EFFECTS OF VARYING PROTEIN LEVELS ON *Clarias gariepinus* (BURCHELL, 1822) GROWTH, PROTEIN UTILIZATION AND YIELD IN HAPA SYSTEM

ABSTRACT

The study evaluated effects of varying dietary protein levels on growth, protein utilization, survival and yield of the African catfish, *Clarias gariepinus* using floating net-hapa (1m x 1m x 1m) system. A total of 300 catfish fingerlings (4.50± 0.01g) were randomly stocked at 20 fish/m^3 hapa. Five diets: Diet 1 (40% cp), Diet 2 (42.5% cp), Diet 3 (45% cp), Diet 4 (47.5% cp) and Diet 5 (50% cp) were formulated and fed to triplicate groups for 24 weeks. Growth responses and economic performances of fish harvested under various treatments were evaluated. Results showed that no significant differences ($p > 0.05$) were observed in metabolic growth rate, percentage survival, total feed intake, cost of feeding and total cost of production in all the treatments. However, significant differences ($p < 0.05$) existed in specific growth rates, gross profit, profit index and economic conversion ratio. The preferential diet being 42.5% protein, produced the highest {mean final weight (946.89g) and specific growth rate (3.21%/day)}; the best protein utilization {food conversion ratio (0.27), protein productive value (59.55%) and protein index (5.29g/day)}, the highest yield {net fish production (17,850kg/hapa), gross profit (₦4,774/hapa) and economic conversion ratio (58.98)}. From these results, *C. gariepinus* would grow best in floating net-hapa when fed diets containing 42.5% protein.

Key Words: Catfish, dietary protein, growth, survival, yield, profit index

INTRODUCTION

The African catfish, *Clarias gariepinus* is an omnivorous species that is indigenous to Africa and one of the most cultured species in Sub-Saharan Africa. It has been shown to have remarkable growth rate as well as high quality meat and excellent taste, hence, of great demand and commands good commercial value in Nigeria market (Adewolu *et al*., 2009). However, sufficient nutritional research has not been carried out on this economic species, thus, hindering the viability of commercial production in non-conventional culture system. Dietary protein has been appraised as the building block of body nutrients and given the most prominent consideration in the formulation of fish feeds. Protein requirement of other catfish groups had been reported. Fagbenro *et al.* (1992) reported 42.5% dietary protein requirement for genetically induced hybrid catfish. Olufeagba and Aluko (1997) recommended 45% for triploid catfish while Jamabo and Alfred-Ockiya (2008) opined that 40% protein produced the best growth in *Heterobranchus bidorsalis* and Effiong (2015) obtained the highest growth at 42.5% crude protein in practical *C. gariepinus* diet. However, NRC (1993) recommended between 38 and 55% for catfish culture in general. The present study has been designed to determine a proper dose response relationship regarding catfish growth and yield in floating net-hapa system for maximum profitability. The objective of the study was to determine the effects of varying crude protein levels on the growth, protein utilization and yield of *C. gariepinus* in floating net-hapa system

MATERIALS AND METHODS

Experimental design

An outdoor concrete tank (8m x 5m x 1.65m) at Vika Farms Limited, Mbak Etoi, Uyo, Akwa Ibom State, located at latitude 5° 3' North and longitude 7° 56' East was used for the study. The experimental design was made up of a module consisting of 8.5m x 6.5m bamboo raft with sixteen 1.5m x 1.5m apartments, out of which fifteen 1m x 1m x 1m net-hapas were fitted and placed on the concrete tank. Each hapa was rigged and suspended to maintain a depth of 0.75m in water and a free board of 0.25m. The float lines were tied to the four corners of each compartment using kuralon rope (No 15) as described by Otubusin (2000). Each hapa was randomly stocked with *C. gariepinus* (4.50±0.01g) at 20 fish/1m^3 hapa and raised for 24 weeks. The stocked fish were fed at 5% of their body weight three times daily. 20% of fish in each unit was sampled fortnightly. Fish weights were measured using a Furi Digital Balance (Model: FEJ-6000) to the nearest 0.1g.

