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Risk Management in Aquaculture by Controlled Feeding Regimen

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Abstract: Fish nutrition researchers often feed fishes at between 3-5% of their body weight daily. Environmental risks associated with excess feed leachate are so enormous in tropical waters leading to algal bloom which can toxify the aquaculture products and threaten their safety. Considering that feed requirements by fishes depend on a number of factors such as size, health status and the general condition of the culture environment; there is every need for the determination of the actual feed desired to meet their physiological needs, promote growth and reproduction based on peculiar conditions. This study was conducted to determine the appropriate feeding rate for tilapia, *Oreochromis niloticus* and consequential changes in the water quality. A 30% crude protein diet was fed to triplicate groups of *O. niloticus* fingerlings (10.13±0.58g) in glass tanks (75x45x40 cm) (20 fish/tank) at 2, 3, 4 and 5% body weight daily. The holding tanks were cleaned every two days after measuring the water quality parameters, pH, temperature and the dissolved oxygen. Results of the experiment indicated that the weight gain (WG, %) and specific growth rate (SGR) of the fishes fed at 3, 4 and 5% body weights were similar ($p>0.05$) but differed significantly ($p<0.05$) from the WG and SGR of the group of fishes fed at 2% body weight. However, there were no significant differences in FCR and PER of fishes fed at the various body weights. While the pH and the temperature of the culture media were not affected by the treatments, the dissolved oxygen was marginally lower in tanks fed at 4 and 5% body weights than in those fed at 2 and 3% body weights. The study established the optimum feeding rate for *O. niloticus* at 3% body weight daily, and the tendency for water quality deterioration with higher feeding rates.

Key words: Aquaculture production, dissolved oxygen, nutrient utilization

Introduction

For aquaculture to fulfil its potentials in both food and wealth creation, it is inevitable that fish farming will be conducted on an increasingly intensive scale and production methods will become more controlled and efficient (Talbot, 2002). Intensive aquaculture production will involve the use of supplemental artificial feeds to meet the nutritional requirements of the culture species. However, improper combinations of feed ingredients, feed formulations and feeding practices have lead to the production of feeds with low water stability and use of excess feeds culminating in feed leachates. Feed leachate into aquaculture systems results in the release of additional nitrogen (N), phosphorus (P), organic matter and trace elements into the water environment. Kerepeczki *et al*. (2002) reported annual nutrient discharge of about 5100kg N, 2900kg P and 29500kg organic matter from a catfish fish farm in USA, due to high level of feed remnants, faeces and excreta in the water. This increases the level of effluent generated by the system. Excess P loadings particularly has been associated with algal bloom leading to eutrophication especially in tropical waters. This problem becomes worse with intensive aquaculture because large quantities of feed are introduced to achieve increased fish production. As effluent treatment is relatively inefficient and costly, an alternative way is to consider feed ingredients, formulation techniques and feeding practices for devising techniques to lessen the damage (Parveen *et al.,* 2002). It would be ideal to practice aquaculture that increases fish production with less risk of environmental pollution or hazards and will reduce externalities.

Fish feed must be least cost to boost production and to raise the profit margin. Feed wastes add quantitatively to the total feed use and increases the total cost of fish production and lowering the profit levels.

Feed wastes, leachate, environmental risk management and the cost of feed/feeding could be minimized by feeding fishes with just enough quantities of feed to meet their physiological needs. Boujard (2002) reported that the present knowledge of the ecological consequences of feed wastes is far from exhaustive and recommended for further studies.

This project was conducted to determine the feeding regime for Tilapia (*Oreochromis niloticus*) and the effect of excessive feed/feeding on the water quality of the culture system.

Materials and Methods

Diet formulation: A diet was formulated to provide 30% crude protein (Table 1). Ingredients purchased from a local market in Akure were thoroughly mixed in a Hobbart A-200 (Troy Ohio USA) pelleting and mixing machine to obtain homogenous mass. The diet was passed through a mincer with die into 0.8 mm pellets

Table 1: Ingredients and proximate composition of the diet

Ingredients (g/100g/DM)	Diet
Fish meal (65% CP)	28.10
Shrimp head meal (52% CP)	22.60
Maize	28.30
Bone meal	3.00
Mineral premix	5.00
Vitamin premix	5.00
Cod liver oil	6.00
Carboxymethyl cellulose	2.00
Proximate Composition (g/100g DM)	
Crude protein	30.3
Ether extract	13.93
Nitrogen free extract	35.05
Crude fibre	3.65
Ash	10.71
Digestible energy (kcal/g/DM)	154.6
Protein energy ratio P/E mg/protein/kcal DE)	114.4

and immediately sun dried (30-32 ^oC) to constant moisture (< 10%) and stored in a freezer –20 ^oC prior to feeding. The proximate composition of the major feedstuffs and diets (Table 1) were carried out according to the procedures of the AOAC (1990). A factor of 6.25 was used to convert nitrogen to protein.

