as the health and growth of the fish is affected by poor quality water. The findings of the present study showed, various physicochemical parameters were within the appropriate ranges for culturing catfish. For maintaining a healthy aquatic environment and for the production of sufficient number of organisms as natural fish food, the role of water quality parameters cannot be overlooked (Bhatnagar and Devi, 2013). Physicochemical characteristics of water body actually determine the aquaculture productivity (Huet and Timmerman, 1986).

Conclusions and Recommendations

The economic profitability of using different feed application levels for the culture of *Clarias gariepinus* in earthen ponds showed that net profit is increased on increasing feeding level from 2 to 4% of wet fish body weight, however, upon further increase in feeding level from 6 and 8%, the feed cost was increased that decreased the net profit and vice versa. Although weight gain is maximum at 8% feeding level, yet based upon cost benefit analysis, feeding at 4% rate was considered best for culturing African catfish in earthen ponds system of Pakistan.

Novelty Statement

For the successful culture of any fish species, the knowledge about proper feeding is very important. This experiment was conducted to determine proper feeding regime, especially appropriate amount of feed offered to African catfish culture in local conditions.

Authors' Contribution

Hasina Basharat: This paper is a part PhD study of 1st Author; she performed this research study.
Muhammad Ramzan Ali and Shamim Akhter: Supervised research**,** help in experimental setup and data analysis and manuscript writing.
Aziz Ahmed: Helped in experimental setup and data collection.
Rehana Kausar: Helped lab analysis, reviewed and edited the manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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