Diets preparation: Five diets were formulated thus: Diet 1 (40% cp), Diet 2 (42.5% cp), Diet 3 (45% cp), Diet 4 (47.5%cp) and Diet 5 (50% cp). The Pearson Square method was adopted for diet formulation while ingredients used for diet preparation are presented in Table 1. All ingredients were carefully weighed out, mixed, made into pellets using 2mm meat mincer, air-dried and labelled separately according to diets. The formulated diets were subjected to proximate analysis for protein, lipid and gross energy contents using standard methods by AOAC (2004). The analysis was carried out at Biochemistry Laboratory, University of Uyo, Nigeria.

Table 1: Ingredients (%/100g) and proximate composition (%) of experimental diets

Ingredients	Diet 1 40.0%	Diet 2 42.5%	Diet 3 45.0%	Diet 4 47.5%	Diet 5 50.0%
Fishmeal	17.21	18.60	20.00	21.53	3.06
Soy meal	17.20	18.60	20.00	21.53	3.06
Corn flour	23.97	18.20	12.43	06.75	01.12
Groundnut cake	34.51	37.50	40.46	43.10	45.66
Fish oil	07.00	07.00	07.00	07.00	07.00
Lysine	0.030	0.030	0.030	0.030	0.030
Methionine	0.030	0.030	0.030	0.030	0.030
Fish premix	0.030	0.030	0.030	0.030	0.030
Analyzed protein level	38.83	40.05	43.43	45.01	48.25
Analyzed lipid level	8.38	8.40	8.64	8.75	8.87
Gross energy (kJ/g)	17.27	17.24	17.38	17.36	17.55

Physico-chemical Parameters of Water in Culture Tank: Water quality parameters (pH, dissolved oxygen (DO) concentration and temperature) were monitored. Water pH was measured using Pen-Type pH meter (Model: pH- 009 111), DO was measured using a digital DO meter (Model: Well-Knit DO-510) and temperature using a mercury in-glass thermometer.

Growth determination: Growth, feed and nutrient utilization indices were evaluated using standard formulae by Dabrowski (1986), Jauncey (2000), Jamabo and Alfred-Ockiya (2008) and Pangni *et al.* (2008). These are given thus:

Mean weight gain (MWG) (g) = final weight (g) – initial weight (g)
Average daily growth (ADG) = MWG (g)/length of feeding trial (days)
Relative growth rate (RGR) = 100[MWG (g)/mean final weight (g)]
Metabolic growth rate (MGR) = $(W_1-W_0)/[\{(W_0/1000)^{0.8}+(W_1/1000)^{0.8}\}/2]t$
Where: W_0 = initial weight (g); W_1 = final weight (g); t= duration of feeding trial (days)
Specific growth rate (SGR, %/day) = $100(\ln W_2 - \ln W_1)/T_2-T_1$
Where: W_2 = Weight at time T_2; W_1 = Weight at time T_1

Protein utilization determination
Feed conversion ratio (FCR) = Total dry feed fed (g)/MWG (g)
Protein efficiency ratio (PER) =MWG (g)/amount of protein fed (g)
Protein productive value (PPV) = 100[(final fish carcass protein- initial carcass protein)/ Crude protein intake]
Protein index (PI) = Survival $(W_1-W_0)t$
Nitrogen metabolism (NM) = $[0.54(W_1-W_0)t]/2$
Where: 0.54 is experimental constant; W_1= Fish final weight (g); W_0 = Fish initial weight (g); t = duration of feeding trial (days)
Percentage survival rate (%SR) = 100(number of fish at end of feeding trial/number at start of feeding trial).

Economic Analysis
The cost-benefit estimation was done using methods of Piedecausa *et al.* (2007) as follows:
Cost of feeding (COF) = Price of feed x total feed intake
Profit index (PI) = Value of fish (₦)/cost of feed (₦)
Economic conversion ratio (ECR) = Cost of diet x FCR

Data Analysis

Comment [@1]: What kind of data analysis was used?
Were the assumptions of normality and homocesdasticity for the data verified?

Data analysis was carried out using Statistical Package for Social Sciences (SPSS 19.0, 2010 version).

RESULTS

The results of growth performances and survival rates of *C. gariepinus* fed diets containing different protein levels for 24 weeks are shown in Table 2. From the results, all the growth indices were highest in diet containing 42.5% protein. There were no significant differences ($p > 0.05$) in metabolic growth in all the treatments. Fish fed Diet 2 (42.5% cp) had the best growth performance ($p < 0.05$), with a mean weight gain of 942.38±2.33g, average daily growth of 5.88g/day and relative growth rate of 218.85±0.58. The least weight gain (769.13±2.29g) and poorest specific growth rate (3.15±0.00%/day) was observed in fish fed Diet 5 (50% cp). Generally, there was an inverse relationship between protein level and growth performance of fish.

