The Effect of Mixed Feeding Schedule of Varying Dietary Protein Contents on The Growth performance, Feed Utilization and Survival of *Clarias Gariepinus* Fingerlings

Udo, Imefon Udo[1]*, William, Augustine Ekpri[1]

[1] Department of Fisheries and Aquatic Environmental Management, Faculty of Agriculture, University of Uyo, Uyo, Nigeria

Email Address

dorime_2004@yahoo.com (Udo, Imefon Udo)
*Correspondence: dorime_2004@yahoo.com

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Abstract:

Great expansion of the aquaculture industry is hamstrung by high feed cost. A 91-day feeding trial was therefore conducted using fingerlings of *Clarias gariepinus* (1.08±0.05 g) to study the effect of mixed feeding schedule of varying dietary protein contents on the growth performance, feed utilization and cost-effectiveness. Coppen feed served as control 1 (A) while control 2 (B) was a basal diet formulated to contain 35% crude protein. Different mixed feeding schedules of these two diets were developed. These include: one day Coppen followed with one-day basal diet feeding (1A+1B), two days Coppen followed with one-day basal diet feeding (2A+1B) and three days Coppen are followed with one-day basal diet feeding (3A+1B). Growth performance, feed utilization, survival and carcass composition were significantly better ($p<0.05$) between A and 3A+1B in terms of final weight, daily weight gains as well as specific growth rate. On the whole, 13.02% feeding cost savings relative to A was obtained for fingerlings maintained on 3A+1B. Fish farmers should adopt this mixed feeding schedule for cost-effective culture of *C. gariepinus*.

Keywords:

Dietary Protein, Feeding Cost, Nutrient Utilization, African Catfish

1. Introduction

The African catfish (*Clarias gariepinus*) is the most cultured fish species in Nigeria because some of characteristics like very good feed conversion efficiency, hardiness, all year round production of fingerlings, rapid growth rate, very good acceptance of artificial feed and good tolerance of overcrowding [1;2]. *C. gariepinus* is omnivorous, feeding on wide arrays of feedstuffs ranging from agricultural products/byproducts to aquatic macrophytes. In culture system it requires high crude protein levels (40-55%) diet depending on their life stage/size classes, for optimal growth [3]. The importance of protein in fish diet is mainly associated with its role as the source of building

materials for growth and the production of enzymes [4]. Protein from fishmeal is often preferred in artificial feeds due to its amino acid profile coupled with it nutrient and dry matter digestibility [5]. According to Tacon [6], fishmeal covers a major proportion to fulfil the demand of dietary protein. This has resulted in the high cost of the fish feed.

Feeding is one of the most important aspects of aquaculture which a farmer cannot do without, mainly when fish are raised under intensive or semi-intensive system [7]. Feeding cost is the highest single cost item of most fish farm operations accounting for about 60% of the total cost of fish production [8]. Many approaches have been adopted to reduce feed cost. Such approaches include proper selection of ingredients prior to feed formulation [5], least-cost feed formulation using optimization techniques [9, 10], fishmeal substitution with cheaper ingredients as protein source [11, 12]. Another approach to reduce feed costs is to develop appropriate feeding management strategies and other improvements in husbandry [13, 14].

The effect of feeding levels on growth performance, feed utilization and body composition of African catfish has recently been emphasized [15]. Both overfeeding and underfeeding can be detrimental to the health of fish and may cause a marked deterioration in water quality, reduced weight, poor feed utilization, and increased susceptibility to infection [16]. This has led to the strategy of mixed feeding for better protein utilization of feed and economic returns of the cultured system [17]. Furthermore, information on the different mixed feeding schedules in pangas with silver carp [18], rainbow trout [19], *Labeo rohita* [20], Nile tilapia [21] revealed that there has been improvement in the feeding strategies and economic performance of these species.

The applicability of the mixed feeding schedule to *C. gariepinus* has been investigated by Adewolu [13]. However, their experimental design did not fit well into the local situation as local farmers prefer using Coppen to jumpstart the growth of their fingerlings instead of locally manufactured or farm-made feeds which cannot be compared with the foreign feed [22]. This research therefore seeks to establish a mixed feeding schedule of Coppen and on-farm medium protein feed that will give the same growth performance and feed utilization as using Coppen feed only while the feeding cost is reduced.

