

Harvesting Techniques and Evaluation of Maggot Meal as Animal Dietary Protein Source for 'Heteoclarias' in Outdoor Concrete Tanks

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Abstract: Two harvesting techniques (HT₁- Screen method and HT₂-Floatation method) and utilization potential of *Musca domestica* maggot was investigated. The growth response, feed conversion ratio and cost benefits of hybrid catfish ♀*Heterobranchus longifilis* x ♂*Clarias gariepinus* fed five maggot meal based diets were also evaluated for 70 days in outdoor concrete tanks. Twenty-five fingerlings of the hybrid fish were stocked in ten outdoor concrete tanks of dimension 1.2 m x 0.13 m x 0.18 m and coded MM₁-MM₅ in relation to their diet name. Five isonitrogenous maggot meal based diets namely MM₁ - 0% maggot meal, MM₂ - 25% maggot meal, MM₃ - 50% maggot meal, MM₄ - 75% maggot meal and MM₅ - 100% maggot meal were used for the experiment. There is no significant difference $p < 0.05$ between the live maggot collected from the HT₁ and HT₂ over a period of four hours. There is higher significant $p < 0.05$ correlation ($r = 0.9987$) between the experimental diets ether extract and crude fibre with increase in maggot inclusion levels. Diet MM₂ had the best growth performance and highest MGR with a significant difference $p < 0.05$ compared to other diets fed fish. No significant differences $p > 0.05$ exist between the growth parameters for diets MM₁, MM₃ and MM₄. A positive correlation ($r = 1.0$) exists ($p < 0.05$, 0.25) between the growth parameters for the different experimental diets. Highest correlation $r^2 = 0.9981$ exists $p < 0.05$ between MGR within the treatments. No significant $p > 0.05$ difference in expenditure, but there is between the profit indices and incidence of cost within the trials. MM₂ has the best yield cost and net profit. Without any reservation, from these results and the foregoing floatation harvesting method is recommended for maggot production and 25% inclusion of maggot based meal diet in the feed of hybrid catfish for growth and profitability is also recommended.

Key Words: Harvesting techniques • maggot meal • hybrid catfish • growth • nutrient • economic benefits

INTRODUCTION

In Nigeria, about 932.5 tonnes of poultry manure is produced annually due to the well-established poultry and livestock industries which are expanding at 6-8% annually [1]. This large turn-out of poultry waste imposes threat of disposal to the poultry industries and as well serious pollution problems to the incumbent environment and man's health. With the emergence of synthetic fertilizer, the previous use of organic fertilizer has lost its tempo if not for the durability it is for the preservation potential. The recycling of this waste has assumed significant role in aquaculture for the enhancement of detritus food chain and production of high quality protein

[2]. Thus, an efficient and effective means of poultry waste disposal becomes imperative. Calvert *et al.* [3] mentioned that the only way out of this problem is to use natural organisms which could break down the poultry dung by biodegradation, thereby providing a source of animal protein for fish and livestock so as to reduce the recurrent cost which has been on a geometrical increase as a result of hike in the prices of the conventional ingredients especially fish meal [4, 5].

Maggot, the larva form of Housefly (*Musca domestica*) grows extensively on animal dung and food waste where it digests them to odour free "scum" with high nutrient value. Maggot is readily available, free from man's competition and has been accredited for its

high quality protein with amino acids profile showing its biological value to be superior to soybean and groundnut cake [1]. This organism can be included in fish feed to promote fish growth and reduce cost like other non-conventional feeds like chironomids, toad, earthworm, polychaetes, duckweed, water hyacinth, garden snail, mussels, periwinkle, lizard and frog [6-13]. Harvesting of the cultured maggot has been a serious problem combating most of the maggot culturists and most maggotry because maggots are known fast crawlers.

The culture of 'Heteroclaris' (♀*Heterobranchus longifilis* x ♂*Clarias gariepinus*) is rapidly increasing in Nigeria. This is due to the high growth rate, resistance to disease and poor environments inherited from *Heterobranchus longifilis* and *Clarias gariepinus*, respectively. 'Heteroclaris' is an omnivorous fish and a renowned maggot feeder, which is culturable in both indoor and outdoor tanks [14, 15]. With the rapid increase in market demand of this species, there is a need to buttress its production so that the aquaculture sector will be able to alleviate the deficit in the supply of this specie.

