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## Effect of Feeding on Fresh (wet) Housefly Maggots (*Musca domestica*) with or without Artificial Diet on Water Quality and Growth Rates of African Catfish (*Clarias gariepinus* Burchell, 1822) Fry under Laboratory Conditions

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ABSTRACT

No or little information on the use fresh (wet) housefly maggots (*Musca domestica*) in African catfish (*Clarias gariepinus*) fry feeding. Therefore, this study was conducted to investigate the effect of feeding on fresh (wet) housefly maggots with or without artificial diet on water quality, growth performance, survival percentage and feed utilization of African catfish fry under laboratory conditions. Housefly maggots produced from a mixture of poultry droppings and foods wastes, it was used to replace artificial feed at 0, 50 and 100% levels. Catfish were fed artificial diet alone (Feed 1), fresh (wet) housefly maggots alone (Feed 2), and 50% fresh housefly maggots with 50% artificial diet (Feed 3) were prepared and tested on triplicate groups of African catfish fry (initial weight of  $0.25 \pm 0.02$  g) for 60 days. Results showed that final weight (g/fish) was significantly ( $P \leq 0.05$ ) higher in fish fed on feed 3 ( $6.03 \pm 0.08$ ), followed by fish fed feed 2 ( $4.62 \pm 0.27$ ), followed by fish fed feed 1 ( $3.15 \pm 0.68$ ). Specific growth rate (%/day) was also significantly higher in fish fed on feed 3 ( $5.31 \pm 0.10$ ), followed by fish fed feed 2 ( $4.86 \pm 0.03$ ), followed by fish fed feed 1 ( $4.18 \pm 0.24$ ). The same trend was observed with total weight gain, percentage weight gain, daily growth rate and relative growth rate. Feed intake and protein intake were significantly ( $P \leq 0.05$ ) higher in fish fed on feed 3 and fish fed on feed 2, followed by fish fed feed 1. While, feed conversion ratio (FCR) and protein efficiency ratio were not significantly ( $P > 0.05$ ), but the improvement in FCR recorded in catfish fry fed feed 3 and feed 2 under the experimental conditions. Survival percentage was within the range 55-75%, with insignificant differences ( $P > 0.05$ ) among treatments. The water quality parameters such as temperature, pH, dissolved oxygen, total ammonia, nitrite and nitrate were not significantly ( $P > 0.05$ ) between the treatments and were tolerable for Catfish culture. Accordingly, use of the 50% fresh (wet) housefly maggots with 50% artificial diet in African catfish fry feeding had positive effect on growth performance and reduce of the feed cost.

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## 1. Introduction

The African catfish is a chordate animal and belongs to Class Osteichthyes (bony fishes), Family Clariidae. It is a dominant freshwater fish. It can grow up to 1.4 and 2 m long and can weigh anything from 8 kg to 59 kg. The South African angling record is 35 kg; however a 58.9 kg specimen was caught in the Vaal River<sup>[1]</sup>. It is popular specie grown in many manmade ponds because of high survival ability<sup>[2]</sup>. The African catfish farming has witnessed an increased production and gained a considerable importance recently in Egypt, turned it from just an undesirable species in tilapia ponds or a 'police-fish' to control overbreeding in mixed-sex tilapia culture in earthen ponds to an important and potential species for aquaculture<sup>[3]</sup>.

Recent high demand and consequent high prices for conventional feed ingredients such as fish meal, groundnut meal and soybean meal etc., has led to the development of insect protein for aquaculture as a new area of research<sup>[4]</sup>. The increasing cost of fish feed has been at an alarming rate and this has affected the development and expansion of aquaculture in African countries<sup>[5]</sup>. The need for more research for vital protein augments to make affordable fishmeal and thus increase the production of catfish becomes eminent<sup>[2]</sup>. The research for suitable and cost-effective alternative protein sources for use in industrial aqua feeds will be the most critical factor in the development of intensive aquaculture<sup>[5]</sup>. Insect meals are nutritious and healthy alternatives to fishmeal because of its rich nutritional values especially protein, fat and minerals<sup>[6]</sup>.