2. Materials and Methods

2.1. Description of Experimental Site

The experiment which lasted for 13 weeks (16^{th} March 2017 – 8^{th} June, 2017) was conducted in 15 plastic aquarium containers at the Hatchery complex of the Department of Fisheries and Aquatic Environmental Management, University of Uyo, Uyo (Latitude 05^{o}02' 30" N and Longitude 07^{o}55' 3"E). The containers were arranged in rows and column of 5x3 and provided with outlets which allowed the removal of water. The source water was borehole and the tanks were filled using hose.

2.2. Procurement and Processing of Ingredients and Commercial Feed

Fish meal (anchovy, 65 % crude protein, Ecuador), soybean meal, yellow maize, rice straw, fish premix, binder (starch), salt and vegetable oil were procured from a local supplier at the Ariaria International market, Aba, Abia State, Nigeria. Coppens (Netherlands) was purchased from a reputable feed retailer in Aba, Abia State,

Nigeria. All ingredients were bought in solid and dry form. They were further ground to ensure homogeneity. Soybean was first toasted before grinding.

2.3. Experimental Diet Formulation

Diet B was formulated using feed formulation software for windows (Winfeed 2.8) which formulate feed by linear programming technique. Diets were formulated on dry matter basis using the proximate composition of the feed ingredients. Nutrient composition of ingredients and digestible energy (DE) used in the experiment are presented in Table 1 and composition and proximate analysis of the experimental diets are presented in Table 2. The cost of feed ingredients was obtained through local market survey.

Table 1. *Proximate composition and digestible energy of the ingredients used in the experimental diet.*

Sample Id	**Cost kg^{-1} (₦)**	**Moisture %**	**Ash %**	**Fibre %**	**Protein %**	**Lipid %**	**CHO %**	**Caloric value (Kcal)**
Rice straw	90.00	0.42	10.89	7.31	11.58	3.69	66.11	345.68
Soybean meal	200.00	1.36	7.22	4.86	43.75	4.63	39.54	374.83
Yellow maize meal	180.00	0.07	2.93	1.65	9.10	13.50	75.82	449.18
Fishmeal	1100.00	6.82	3.38	1.40	61.6	8.41	25.10	422.85

Table 2. *Composition and proximate analysis of experimental diets.*

Ingredients (%)	**Diet**	
	A	**B**
Rice straw	-	22.96
Soybean meal	-	25.00
Yellow maize meal	-	20.00
fishmeal	-	32.04
Total		100
Proximate analysis (% dry matter)		
Dry matter %age	-	97.37
Crude protein	42	35.15
Total ash	-	5.97
Crude fibre	-	3.67
Ether extract	-	7.40
Nitrogen free extract[1]	-	47.81
Gross energy (Kcal)[2]	-	398.39
[1]NFE=100-(protein + ether extract + Ash + fiber)		
[2]Calculated on an estimated 5.65 kcal g^{-1} Protein, 9.45 kcal g^{-1} Ether extract, 4.10 kcal g^{-} [1]Carbohydrate.		

2.4. Experimental Diet Production

Ingredients for diet production were all measured out according to the feed formula using Camry kitchen weighing balance and mixed homogenously on a clean floor with the help of a spade. Vegetable oil and salt were then added in the right proportion and mixed continuously to obtain a homogenous mixture. Hot water was then poured onto the mixture to obtain dough. Binder (starch) was prepared using hot water and was added to the dough. The dough mixture was subjected to a manual pelletizing using meat mincer with 2 mm die ring. The pellets were sun-dried to 10 per cent

moisture. During these periods vitamin/mineral premix was prepared using lukewarm water and sprayed on the pellets which after a short time were packed in air tight polyethylene bags and stored in a refrigerator at 20^{o}C.