Hence, the major aim of this study is to evaluate the efficiency of maggot harvesting techniques as well as the economics and production capacity of feeding 'Heteroclaris' with maggots meal supplemented diets.

MATERIALS AND METHODS

Culture and harvesting of maggot:

Culture of maggot: Maggots used for this experiment were cultured from chicken manure using sack method as described by Madu and Ufodike [16]. One kilogram of fresh chicken manure was collected from the Veterinary Poultry farm of University of Ibadan in a jute sack, oven dried to constant weight and wet with water twice daily within 6.00-7.00 h and 17.00-18.00 h. The dung was exposed to housefly (*Musca domestica*) between 7.00-10.00 h, during which they lay eggs on the dung. After the exposure time, the sacks were tied in the mouth and placed under a shade to allow for development of maggot. The emergence of maggots started after 24 h, after eggs were presumed to have been laid.

Harvesting techniques: Two methods were adopted in collection of maggots viz: Screened and Flootation methods.

The first harvesting method adopted is Screened method. Collection was done as described by Sogbesan [10] using screen nets of mesh size 3 mm. The maggot-containing dung was thinly spread on the screen net

under an intensive sunlight with a basin placed under the screen net. In an attempt to escape from the traces of sunlight, maggots passed through the 3 mm-mesh size net and dropped in the basin under the net where they are collected and weighed and the weight recorded.

The Second harvesting method adopted is Flootation method. The dung with maggots was first soaked in water in a basin, wherein the maggots float on the water. They were thereafter sieved with 3 mm-mesh size net, weighed and recorded.

The two harvesting methods were time four hours and the quantities of maggot harvested were recorded. This experiment lasted for four weeks.

Processing of maggot meal: The Maggots collected were weighed, blanched in hot water, oven dried at 80°C for 6 h, re-weighed and grounded into powdery form using blender machine to form maggot meal.

Experimental fish collection: A total of 250 Heteroclaris ((♀*Heterobranchus longifilis* x ♂*Clarias gariepinus*) fingerlings were purchased the Fish Biotechnology Laboratory of the National Institute for Freshwater Fisheries Research (NIFFR), New-Bussa, Nigeria. The total weight of the fish was taken and fish were distributed into two rectangular troughs for acclimatization in the Fish Nutrition Laboratory of NIFFR, New-Bussa. For 7 days and fed a commercial catfish feed formulated at 35% Crude Protein twice a day.

Fish feed ingredients: Fish meal, Soybean oil, blood meal, groundnut cake, yellow maize, cassava starch, Dicalcium sulphate and vitamin/mineral premix were purchased from Hope Farms Ltd., Ibadan, Nigeria and transported to New-Bussa, Nigeria for formulation and compounding.

Formulation of the experimental diets: A complete randomized experimental design was adopted in which five (5) isonitrogenous at 40% crude protein and caloric values of 1757.70-1988.11 kJ/100 g diets were formulated. The maggot meal inclusions were randomized at 0% (Control), 25%, 50%, 75% and 100% as replacement for fish meal clupeids (Table 1). After formulation, the ingredients were measured using electric sensitive weighing balance (OHAUS-LS 2000 Model), milled into fine particulate, using Laboratory Mill model 1029-B machine to obtain a homogeneous mass. Hot water was added and mixed further to obtain dough-like paste. The diets were Pelleted through a 2 mm die mixer (OHMACHI) model OMG12B pelleting machine to form cylindrical

