Asian Journal of Biology

5(1): 1-6, 2018; Article no.AJOB.35557
ISSN: 2456-7124

Effects of Varying Protein Levels on *Clarias gariepinus* (Burchell, 1822) Growth, Protein Utilization and Yield in Hapa System

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Authors' contributions

This work was carried out in collaboration between both authors. Author MUE designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author IKE managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJOB/2018/35557
Editor(s):
(1) Reuben Omondi, Department of Aquatic and Fishery Sciences, Kisii University, Kenya.
Reviewers:
(1) Victor Oscar Eyo, Institute of Oceanography, Nigeria.
(2) Olarinke Victoria Adeniyi, Kwara State University, Nigeria.
(3) José Luis Gómez Márquez, National Autonomous University of Mexico, Mexico.
(4) U. D. Enyidi, Nigeria.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/22731

Original Research Article

Received 19th July 2017
Accepted 8th January 2018
Published 13th January 2018

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 (1 m x 1 m x 1 m) system. A total of 300 catfish fingerlings (4.50± 0.01 g) 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 (946.89 g), specific growth rate (3.21%/day), food conversion ratio (0.27), protein productive value

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(59.55%) and protein index (5.29 g/day), highest yield (17,850 kg/hapa), gross profit (774/hapa) and economic conversion ratio (58.98). From these results, it was concluded that *C. gariepinus* would grow best in floating net-hapa when fed diets containing 42.5% protein.

Keywords: Catfish; dietary protein; growth; survival; yield; profit index.

1. 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. It enjoys great demand and commands good commercial value in the Nigerian market [1]. However, sufficient nutritional research has not been carried out on this economic species, thus, hindering the viability of its commercial production in non-conventional culture system. Dietary protein has been appraised as the building block of body nutrients and it is given the most prominent consideration in the formulation of fish feeds. Protein requirements of other catfish groups had been reported. In previous studies, Fagbenro et al. [2] reported 42.5% dietary protein requirement for genetically induced hybrid catfish. Olufeagba and Aluko [3] recommended 45% for triploid catfish while Jamabo and Alfred-Ockiya [4] opined that 40% protein produced the best growth in *Heterobranchus bidorsalis* and Effiong [5] obtained the highest growth at 42.5% crude protein in practical *C. gariepinus* diet. However, National Research Council (NRC) [6] 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.

2. MATERIALS AND METHODS

2.1 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 compartments of 1.5m x 1.5m, in which fifteen 1m x 1m x 1m net-hapas were fitted and placed on the concrete tank. Each hapa was rigged and suspended in water to maintain a depth of 0.75m 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 [7]. Each hapa was randomly stocked with *C. gariepinus* (4.50±0.01 g) 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 0.1 g.

2.2 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 [8]. The analysis was carried out at Biochemistry Laboratory, University of Uyo, Nigeria.

2.3 Physico-chemical Parameters of Water in Culture Tank

Water quality parameters (pH, dissolved oxygen (DO) 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.

2.4 Growth Determination

Growth, feed and nutrient utilization indices were evaluated using standard formulae by Dabrowski [9], Jauncey [10], Jamabo and Alfred-Ockiya [4] and Pangni et al. [11]. These are given thus:

Mean weight gain (MWG) (g) = final weight (g) – initial weight (g).

Table 1. Ingredients (%/100 g) 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

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

2.5 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).

2.6 Economic Analysis

The cost-benefit estimation was done using methods of Piedecausa et al. [12] 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 feed x FCR.

3. 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 diets 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±2.33 g, average daily growth of 5.88 g/day and a relative growth rate of 218.85±0.58. The least weight gain (769.13±2.29 g) and the poorest specific growth rate (3.15±0.00%/day) were observed in fish fed Diet 5 (50% cp). Generally, there was an inverse relationship between protein level and growth performance of fish.

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±0.18 g/day), nitrogen metabolism (44.76±0.15) and protein productive value (59.55±0.56%) were obtained in the group fed 42.5% protein diet. Inverse relationship also existed between protein content in diet and protein utilization of catfish.

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°C and 7.52 mg/l respectively (Table 5).

Table 2. Growth performances 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%
MIW (g)	4.51±0.01	4.51±0.01	4.51±0.01	4.51±0.02	4.50±0.01
MFW (g)	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 (g)	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 (g/day)	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 (g/kg$^{0.8}$/day)	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 (g/kg$^{0.8}$/day)	2.96±0.00	2.96±0.00	2.96±0.00	2.94±0.02	2.95±0.01
SGR (%/day)	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)*

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 (g/day)	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 (%)*

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 47.5%	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*

Table 5. The physico-chemical parameters of water in the culture tank

	Parameters	Means ± Standard Error	Range
1	Temperature (°C)	28.2±0.31	26.80 – 29.60
2	pH	7.31±0.19	6.50 – 8.50
3	Dissolved Oxygen (mg/L)	7.52±0.23	6.70 – 8.90

4. 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 [13]. However, in this study survival rates were not affected by dietary protein levels. The growth performances of *C. gariepinus* obtained in this study were influenced by dietary protein levels. Similar results were also reported in hybrid catfish fry by Diyaware et al. [14], in *Chrysichthys nigrodigitatus* fingerlings by Adewolu et al. [1] and in *H. longifilis* larvae by Babalola and Apata [13]. Diyaware et al. [14] also reported that growth rate and weight gain increased progressively with dietary protein level to a maximum of 50%. Jana et al. [15] 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. [16] 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 [17]. The highest profit index and economic conversion ratio of fish fed at 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.

5. CONCLUSION

The high growth performance in 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 shows that for optimal growth and production performance, *Clarias gariepinus* requires relatively low dietary protein content of 42.5%.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://prh.sdiarticle3.com/review-history/22731