2.5. Experimental Design

One hundred and fifty (150) healthy fingerlings of African catfish (*C. gariepinus*) having mean body weight of (1.08±0.05 g) was procured from Fulfillment Fish Farm, Abak Road, Uyo Local Government Area, Akwa Ibom State and transported to the experimental site in a fifty (50) liter rubber container in which the surface was open for oxygen to penetrate. No mortality was incurred during transportation. Fish were acclimated outdoor in mobile tanks for two weeks; a commercial feed (Coppen, 2 mm pellet size) of 42 percent crude protein were fed *ad libitum* to the fish during this period.

The feeding trial was mixed feeding schedule of varying dietary protein content using a high protein commercial diet of 42% CP (Coppen) as diet A and a medium protein formulated diet (35% CP locally formulated) as diet B. The experimental design was composed of 5 treatments (feeding schedules) with 3 replicates for each treatment. Treatment 1 (control for A) was feeding with only commercial feed (1A). Treatment 2 (control for B) was feeding with locally formulated diet (1B). Treatment 3 was a one-day commercial feed and a one-day locally formulated diet (1A+1B) feeding schedule. Treatment 4 was a two-day commercial feed and a one-day locally formulated diet (2A+1B) feeding schedule while Treatment 5 was a three-day commercial feed and a one-day locally formulated diet (3A+1B) feeding schedule. Each tank was filled with 1000 liters of water to a depth of 1.5 feet. The tanks were labeled A_1, A_2, A_3; B_1, B_2, B_3; $(1A+1B)_1$, $(1A+1B)_2$, $(1A+1B)_3$; $(2A+1B)_1$, $(2A+1B)_2$, $(2A+1B)_3$ and $(3A+1B)_1$, $(3A+1B)_2$, $(3A+1B)_3$ for treatments 1, 2, 3,4, and 5 respectively as presented in Table 3.

Table 3. *Feeding schedule used during the feeding trial.*

Feeding schedule	**Remarks**
Diet A (Coppen feed, 42% cp)	Control
Diet B (formulated diet, 35% cp)	Control
1A+1B	Alternate day of A and B
2A+1B	Two consecutive days of A followed by 1 day of B
3A+1B	Three consecutive days of A followed by 1 day of B

Six weeks old acclimated fingerlings of C. *gariepinus* (initial mean weight =1.08±0.05 g) starved for 24 hours were stocked at a density of 10 fingerlings per tank. Fish were fed 3 times daily at 5% of fresh body weight for 91 days (13 weeks). Feeding rate was adjusted after each sampling date. Pellet size of 2 mm was used for both experimental diets (A and B) throughout the duration of the experiment. Fingerlings were weighed fortnightly and feed ration adjusted accordingly. Physico-chemical parameters were monitored weekly and water was changed thrice a week.

2.6. Data Collection

Fish was sampled fortnightly by emptying all water in the plastic aquarium tanks. Fingerlings from each tank were then collected with a plastic filter basket and weighed to nearest 0.01 g using a sensitive weighing balance (TD6002A). Data

obtained were used to determine growth performance parameters such as final mean weight, daily weight gain, mean weight gain, specific growth rate and feed utilization parameters such as feed conversion ratio, protein efficiency ratio and survival rate using the following formulae:

2.6.1. Daily Weight Gain (g/day) (DWG)

$$DWG = \frac{\text{Final mean weight} - \text{initial mean weight}}{\text{Rearing period in days}}$$

2.6.2. Specific Growth Rate (%/day) (SGR)

$$SGR = \frac{100 \times [\text{In (Final average weight)} - \text{In (Initial average weight)}]}{\text{Rearing duration in days}}$$

Where In = Natural logarithm reading (Log_e)

2.6.3. Feed Conversion Ratio (FCR)

$$FCR = \frac{\text{Dry weight of feed given (g)}}{\text{Wet weight gain by fish (g)}}$$

2.6.4. Protein Efficiency Ratio (PER)

$$PER = \frac{\text{Wet weight gain by fish (g)}}{\text{Protein intake (g)}}$$

Where;

$$\text{Protein intake} = \frac{\text{\% protein in feed} \times \text{total weight (g) of diet consumed}}{100}$$