Table 1: Formulation and production cost of the experimental diets

Feed Ingredients	MM ₁	MM ₂	MM ₃	MM ₄	MM ₅
Maggot inclusion levels	0% (Control)	25%	50%	75%	100%
Fish meal	30.00	22.50	15.00	7.50	-
Maggot meal	-	7.50	15.00	22.50	30.00
Blood meal	7.50	7.50	7.50	7.50	7.50
Groundnut cake	22.17	27.67	33.17	38.67	44.17
Yellow maize	35.33	29.83	24.33	18.83	13.33
Soybean oil	2.00	2.00	2.00	2.00	2.00
Cassava starch	0.50	0.50	0.50	0.50	0.50
Dicalcium phosphate	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50
Vitamin/mineral premix	1.50	1.50	1.50	1.50	1.50
Total	100.00	100.00	100.00	100.00	100.00
Calculated crude protein %	40.10	40.01	40.01	40.01	40.00
Calculated gross energy kJ/100 g	1757.70	1776.11	1825.06	1867.30	1889.90
¹ Production cost of feed (₦/ kg)	78.59	71.64	64.69	57.74	50.79
Cost of production (₦) of 1 bag of feed (45 kg)	3536.55	3223.80	2911.10	2598.30	2285.60
² Cost of production (US \$) of 1 bag of feed	25.26	23.03	20.79	18.56	16.33

¹Ingredients costs were calculated based on the current cost (₦/kg) in Nigeria livestock feeds market

²Costs were based on the current exchange rate in the country

model-like strands, which were sun-dried to constant weight and stored at -20°C in airtight polyethylene bags prior to use. The Pelleted diets were mechanically crushed into pellets of suitable size for hybrid catfish fingerlings.

Feeding trials experiment: Ten (10) outdoor concrete tanks each of dimensions 1.28 x 0.64 m x 0.58 m were used for the feeding trial at the Hatchery complex of NIFFR, New-Bussa, Nigeria. The tanks were screened with mosquito net to protect the fingerlings from predators. 'Heteroclaris' fingerlings of weight 1.75±0.15 g used for the feeding trials were starved for 24 h before stocking and commencement of the feeding trials. The fingerlings were randomly distributed into the ten outdoor tanks at the rate of 20 fish per tank and fed twice daily (between 8.00-8.30 h and 18.00-18.30 h) at 5% body weight for 70 days. Each experiment was duplicated. The quantity of feed was adjusted based on the new weekly weight of fish.

Growth performance and nutrient utilization: The weekly weights recorded and feed supplied were used to compute the growth and nutrient utilization parameters following the method of Burel *et al.* [17].

Mean weight gain =

$(W_f - W_i) / \text{no. of days}$. (W_f = Final weight (g), W_i = Initial weight (g))

Relative growth rate =

$\text{Weight gain} \times 100 / \text{Initial body weight}$

Specific growth rate =

$\text{Log } w_f - \text{Log } w_i \times 100 / \text{no. of days}$. (w_f = Final weight (g), w_i = Initial weight (g))

Food conversion ratio =

$\text{Feed intake (g)} / \text{Fish weight gain (g)}$

Gross Efficiency of Feed Conversion (%) =

$1 / \text{Feed conversion rate} \times 100$

Protein Efficiency Ratio =

$\text{Mean weight gain (g)} / \text{Mean protein intake}$

Productive Protein value =

$\text{Final body protein} - \text{Initial body protein} / \text{Protein Intake}$

Metabolic growth rate was determine according to Becker *et al.* [18].

Water quality measurement: Water temperature (°C) was taken daily (7.00-8.00) with graduated mercury-in-glass thermometer while dissolved oxygen and pH were determined using the methods described by Boyd [19].

Proximate analysis of the experimental diets: The maggot meal, fish meal and experimental diets were

analyzed for the proximate composition following Association of Analytical chemist methods [20]. Moisture content was determined by drying in an oven at 85°C to constant weight. Crude protein was determined indirectly from the analysis of total nitrogen (crude protein = amount of Nitrogen x 6.25) using Kjeldahl method while crude lipid was determined after soxhlet extraction of dried samples with 1.25% H₂SO₄ and 1.25% NaOH. Ash content after ashing in a porcelain crucible placed in a muffle furnace at 550°C for 16 h. Gross energy content was determined using bomb calorimeter.