Table 2: Growth performances of *C. gariepinus* fed diets containing different protein levels for 24 weeks.

Comment [@2]: What kind ANOVA was used?

Variables	Diet 1 40.0%	Diet 2 42.5%	Diet 3 45.0%	Diet 4 47.5%	Diet 5 50.0%
MIW	4.51±0.01	4.51±0.01	4.51±0.01	4.51±0.02	4.50±0.01
MFW	884.17±0.82^{c}	946.89±2.33^{d}	843.27±6.61^{b}	790.23±8.04^{a}	773.63±2.29^{a}
MWG	879.66±0.82^{c}	942.38±2.33^{d}	838.70±6.61^{b}	785.72±8.05^{a}	769.13±2.29^{a}
ADG	5.32±0.01^{a}	5.88±0.01^{c}	5.77±0.04^{b}	5.38±0.05^{a}	5.32±0.01^{a}
RGR	198.74±0.31^{a}	218.85±0.58^{c}	214.79±1.50^{b}	200.54±2.38^{a}	198.33±0.93^{a}
MGR	2.96±0.00	2.96±0.00	2.96±0.00	2.94±0.02	2.95±0.01
SGR	3.16±0.00^{a}	3.21±0.00^{b}	3.20±0.00^{b}	3.16±0.01^{a}	3.15±0.00^{a}

*Means with different superscript letters within a row are significantly different ($p < 0.05$). Where: MIW-mean initial weight (g); MFW-mean final weight (g); MWG-mean weight gain (g); ADG-average daily growth (g/day); RGR-relative growth rate; MGR-metabolic growth rate (g/kg$^{0.8}$/day); SGR-specific growth rate (%/day);

The results of protein utilization of *C. gariepinus* fed diets containing different protein levels for 24 weeks are shown in Table 3. The ability of fish to convert food given to muscle increased with increasing protein level in diet. The best food conversion (0.27±0.00), protein efficiency (9.41±0.02), protein index (5.29±0.18g/day), nitrogen metabolism (44.76±0.15) and protein productive value (59.55±0.6%) were obtained in group fed 42.5% protein diet. Inverse relationship also existed between protein content in diet and protein utilization of catfish.

Table 3: Feed and protein utilization and survival rates of *C. gariepinus* fed diets containing different protein levels for 24 weeks.

Variables	Diet 1 40.0%	Diet 2 42.5%	Diet 3 45.0%	Diet 4 47.5%	Diet 5 50.0%
FCR	0.28±0.00^{b}	0.27±0.00^{a}	0.27±0.01^{a}	0.28±0.01^{b}	0.29±0.00^{c}
PER	9.08±0.07^{d}	9.41±0.02^{e}	8.45±0.23^{c}	7.93±0.16^{b}	7.25±0.08^{a}
PPV	49.08±1.75^{d}	59.55±0.56^{e}	41.78±0.55^{c}	36.95±2.12^{b}	31.83±1.10^{a}
PI	4.80±0.00^{b}	5.29±0.18^{d}	5.00±0.34^{c}	4.76±0.21^{b}	4.61±0.19 ^{a}
NM	40.67±0.00^{a}	44.76±0.15^{c}	44.00±0.26^{b}	41.13±0.40^{a}	40.52±0.15^{a}
SR	90.00±0.00	90.00±0.00	86.67±6.01	88.33±3.33	86±3.33

*Means with different superscript letters within a row are significantly different ($p < 0.05$). Where: FCR-food conversion ratio; PER-protein efficiency ratio; PPV-protein productive value (%); PI-protein index (g/day); NM-nitrogen metabolism; SR-percentage survival rate (%).

In all dietary levels tested, economic indices including feed consumption, cost of feed supply and total cost of production were not significantly different ($p > 0.05$). There was an inverse relationship between net fish production, gross profit, and value of fish (Table 4). The best economic conversion ratio (58.98±0.13), profit index (8.50±0.02) and gross profit (₦4,774/hapa) were recorded in fish fed the 42.5% protein diet. The pH value of culture water ranged from 6.50 - 8.50 with a mean value of 7.31. Mean water temperature and DO were 28.20^{o}C and 7.52 mg/l respectively.