Housefly maggot (*Musca domestica*) is the larva phase of a housefly which grows extensively on animal dung including cow, sheep, goat and poultry droppings under favorable conditions. Maggot is a potential alternative protein source for fish as reflected in its chemical composition<sup>[7]</sup>. Also, the ease of maggot production and processing, and acceptability by fish qualifies it as a suitable supplementary feed for fish. Housefly (*Musca domestica*) maggot meal was reported to contain 39-65% protein<sup>[8, 9]</sup>, depending on the age of maggots at harvesting. Such variations in protein content could be attributed to the processing, drying, storage and protein estimation methods employed, or the substrate used for the production of housefly maggots<sup>[9, 10]</sup>. Maggot has come to be known not only as safe food for fishes, but also as rich protein source for them<sup>[11]</sup>.

Data of Ipinmoroti *et al.*<sup>[12]</sup> showed that 75% of wet maggots can be recommended as an inclusion level in commercial feed for adequate utilisation by *Clarias*

*gariiepinus* juveniles. Moreover, Okore *et al.*<sup>[2]</sup> implies that the maggot meal can successfully replace fishmeal in fish diets. As well as Fashina-Bombata and Balogun<sup>[13]</sup> and Ajani *et al.*<sup>[14]</sup> reported that maggot meal can replace up to 100% of fish meal in the diets of Nile tilapia (*Oreochromis niloticus*). Because of the consumers concern and perceived public health implications, as maggots are associated with decomposing filthy organic matters, the safety and acceptability of fish produced with larvae (maggot) meal need to be ascertained. Therefore, the substitution of expensive fishmeal with cheap maggot meal in fish diet had no negative effects on the quality and acceptability of the final products<sup>[15]</sup>.

Several studies have been reported on the use of housefly maggots (*Musca domestica*) as alternative protein sources in fish feed to partially or completely replace conventional feedstuff such as fishmeal and soybean meal. However there is no or little information on the use fresh (wet) housefly maggots (*Musca domestica*) in African catfish (*Clarias gariiepinus*) fry feeding. Therefore, the present study aims to investigate the effects of feeding on fresh (wet) housefly maggots (*Musca domestica*) with or without artificial diet on water quality, growth performance, survival rate and feed utilization of African catfish (*Clarias gariiepinus*) fry under laboratory conditions.

## 2. Material and Methods

The present study was conducted at Shakshouk Fish Research Station, El-Fayoum Governorate, National Institute of Oceanography and Fisheries (NIOF), Egypt, to investigate the effect of feeding on fresh (wet) housefly maggots (*Musca domestica*) with or without artificial diet on water quality, growth performance, survival rate and feed utilization of African catfish (*Clarias gariiepinus*) fry under laboratory conditions. The experimental done through July -August and lasting 60 days after start. African catfish (*Clarias gariiepinus* Burchell, 1822) fry (0.25±0.02 g initial body weight) were obtained after broodstock hatching in Shakshouk Fish Research Station, NIOF.

### 2.1 Feeding and Rearing Conditions

This experiment consists of three treatments. The first treatment: catfish fed on artificial feed only. The second treatment: catfish fed on fresh (wet) housefly maggots (*Musca domestica*) only. The third treatment: catfish were fed of half feeding rate on artificial feed and other fresh housefly maggots. Did not take into consideration the percentage of protein feed, but was

taking the variety feed. Ten fish were randomly stocked in nine glass aquaria (30 L capacity/ aquarium) filled with dechlorinated tap water. Each treatment consisted of three aquaria. The aquaria were provided with air stonws for continuous aeration by electrical air pumps. Fish were fed three times daily (9:30, 13:30 and 16:30 h) for six days a week at a rate of 5% of their wet biomass per day and readjusted bi-weekly after the biomass of fish in each aquarium was determined. Feed was offered by hand on dry weight basis. After weighing, each aquaria was cleaned to prevent accumulation of faeces and to reduce algal growth. The feces and other wastes were siphoned daily from the aquaria immediately before feeding. In addition, about 30% of the water was siphoned and replaced by new, fresh, dechlorinated water that was stocked in fiberglass tank and aerated by electrical air pumps. Feed consumption was recorded daily and rate of mortality was recorded. Water temperature, dissolved oxygen, pH, total ammonia, un-ionized ammonia, nitrite and nitrate were measured during experimental period. Fish were kept in a natural photoperiod condition throughout the experimental period (60 days). At the end of the study, fish in each aquarium were netted, counted and weighed.