Economics analysis: The economic analysis was computed to estimate the cost of feed required to raise a kilogram of fish using the various experimental diets. The major assumption is that all other operating costs for commercial fish production will remain the same for all diets. Thus cost of feed was the only economic criterion in this case. The cost was based on the current prices of the feed ingredients as at the time of purchase. The cost of producing maggot meal was put as cost of transporting poultry dung and processing costs. The economic evaluations of the diets were calculated from the method of New [21] as:

$$\begin{aligned} \text{Estimated investment cost analysis} &= \\ \text{Cost of feeding (₦)} + \text{Cost of fingerlings stocked (₦)} & \\ \\ \text{Profit index} &= \\ \text{Value of fish (₦)} / \text{cost of feed ((₦))} & \\ \\ \text{Incident of cost} &= \\ \text{Cost of feed ((₦))} / \text{mean weight gain of fish produced (g)} & \\ \\ \text{Net profit} &= \\ \text{Total Cost of fish cropped (₦)} - \text{Total expenditure (₦)} & \\ \\ \text{Cost: Benefit ratio (Br)} &= \frac{\text{Total cost of fish cropped (₦)}}{\text{Total Expenditure (₦)}} \quad [22] \end{aligned}$$

Statistical analysis: Data generated from the experiment were subjected to one-way of analysis of variance using the SPSS (Statistical Package Computer Software 2000 version), Duncan Multiple Range Test. Fisher least significant differences were used to compare differences among individual means at (p<0.05).

RESULTS

The quantity of maggot harvested using the two experimental techniques were shown on Fig. 1. From the

figure, higher quantity of maggots was collected using the floatation techniques than the screening technique over equal time duration. There is rising increasing in the quantity of maggot from floatation method than the screening method as the experiment continues from week to week 4. Higher correlation value of r=0.8145 with coefficient of determination of r²=0.6631 were computed statistically from the quantity of maggot harvested from using the two techniques. The ANOVA between the quantity of maggot harvested gave F=3.937 which is insignificantly different at p>0.05.

The proximate analysis of fish meal, maggot meal and the five experimental diets used is presented on Table 2. The crude protein, crude lipid, ash and crude fibre ranged from 41.16-70.65, 7.89-20.61, 6.98-20.05 and 1.03%-3.74%, respectively. There was significant difference (p<0.05) between the proximate composition of crude lipid and Ash content.

The weekly changes in weight has shown on Fig. 2 implies that 25% maggot meal inclusion levels gave the final highest weight increase as at the last sampled week. Increase in weight was recorded in all the experimental treatments though the fish respond positively early enough to maggot supplemented diets as shown from week 1 result on Fig. 2. The highest total weight gain of 91.2 g was recorded in fish fed 25% maggot meal supplemented diets followed by 72.8 g from 75% maggot meal supplemented diet fed fish while the least total weight gain of 55.6 g was computed from fish fed 100% maggot meal supplemented diet (Table 3). The best specific growth rate of 0.83% /day was recorded from fish fed 25% maggot meal supplemented diets. The result of the feed conversion rate and gross efficiency of feed conversion ranged between 1.71-2.55 and 39.22%-58.48%, respectively. The highest protein efficiency ratio of 6.14 was computed from fish fed 25% maggot meal supplemented diets. The survival rate ranged from 95%-100%. The best net profit of N 105.85 and cost: benefit ratio of 3.86 was recorded from fish fed 25% maggot meal supplemented diets.

DISCUSSION

The optimum aim of every agricultural investor is to make profit at the end of the cultural season. This same phenomenon is as well applicable to fisheries. Since cost of feed has been one of the major constrain to the development of aquaculture sector; provision of an alternative ingredient that will be able to reduce certain percentage of the incurred overhead cost as a result of feeding should be embraced.