Table 4: Economic indices of *C. gariepinus* fed diets containing varying levels of protein in floating hapa system for 24 weeks.

Indices	Diet 1 40.0%	Diet 2 42.5%	Diet 3 45.0%	Diet 4 47.%	Diet 5 50.0%
TFI	3059.33±32.9	3142.97±14.3	3172.23±75.2	3042.1±53.9	3062.57±28.9
COF	1000.6±10.6[a]	1050.23±38.2[b]	1047.3±95.8[b]	1048.24±54.9[b]	1061.09±40.7[b]
TCP	4100.62±10.6	4150.23±38.2	4147.0±95.8	4148.24±54.9	4161.09±40.8
NP	15915.0±10.5[bc]	17043.9±57.0[c]	14603.5±10.1[b]	13970.1±65.7[ab]	13417.1±61.1[a]
VOF	7957.4±52.6[bc]	8522.0±28.4[c]	7301.7±50.4[ab]	6985.1±32.8[ab]	6708.5±30.5[a]
GP	3856.8±54.4[b]	4771.7±248[c]	3154.4±415[ab]	2836.8±276[a]	2547.4±266[a]
PI	7.96±0.10[c]	8.50±0.02[d]	7.01±0.27[b]	6.67±0.10b[b]	6.32±0.09[a]
ECR	61.84±0.64[a]	58.98±0.13[a]	62.17±1.60[a]	65.62±1.27[b]	68.61±0.73[b]

*Means with different superscript letters within a row are significantly different ($p < 0.05$). Where: TFI-total feed intake (g); COF-cost of feeding (₦/hapa); TCP-total cost of production (₦/hapa); NP-net production (kg/hapa); VOF-value of fish @ ₦500/kg; GP-gross profit (₦/hapa); PI-profit index; ECR-economic conversion ratio.

DISCUSSION

The culture of *C. gariepinus* in net-hapas seems to be feasible if these results are compared with those obtained in conventional culture systems. At the end of the 168-day feeding trial, the percentage survival rate ranged from 88.33% in Diet 4 to 90.00% in Diets 1 and 2. These values were comparable with survival of *Heterobranchus longifilis* (90%) cultured in earthen pond by Babalola and Apata (2006). However, in this study survival rates were not affected by dietary protein levels. The growth performances of *C. gariepinus* obtained in this study was influenced by dietary protein levels. Similar results were also reported in hybrid catfish fry by Diyaware *et al*. (2009), in *Chrysichthys nigrodigitatus* fingerlings by Adewolu *et al*. (2009) and in *H. longifilis* larvae by Babalola and Apata (2006). Diyaware *et al* (2009) also reported that growth rate and weight gain increased progressively with dietary protein level to a maximum at 50%. Jana *et al* (2006) observed high growth in terms of live weight gain and specific growth rate in milkfish (*Chanos chanos*) fed at 40% protein level. In addition, Alatise *et al* (2005) reported that catfish fingerlings fed with 40% protein gave the best growth (SGR: 1.06%/day and FCR: 0.62). In this study, best growth was observed in fish fed 42.5% protein. The intraspecific differences observed could be explained by the varieties of methodology (feed formulation and feeding rate tests) and culture system used in individual experiment. In this study, low protein content in diet resulted to increased fish growth. This could be seen in fish fed diet containing 42.5 % protein producing better growth when compared with those fed between 45.0 and 50.0 % protein diets. This indicated the capacity of this species to accept and utilize compounded diet with moderate protein contents. The highest feed conversion ratio of 0.28 obtained in this study was better than 1.28 observed in *C. gariepinus* fed with 40% protein (Sotolu, 2010). The highest ($p < 0.05$) profit index and economic conversion ratio of fish fed 42.5% protein diet probably pointed to the fact that this dietary protein level may be better in economic terms than all other protein diets in this study. This is also reflected in lack of significant differences ($p > 0.05$) in metabolic growth rate in all treated fish.

CONCLUSION

High growth performance and fish production obtained in this study points to the realization that biological and economic benefits could be achieved in intensive culture of catfish in floating net-hapa system. It also show that for optimal growth and production performance, *Clarias gariepinus* required relatively low dietary protein content of 42.5%.

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