2.6.5. Survival Rate (%) (SR)

$$SR = \frac{\text{Total number of fingerlings that survived} \times 100}{\text{Total number of fingerlings stocked}}$$

2.7. Monitoring of Physico-Chemical Parameters

The physico-chemical parameters monitored include dissolved oxygen (DO), temperature and pH. These were observed weekly (07:00 am, Thursdays) and were measured in situ. Dissolved oxygen and temperature were measured using DO meter (HI 9461) which measured both DO and temperature in mg/l and ℃ units respectively while pH was measured using a pen type pH meter (pH-009 111).

2.8. Chemical Analysis

Bulk ingredients (fishmeal, soybean meal, yellow maize, rice straw) were sent to Biochemistry Laboratory, University of Uyo for proximate composition analysis. Method used was the standard method of Association of Official Analytical Chemists of USA [23].

The proximate analysis of the fish before and after the experiment was carried out in the Department of Biochemistry Laboratory, University of Uyo, Nigeria using methods described in AOAC [23].

A dried sample of the locally compounded feed was also sent to Biochemistry Laboratory of University of Uyo for proximate nutrient analysis (moisture, protein, oil, fibre, ash) using standard methods [6]. Moisture was determined by oven drying the ingredients at 105 ^{o}C for 24 hours. Crude protein (N × 6.25) was determined by the Kjeldahl method after digestion with concentrated H_2SO_4. Ash content was determined by incineration in a muffle furnace at 600 ^{o}C for 16 hours. Crude lipid was determined by the Soxhlet method using petroleum ether and crude fibre was determined by digestion with 1.25% NaOH and 1.25% H_2SO_4. Gross energy was calculated using the conversion factors for protein, lipids and carbohydrates provided in [29]. Nitrogen free extract (NFE) was calculated by subtracting the sum of moisture, protein, oil, fibre and ash from 100. The proximate composition of the commercial feed used was according to the manufacturer's specification.

2.9. Statistical Analysis

Data from growth and water quality parameters were subjected to a one-way analysis of variance (ANOVA) at 0.05 level of probability to test for significant difference. Results with $P \leq 0.05$ were considered significant [24]. Where there was significant difference, Duncan Multiple Range Test was used to separate the means. The statistical analysis was done using IBM SPSS Inc. (Windows version 24.0).

3. Results and Discussion

3.1. Water Quality

The mean values of the physico-chemical parameters of the cultured water are presented in Table 4. There was no significant difference ($p>0.05$) in the dissolved oxygen. Morning temperature was significantly higher in A while pH was significantly higher in both1A+1B and 2A+1B. The mean values of the physico-chemical parameters were observed to be within the ranges recommended for the culture of fresh water fishes in the tropical regions [25].

Table 4. *Physico-chemical parameters of tank water during the 91-day culture period.*

Parameter	**A**	**B**	**1A+1B**	**2A+1B**	**3A+1B**
Dissolved oxygen	5.10 ± 0.83^{a}	5.54 ± 0.76^{a}	5.49 ± 0.69^{a}	5.31 ± 0.44^{a}	5.21 ± 0.60^{a}
Morning temperature (^{o}C)	28.31 ± 1.08^{b}	27.04 ± 0.51^{a}	27.09 ± 0.65^{a}	27.06 ± 0.43^{a}	27.16 ± 0.63^{a}
pH	7.27 ± 0.18^{b}	7.01 ± 0.32^{a}	7.26 ± 0.21^{b}	7.33 ± 0.18^{b}	7.20 ± 0.10^{ab}
Values are mean ±SD from three replicates. Mean with the same superscript letter are not significantly different ($P<0.05$). A=Coppen feed; B=formulated feed					

3.2. Effect of Mixed Feeding Schedules on Growth Performance of African Catfish (C. gariepinus) Fingerlings

Generally, best response was observed when fingerlings were maintained on a mixed feeding schedule of three days Coppen feed followed by a one-day formulated ration (3A+1B) and Coppen (A) only while the worst response was observed in fingerlings fed formulated diet (B) only as shown in Fig. 1. There was no significant difference (P>0.05) between diets A and 3A+1B in terms of final weight, daily weight gain as well as specific growth rate. These two diets were significantly (p<0.05) better than others. The Poorest performance was observed in treatment B as shown in Table 5.