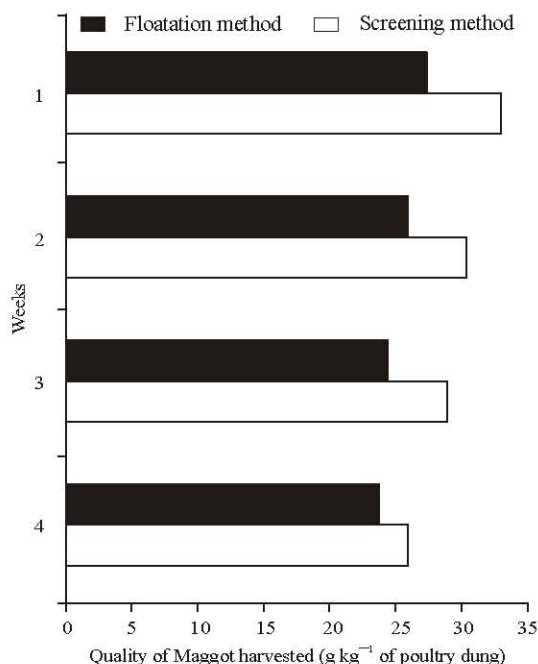


Fig. 1: Quantity of Maggot harvested from 1 kg of Poultry dung using two harvesting techniques for 4 h

Table 2: Proximate and energy composition of fish meal (Clupeids), maggot meal and the experimental diets (% DM/100 g)

Composition	Fish meal	Maggot meal	Maggot meal				
			0%	25%	50%	75%	100%
Crude protein (%)	70.65 ^a	50.42 ^b	41.16 ^e	41.43 ^e	41.71 ^e	41.98 ^e	42.25 ^e
Ether extract (%)	7.89 ^e	20.61 ^a	8.87 ^f	10.92 ^e	12.96 ^d	15.00 ^e	17.04 ^b
Crude fibre (%)	1.03 ^e	1.56 ^d	3.02 ^e	3.20 ^b	3.38 ^b	3.56 ^a	3.74 ^a
Ash (%)	20.05	11.65	8.57	8.19	7.34	7.38	6.98
Nitrogen free extract (%)	1.38	5.62	24.46	22.30	20.61	18.04	15.90
Dry matter (%)	90.20	89.86	86.08	86.04	86.00	85.96	85.91
Gross energy kJ/100 g	2021.14 ^b	2114.88 ^a	1741.72 ^e	1794.98 ^e	1854.81 ^a	1898.99 ^d	1951.04 ^e
Digestible energy kcal/100 g	1631.30	1764.85	1447.96	1494.48	1547.37	1587.92	1634.40
P: DE mg protein / kcal DE	28.61	41.95	42.32	43.33	44.47	45.24	4617.85

*All superscripts with different alphabet are significantly difference (p<0.05)

Heteroclaris fingerlings fed the control diet would have been expected to show the best growth performance since its contains fish which is high in protein content and the reported best source of animal protein feed for fish [23, 24], but this was not so. However, Massumotu *et al.* [24] reported that the biological value of protein source does not only depend on its amino acid profile but also on its digestibility. Since inclusion of maggot meal increases the crude fibre content of the feeds and this has been documented to enhance growth performance in fish [25]. This probably affected the food conversion ratio and

the feed utilization by the fingerlings since high fibre in feed has been reported by Fagbenro and Arowosoge [26] to play a significant role in digestion of feed. According to Jhringran [27] maggots are easily digested by fish. Heteroclaris fingerlings fed combined animal protein feed had better weight gain, daily growth index, relative weight gain, metabolic growth rate and specific growth rate values than those fed single animal protein source feed. The higher growth performance observed in combined feeding can be explain by the synergetic effect of combining two biological compounds