Growth experiment: Tilapia fingerlings, *Oreochromis niloticus*, (10.13±0.58g) were harvested from the Federal University of Technology Akure (FUTA) Teaching and Research Fish Farm, sorted and grouped into triplicate in glass tanks (70x45x45 cm) containing 70 litres of tap water each, at 20 fishes per tank. The fishes were acclimated by starving them for seven days before the feeding experiment. The total water in each tank was replaced two days after each successive feeding, and after the water parameters (Temperature, pH and dissolved oxygen were taken. The fishes were fed at 2, 3, 4 and 5% body weights twice daily (0900-1000 and 1500-1600h) for eight weeks. Weighing was done weekly using electronic top-loading balance (Model Mettler E200). Mean weight gain (WG), specific growth rate (SGR), protein efficiency ratio (PER) and food conversion ratio (FCR), were calculated were calculated from the weekly weight data as described by Olvera *et al*. (1990).

WG = Mean final weight-mean initial weight

SGR = 10^2 (Lnwt-Lnw0)/t, where wt is the weight of fish at time t, w0 is the weight of fish at time 0, and t is the culture period in days.

PER = Weight gain/protein fed

FCR = total dry feed fed/ total weight gain.

Measurement of water quality parameters: Water temperature was measured in the morning every other day (0800-0830h) using a temperature meter (JENWAY MODEL No. 9071 UK)

Dissolved oxygen concentration DO_2 was measured in the morning every other day (0840-0910h) using a DO_2 concentration meter (Digital DO_2 Meter JENWAY 9071, UK) calibrated in mg/l.

PH was measured with a pH meter every other day (0920-09500h) using pH MODEL NO. METTLER TOLEDO 20, UK.

Cost analysis: Profit index (PI) and incidence of cost (IC) were calculated from Vincke (1969) model as follows:

PI = Value of fish/Cost of feed

IC = Cost of feed/kg of fish produced

Exchange rate is fixed at N50 : US$1

Statistical analysis: Data resulting from the experiment were subjected to one way analysis of variance using SPSS (Statistical package for Social Scientists. Duncan multiple range test was used to compare differences among individual means at P = 0.05 (Duncan 1955).

Results

The gross composition of the experimental diet, and the proximate composition (Table 1) showed the crude protein content of the diet as 30.3%, ether extract 19.93, nitrogen free extract 35.05, crude fibre 3.65 and ash content of 10.71. The digestible energy of the diet was 154.6 (kcal/g DM) while the protein energy ratio of the diet was 114.4 (mg/protein/kcal DM). Table 2 shows that the mean weight gain of the fishes fed at different body weights ranged between 4.70 and 7.00, SGR 0.67 and 0.94, PER 0.68 and 0.78 and FCR 2.82 and 3.00. The results indicate that the mean weight gain (WG %) and specific growth rate (SGR) of the fishes fed at 3, 4 and 5% body weights per day were similar (p>0.05) but differed significantly (p<0.05) from the WG and SGR of the group of fishes fed at 2% body weight per day. However, there were no significant differences in food conversion ratio (FCR) and protein efficiency ratio (PER) of fishes fed at the various body weights. Analysis of cost (Table 3) indicated that the incidence of cost (IC) varied from 1.59 to 1.80, while the profit index (PI) ranged between 3.33 and 3.78. The table also explained that the fishes fed at 3, 4 and 5% body weights had slightly lower IC and higher PI than the group of fishes fed at 2% body weight. The trend shows a potential for increase in the PI with intensive aquaculture production. The results of the water quality parameters [Temp., pH and dissolved oxygen (DO_2)] of the culture waters are presented in Fig. 1-3. Fig. 1 shows that feeding the fishes at different body weights did not affect the temperature of the water used in culturing the fishes. The temperature ranged between 25 and 27 ^oC in 8 weeks. The pH of the culture tank waters (Fig. 2) varied from 7.5 to 8.0, and there were no significant differences in the values and no