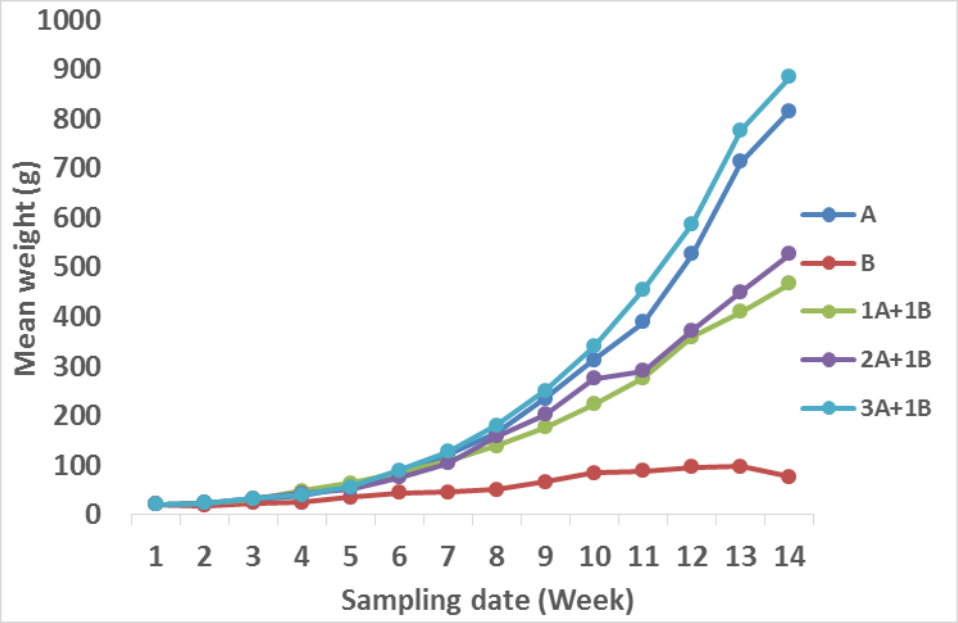

Figure 1. *Growth trend of Clarias gariepinus during the 91 days culture.*

Table 5. *Growth performance and feed utilization of C. gariepinus fed different experimental diets.*

Parameters	Experimental diets (%)				
	A	B	1A+1B	2A+1B	3A+1B
Growth performance					
Initial weight	21.50 ±0.08a	21.52 ±0.23 a	21.57 ±0.12a	21.52 ±0.12a	21.40 ±0.08a
Final weight	235.77 ±253.89b	55.50 ±32.77a	201.86 ±186.07 ab	178.25 ±152.54 ab	252.69 ±263.71b
Daily weight gain	2.35 ±1.56b	0.37 ±1.18a	1.98 ±0.71b	1.72 ±1.26ab	2.54 ±1.34b
Specific growth rate	2.63 ±0.27b	1.04 ±0.81a	2.45 ±0.18ab	2.32 ±0.33ab	2.71 ±0.08b
Feed utilization					
Feed conversion	2.46 ±0.62a	4.12 ±1.99b	1.61 ±0.82a	2.39 ±0.24a	2.46 ±0.81a

ratio					
Protein efficiency ratio	0.97 ±0.22a	0.69 ±0.51a	1.62 ±0.28b	1.05 ±0.12a	1.01 ±0.02a
Survival rate (%)	94.30 ±0.51bc	82.10 ±1.48 a	87.10 ±0.91ab	87.95 ±1.37ab	99.2 ±0.27c
Values are mean ±SD from three replicates. Mean with the same superscript letter are not significantly different (P<0.05). A=Coppen feed; B=formulated feed					