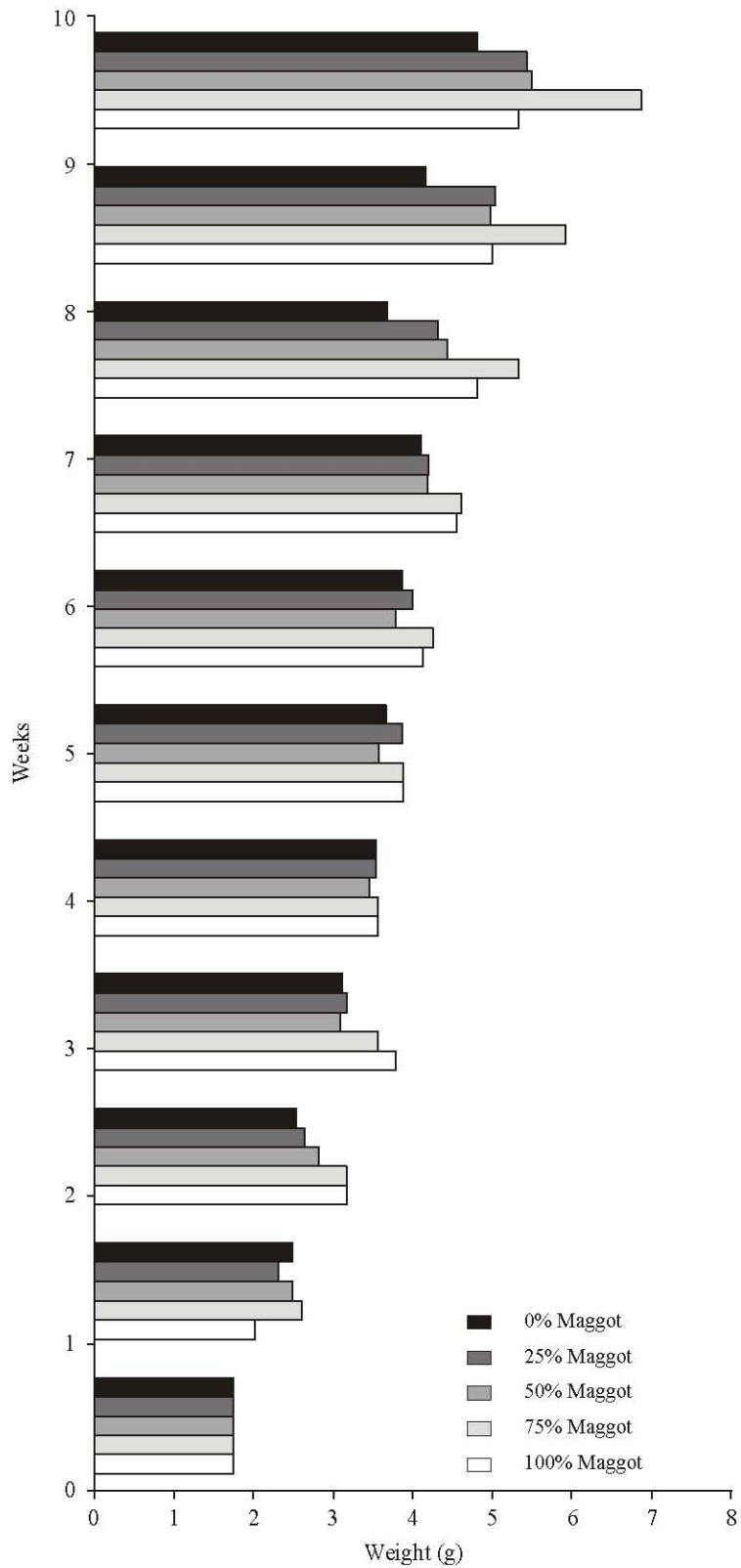


Fig. 2: Weekly growth pattern of *Heteroclaris* fingerlings fed Maggot meal based diets for 70 days

Table 3: Growth parameters, nutrient utilization and economic benefits of hybrid catfish fed maggot meal based diets for 70 days