## 2.2 Feed Formulation and Preparation

Artificial diet was formulated based on fish meal as the only animal protein source and a mixture of soybean meal and yellow corn as plant protein sources. Soybean oil was added as the major dietary lipid source to the artificial diet. The artificial feed formulated to be almost containing 40% crude protein (Tables 1 and 2), diet was hand made.

Housefly maggots (the larva stage of the housefly, *Musca domestica*) produced from poultry droppings and foods wastes. Fifteen kilogram of poultry droppings and foods wastes were mixed together and spread on three wood box (40 cm length, 40 cm width and 10 cm height) to a thickness of 7 cm to constitute the substrate. The odor of fresh poultry droppings and foods wastes, fermenting substrate attracted flies, which later laid eggs on it. The eggs hatched into larvae within two days and were allowed 48 hours to develop further. The mature maggots were harvested. Housefly maggots were caught from wood box by using tweezers then stored in plastic bags in the freezer (-18°C ±1°C) until used. Moisture in wood box was maintained high all time during housefly maggot production period<sup>[16,17]</sup>. Chemical composition of housefly maggots (*Musca domestica*) are shown in Table 2.

**Table 1.** Percentage composition of the artificial feed

Ingredients, %	Artificial diet
Fish meal, (CP 63%)	47
Soybean meal	18
Yellow corn	28
Soybean oil	4
Commercial yeast	1
Starch	1
Vitamins mixture <sup>1</sup>	0.5
Minerals mixture <sup>2</sup>	0.5

**Notes:** <sup>1</sup> Vitamins each 3 Kg contains: 1200 000 IU Vit. A, 300 000 IU Vit. D<sub>3</sub>, 700 mg Vit. E, 500 mg Vit. K<sub>3</sub>, 500 mg Vit. B<sub>1</sub>, 200 mg Vit. B<sub>2</sub>, 600 mg Vit. B<sub>6</sub>, 3 mg Vit. B<sub>12</sub>, 450 mg Vit. C, 3000 mg Niacin, 3000 mg Methionine, 10 000 mg Cholin chloride, 300 mg Folic acid, 6 mg Biotin, 670 mg Panthonic acid. <sup>2</sup> Minerals each 1 Kg contains: 1472 mg Manganese sulphat, 1030 mg Zinc sulphat, 2359 mg Iron sulphat, 747 mg Copper sulphat, 5 mg Cobalt sulphat, 33 mg Potassium iodide, 1.28 mg Sodium selenite, 4300 mg Sodium sulphat 32.37%, 4000 mg Potassium chloride 52%.

**Table 2.** Proximate chemical analysis (% on dry matter basis) of the experimental feeds

Chemical analysis (%)	Artificial diet	Fresh housefly maggots	Diet + maggots
Moisture	9.98	74.43	42.21
Dry matter, DM	90.02	25.57	57.79
Crude protein, CP	40.75	58.60	49.67
Ether extract, EE	9.40	15.82	12.61
Crude fiber, CF	1.93	--	0.97
Ash	8.84	24.18	16.51
Nitrogen free extract, NFE <sup>1</sup>	39.08	1.40	20.24
Gross energy, GE kcal/g <sup>2</sup>	4.922	4.806	4.864
Digestible energy, DE kcal/g <sup>3</sup>	4.117	3.768	3.943

**Notes:** <sup>1</sup> Calculated by differences. <sup>2</sup> Calculated according to NRC<sup>[18]</sup>. <sup>3</sup> Calculated according to Garling and Wilson<sup>[19]</sup>.

## 2.3 Growth Performance Indices

The growth and feed utilization parameters were calculated according the following equations:

Weight gain (g) = final weight, g - initial weight, g.

Percentage weight gain (%) = (weight gain)/ (final weight) × 100.