Survival rate was significantly (P<0.05) higher in treatment 3A+1B and lower in B. Generally, survival rate was high in all the treatments. This finding is similar to that of Nandeesha[26] in *Cyprinus carpio*, Arun[27] in *Oreochromis niloticus* and Ali[28] in *Pangasius hypophthalmichthys* who observed that mixed feeding schedule of low protein diet alternated with high protein diet result in best growth or similar growth with those fed continuously with high protein level. This work was however, in contradiction with the works of Hashim[29] and Adewolu[13] who found that best growth performance was observed in fish maintained at 35% crude protein diets. In this work fingerlings fed low/medium (35%) protein level did not have improved growth rate. Alternating protein levels appeared to improve all the growth performance parameters which include final weight of fish harvested, daily weight gain, specific growth rate and survival as against the findings of Adwolu[13]. This is evident by the maximum score of 21 points obtained for mixed feeding schedule 3A+1B (Table 8) compared with the score of 17 for diet A which ranked fourth.

3.3. Effect of Mixed Feeding Schedules on Feed Utilization of African Catfish (C. gariepinus) Fingerlings

Feed utilization parameters are presented in Table 5. All other diets except B had similar feed conversion ratio. Diet B had significantly higher (P<0.05) FCR than other diets. Diet 1A+1B had significantly (P<0.05) higher protein efficiency ratio value than all other diets. The results of this work are in agreement with the hypothesis of De Silva [30, 31] which state thus "when fish are maintained at high protein level throughout the period of culture, feed utilization efficiency could be reduced with time". This hypothesis was first tested with Nile tilapia (*O. niloticus*), and later in Asian cichlid, *Etroplus suratensis* [32].

3.4. Effect of Mixed Feeding Schedules on Carcass composition of African Catfish (C. gariepinus) Fingerlings

No significant differences (P>0.05) were observed in carcass composition among the feeding schedules as presented in Table 6. However, carcass analysis of the fingerlings showed highest protein content in the initial and lowest in treatment A while others were similar. Higher fat deposit was also observed in the initial while the lowest was observed in Treatment B. Others were similar. Ash, crude fibre and nitrogen free extract were significantly lower in the initial and higher in Treatments A, B and IA+1B. Caloric values were significantly higher in the initial and lower in B. However, moisture was significantly higher in all treatment than the initial. On the whole, meat quality was not shown to be affected by the mixed feeding schedules.

Table 6. *Carcass composition of Clarias gariepinus fingerlings maintained under varying feeding schedules after 91days.*

Nutrient	Initial	A	B	1A+1B	2A+1B	3A+1B
Crude protein	62.30 ± 0.64^{c}	46.25 ± 1.93^{a}	47.46 ± 0.15^{ab}	48.65 ± 0.96^{b}	46.20 ± 0.23^{ab}	47.95 ± 0.55^{ab}
Ether extract	20.56 ± 0.12^{d}	16.88 ± 0.78^{b}	12.91 ± 0.88^{a}	18.67 ± 0.58^{c}	19.24 ± 0.07^{c}	16.86 ± 0.75^{b}
Total ash	7.15 ± 0.02^{a}	13.53 ± 0.06^{e}	13.14 ± 0.07^{d}	13.78 ± 0.02^{f}	12.15 ± 0.11^{c}	10.78 ± 0.32^{b}
Crude fibre	6.86 ± 0.05^{a}	9.05 ± 0.02^{f}	8.34 ± 0.04^{d}	9.31 ± 0.08^{e}	8.22 ± 0.07^{c}	7.79 ± 0.01^{b}
Caloric value	448.08 ± 0.79^{f}	396.50 ± 1.32^{b}	378.72 ± 1.34^{a}	403.42 ± 0.36^{c}	415.47 ± 0.61^{e}	411.12 ± 0.62^{d}
Nitrogen free extract	2.98 ± 0.62^{a}	13.75 ± 0.62^{c}	17.55 ± 0.32^{f}	9.35 ± 0.05^{b}	14.53 ± 0.46^{d}	16.23 ± 0.15^{e}
Moisture	34.48 ± 0.79^{a}	73.10 ± 0.85^{b}	72.95 ± 0.08^{b}	73.14 ± 0.09^{b}	73.09 ± 0.08^{b}	73.68 ± 0.29^{b}