Parameter	Maggot meal				
	0%	25%	50%	75%	100%
Initial mean weight (g/fish) /SEM	1.75±0.02	1.75±0.04	1.75±0.01	1.75±0.04	1.75±0.03
Total initial weight (g)	35.40	35.80	35.20	35.80	35.60
Mean final weight (g/fish) /SEM	5.36±0.07	6.68±0.04	5.49±0.01	5.43±0.06	4.56±0.08
Total final weight (g)	107.20 ^b	126.92 ^a	104.31 ^b	108.60 ^b	91.20 ^c
Mean weight gain (g/fish)	3.61 ^b	4.93 ^a	3.74 ^b	3.68 ^b	2.81 ^c
Total weight gain (g)	71.80	91.12	69.11	72.8	55.60
Relative weight gain %	202.80 ^b	254.50 ^a	196.30 ^b	203.30 ^b	156.20 ^c
Mean daily weight gain (g/day/fish)	0.052	0.07	0.053	0.053	0.040
Specific growth rate (%/day)	0.69 ^b	0.83 ^a	0.71 ^b	0.70 ^b	0.59 ^c
Metabolic growth rate	11.82	13.60	12.09	12.15	10.17
Total feed intake (g)	36.67	38.44	34.08	34.88	32.91
Feed conversion ratio	1.97 ^b	2.55 ^a	2.17 ^b	2.11 ^b	1.97 ^b
Gross efficiency conversion rate (%)	50.76	39.22	46.08	47.39	58.48
Protein intake (g/100g)	15.09	15.93	14.21	14.64	13.91
Protein efficiency rate	4.78 ^{bc}	6.14 ^a	5.23 ^b	5.03 ^b	4.04 ^c
Productive protein value (%)	6.03 ^b	5.90 ^d	6.19 ^a	5.60 ^c	6.12 ^a
Survival %	100.00	95.00	95.00	100.00	100.00
Cost of feeding (₦)	28.74 ^a	27.45 ^a	22.05 ^f	20.14 ^e	16.71 ^d
Cost of fingerlings (₦)	400.00	400.00	400.00	400.00	400.00
Expenditure (₦)	428.74 ^a	427.45 ^a	422.05 ^b	420.14 ^b	416.71 ^c
Value of fish (₦)	1225.10 ^b	1450.50 ^a	1192.10 ^b	1241.10 ^b	1042.30 ^c
Incidence of cost (₦/g)	0.268 ^a	0.216 ^b	0.211 ^b	0.185 ^c	0.183 ^c
Profit index	3.73 ^d	4.62 ^c	4.73 ^c	5.36 ^a	5.46 ^a
Net profit	83.86 ^d	105.85 ^a	87.45 ^c	93.86 ^b	79.09 ^d
Cost ratio: Benefit (Bcr)	2.92 ^e	3.86 ^d	3.97 ^c	4.66 ^b	4.73 ^a

*All superscripts with different alphabet are significantly difference ($p < 0.05$)

to have a single and superior effect than when applied individually. This observation is in agreement with suggestions by previous authors that combined protein source is better than single protein source for fish diets [13, 22, 28, 29].

The results on the survival rate indicated that the feeding of *Heteroclaris* fingerlings on maggot diets resulted into high survival rate. This can be connected to the high acceptability of this meal, which was observed during the study and also in accordance to the earlier report of Babatunde [15], Madu & Ufodike [16] and Faturoti [30].

The economic evaluation of feeding *Heteroclaris* fingerlings on experimental diets shows that 25% maggot meal based diet recorded the highest net gain and cost: benefit ratio. The positive net gain and cost: benefit ratio recorded in all the diets indicate that

Heteroclaris can be economically reared on all diets. However, the result further indicated that substitution of fishmeal with maggot meal to 50% in the diet of *Heteroclaris* can result into better cost: benefit ratio than when fed with either fishmeal or maggot diet alone.

The cost of production and the benefits positively favored all treatments since the values computed are > 1.0 which shows an increase in the fish value above the amount invested. This notwithstanding, more monetary profit awaits a farmer when 100% of maggot meal is used to replace fish meal in the diets of *Heteroclaris*. Maggot meal utilization in aquaculture will promote sustainable aquaculture in Nigeria and helps in the control of the nuisance poultry dung which production is increasing as the poultry industry expands.

CONCLUSIONS

This study has shown the possibility of inclusion of maggot meal in the formulation of fish feed and that this meal can be used to supplement fishmeal to about 25% inclusion levels which gave the best growth performance from this study.

The economic analysis also justifies the growth performance findings. Based on these results, the use of maggot to supplement for the costly fishmeal to about 100% inclusion levels is recommended to fish farmers and feed industry.

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