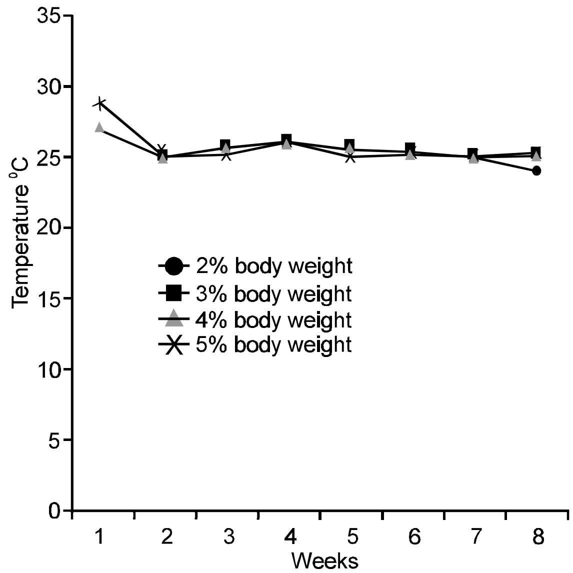

Fig. 1: Changes in water temperature of culture tanks for *O. niloticus* fed at different body weights

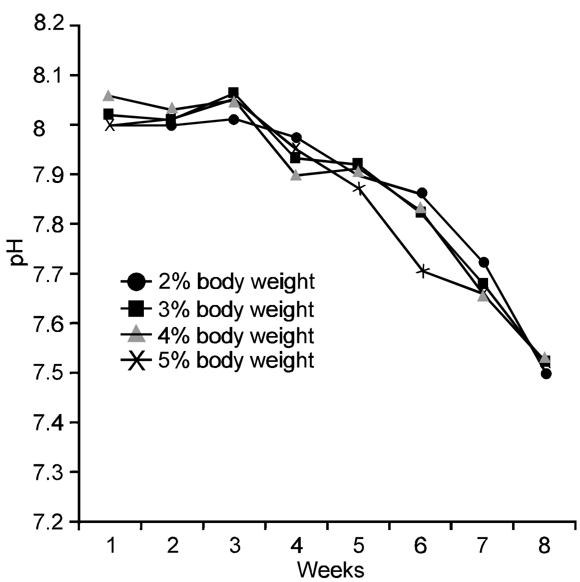

Fig. 2: Changes in water pH of culture tanks for *O. niloticus* fed at different body weights

consequences on the fish. However, the values decreased continuously as the quantity of feed supplied increased. This trend is similar with the DO_2 contents of the tank waters (Fig. 3). There were no significant differences in the dissolved oxygen levels, and the values varied from 6.5 to 8.5 during the period. The general trend of pH and the dissolved oxygen clearly shows a tendency for more reduction in the values and more water quality deterioration with intensive aquaculture production.

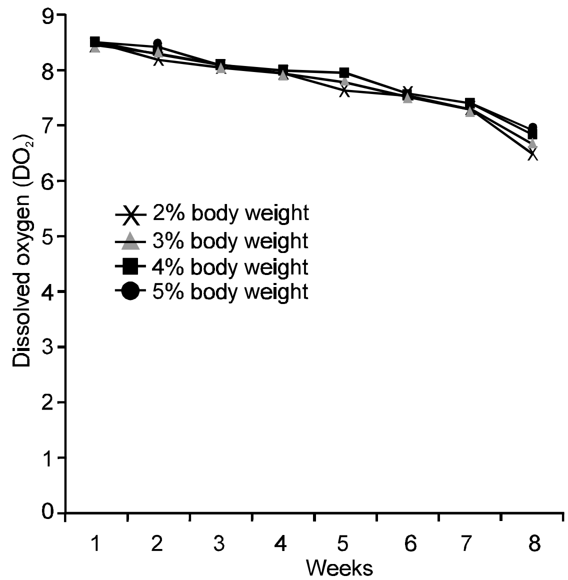

Fig. 3: Changes in water DO_2 of culture tanks for *O. niloticus* fed at different body weights