3.5. Cost-Effectiveness of C. gariepinus Fingerlings Culture

The ranking order for the different growth parameters and survival rate for each feeding schedule is presented in Table 7. A maximum score of 5 was awarded for best performance in each growth parameter and survival. The total score for each feeding schedule is shown in Table 8. The highest total score of 21 was obtained for feeding schedule 3A+1B while the lowest total score of 5 was obtained for feeding schedule B. On the whole, 13.02% feeding cost savings relative to diet A was obtained for fingerlings maintained on the 3A+1B feeding schedule as calculated in Table 9. De Silva [33] suggested that alternating high protein diet with low protein diet could be a possible solution to reducing feed and production cost.

Table 7. *Ranking for each dietary feeding schedule based on growth performance of C. gariepinus.*

Rank order	DWG	SGR	FCR	PER	Survival
1	3A+1B	3A+1B	1A+1B	1A+1B	3A+1B
2	A	A	2A+1B	2A+1B	A
3	1A+1B	1A+1B	3A+1B; A	3A+1B	1A+1B; 2A+1B
4	2A+1B	2A+1B	-	A	-
5	B	B	B	B	B
DWG=Daily weight gain; SGR=Specific growth rate; FCR=Feed conversion ratio; PER=Protein efficiency ratio					

Table 8. *The total score obtained for each feeding schedule for C. gariepinus fingerlings. The maximum possible score for a feeding schedule is 25.*

Feeding Schedule	Group 1
A	17
B	5
1A+1B	19
2A+1B	19
3A+1B	21

***Table 9**: Feed cost saving for the mixed feeding schedule, 3A+1B relative to diet A for a culture period of 91 days.*

		Schedule	
		A	3A+1B
Number of days of presentation	A	91	69
Number of days of presentation	B	-	22
Cost of feed (₦)[1]		1179	1025.20
Feeding cost saving over 13 weeks		153.5 (13.02%)	
[1] Cost of Diet A=₦2400 kg^{-1} ; Diet B=₦500.00			

Although many studies support mixed feeding schedule for best performance and feed cost reduction, disparity exist however in terms of the number of days or frequency of alternation. For instance, a study by De Silva [34] reported that growth performance of two different sizes of *O. niloticus* was influenced by its feeding schedule with the best performance obtained when fry were fed 2 days on a low protein diet alternating with 3 days of high protein level (3H+2L). Ali [28] documented that for profitable sutchi catfish culture with silver carp, farmers can use the mixed feeding schedule of alternate day feeding of low protein and high protein (1H+1L) as a means of reducing feed costs. However, this schedule of (3A+1B) harmonizes well with that of Srikanth [35] who observed that a feeding schedule of three days high protein and one-day low protein (3H+1L) resulted in growth similar to the high protein diet. The 13.02% savings in feed cost further suggest that the schedule is capable of reducing feed cost.

4. Conclusions

Using a proper mixed feeding schedule through alternate days of high-protein and low-protein achieved better growth and feed utilization of African catfish rather than continuous feeding with high protein levels. Thus, a mixed feeding schedule of 3 days high protein level, preferably from Coppen with 1 day of low protein level could be considered promising for *C. gariepinus* in terms of growth performance, feed utilization, survival and feed cost reduction. The results open up a new avenue in the development of more efficient mixed feeding schedules using two separate diets, foreign and on-farm within alternate days of feeding. Further research is needed to develop this new strategy. Collaboration among fish nutritionists, farmers, and feed manufacturers are needed to put the mixed feeding schedules into practice. Fish farmers should continue to use Coppen in feeding their fingerling especially during the first two months, as this helps in jumpstarting the growth of the fish. However, for better growth, feed utilization, survival and feed cost reduction, a low/medium protein diet should be formulated on-farm and used to alternate the feeding days using the mixed feeding schedule of 3 days high protein level alternated with a one-day low protein (3H+1L) level.

Conflicts of Interest

There is no conflict of interest regarding the publication of this article.

Acknowledgments

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