Discussion

Li *et al*. (1991) showed that protein energy ratio (P/E) of diets influences nutrient utilization and growth; and optimum/balanced P/E ratios boost the profitability of diets and protein sparing ability of the diets (Xiquin *et al*. 1994). Santiago and Laron (1991) obtained optimum P/E ratio requirements of red tilapia fed 30% protein diet as 100mg/kcal, and Li *et al*. (1991) recommended P/E ratio of 128 as optimum for *O. niloticus* fed 33.2% protein. The mean value of P/E ratio of 114.4 obtained from the present study compares favourably well with the values reported by Santiago and Laron (1991) and Li *et al*. (1991). The development of appropriate feeding regime for fishes is a major tool for fish culture effluents reduction and management, more so that such regimes do not affect the growth of fishes significantly. Lin and Yi (2003) reported no significant differences in the yield of Nile tilapia fed at 50, 75 and 100% of their body weights. This finding supports the results of the present study which showed no significant differences in the mean weight gain (%) and specific growth rate of Nile tilapia fed 3, 4 and 5% of their body weights. The comparison of the profit index obtained by feeding the fishes at 3, 4 or 5% of their body weights shows an insignificant differential of 1.4%. This indicates that a lot of costs could be saved by feeding the fishes at 3% instead of at 4 or 5%. In intensive commercial fish farming, where fish feed alone constitutes over 60% of the operating costs, this saved costs could transform into rewarding returns to investment.

Aquaculture feeds and feeding regimes can play a major role in determining the quality and potential environmental impact or not of finfish and crustacean

Table 2: Nutrient utilization of *O. niloticus* fed at different body weights

Parameters	Treatments			
	2%	3%	4%	5%
Initial mean weight (g)	10.3±.12[a]	10.1±.10[a]	10.0±.11[a]	10.1±.13[a]
Final mean weight (g)	15.0±.96	16.7±.91	16.9±.85	17.1±.92
Mean weight gain	4.7±1.0[a]	6.60±1.2[b]	6.90±1.1[b]	7.00±1.0[b]
Mean weight gain (%)	45.6±11[a]	65.3±11[b]	69.0±10[b]	69.3±9.8[b]
SGR	0.67±.13[a]	0.90±.12[b]	0.94±.11[b]	0.94±.12[b]
PER	0.68±.04[a]	0.73±.04 [a]	0.76±.03[a]	0.78±.05 [a]
FCR	3.00±.09[a]	2.84±.09 [a]	2.82±.08[a]	2.83±.06 [a]

Similar superscripts along the same row are not significantly different (p>0.05)

Table 3: Cost analysis for *O. niloticus* fed at different body weights for 56 days

Parameters	Treatments			
	2%	3%	4%	5%
Cost of feed fed (US$)	0.54	0.54	0.54	0.54
Total fish produced (kg)	0.30	0.33	0.34	0.34
Value of fish (US$)	1.80	1.98	2.04	2.04
Incidence of cost	1.80	1.64	1.59	1.59
Profit index	3.33	3.67	3.78	3.78

farm effluents (Tacon and Forster, 2003). Lin and Yi (2003) described that improving feeding efficiency through optimization of feeding regime ruduced nutrient input in Nile tilapia culture system, and resulted in non-significant differences in fish yield among daily feed rations at 50, 75 and 100% satiation, with escalation of nutrient loading with increasing rations. This observation is in line with the present study where feeding *O. niloticus* fingerlings at 3, 4 and 5% of their body weight neither affected the weight gain nor the specific growth rate of the fishes, but feeding at 4 and 5% resulted in slight and continuous decrease in the pH and dissolved oxygen concentrations of the culture systems. This decrease increased with increase in the quantity of the feed supplied. The decrease in the pH and DO_2 concentrations of the culture waters could be attributed to increase in the total suspended solids (TSS) from accumulation of uneaten feed, leached feed and faecal matters leading to increase in biological oxygen demands (BOD) and a tendency for water quality deterioration. This assertion confirms the work of Michael Jr. (2003) who reported that nutrients in Salmon hatchery wastewater increased the total solids, phosphorus and nitrogen compounds leading to reduction in BOD of the in fluent water. Water quality deterioration as a result effluent discharges and accumulation of TSS, P and N, has also been reported (Yokoyama, 2003) as the factor that lead to the enactment of Law to ensure sustainable aquaculture production and management of effluents in Japan in 1999. The trend of results and findings from the present study established that feed wastes, feed costs and water quality deteriorations could be minimized by the development of accurate/appropriate feeding regime in aquaculture programmes. This in turn will reduce the risk involved in the management of aquaculture effluents and the impact of externalities.

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