Daily growth rate (mg/day) = weight gain, mg / experimental period, day.

Relative growth rate (%) = (weight gain)/ (initial weight) × 100.

Specific growth rate (%/day) = [(ln final weight - ln initial weight)/period in days] × 100, where ln is the natural log.

Condition factor (g/cm<sup>3</sup>) = (fish weight)/ (fish length<sup>3</sup>) × 100.

Survival percentage (%) = (number of fish at end/ number of fish at start) × 100.

Feed conversion ratio (FCR) = dry feed intake, g/ weight gain, g.

Protein intake (g/fish) = total feed intake × protein content of feed.

Protein efficiency ratio (PER) = weight gain, g/ protein intake, g.

Energy intake (Kcal/ fish) = total feed intake × energy content of feed.

Energy efficiency ratio (EER) = weight gain, g/ energy intake, Kcal.

## 2.4 Water Quality Analysis

Water temperature was measured daily by using centigrade thermometer. Dissolved oxygen (DO) and pH were measured every week by using Tintometer® group (pH/ORP, DO, CD/TDS, Nr: 00724200. Germany 01/16). Water ammonia, nitrite and nitrate were determined every two weeks by using Spectrophotometer model (LKB Bichrom UV visible spectrophotometer) according to the method described by APHA [20]. To determine un-ionized ammonia concentration, multiply total ammonia concentration by the percentage which is closest to the observed temperature and pH of the water sample [21].

## 2.5 Chemical Analysis of Feeds

Feeds used were analyzed for their proximate composition in triplicates following the methods described by AOAC [22]. Gross energy (GE) content was calculated according to NRC [18] by using factors of 5.65, 9.45 and 4.22 kcal/g of protein, lipid and carbohydrate, respectively. Digestible energy (DE) content was calculated from standard physiological fuel values as 4, 4 and 9 kcal/g of protein, carbohydrate and lipid, respectively [19].

## 2.6 Statistical Analysis

Data of water quality, growth performance and feed utilization at different feeds were statistically analyzed using a one-way analysis of variance (ANOVA test) using SPSS Statistical Package Program, version 23 [23]. Mean of treatments were compared by Duncan multiple range test when the differences were significant [24]. Level of significance in all tests was  $P \leq 0.05$ . The results are expressed as means ± standard error (SE).

## 3. Results

### 3.1 Water Quality Parameters

Criteria on water of aquarium such as: temperature, pH,

dissolved oxygen, total ammonia, un-ionized ammonia, nitrite and nitrate were presented in Table (3). Water quality parameters were not significantly ( $P > 0.05$ ). Similar water quality characteristics were observed in all aquaria.

**Table 3.** Average water quality criteria (mean±SE) recorded during the experimental period

parameters	Artificial diet	Fresh housefly maggots	Diet + maggots	CV, %*
Temperature, °C	30.25±0.75 <sup>a</sup>	30.10±0.90 <sup>a</sup>	30.20±0.80 <sup>a</sup>	2.98
pH	8.20±0.09 <sup>a</sup>	8.25±0.02 <sup>a</sup>	8.17±0.07 <sup>a</sup>	0.97
Dissolved oxygen, mg/l	6.55±0.15 <sup>a</sup>	6.90±0.30 <sup>a</sup>	6.70±0.20 <sup>a</sup>	4.36
Total ammonia, mg/l	0.363±0.10 <sup>a</sup>	0.349±0.07 <sup>a</sup>	0.351±0.09 <sup>a</sup>	27.54
Un-ionized ammonia, mg/l	0.040±0.011 <sup>a</sup>	0.039±0.009 <sup>a</sup>	0.039±0.009 <sup>a</sup>	27.38
Nitrite, mg/l	0.76±0.19 <sup>a</sup>	0.66±0.06 <sup>a</sup>	0.68±0.11 <sup>a</sup>	21.82
Nitrate, mg/l	1.45±0.22 <sup>a</sup>	1.44±0.01 <sup>a</sup>	1.43±0.19 <sup>a</sup>	12.92

**Notes:** Values are mean of three replicates. Value in the same row having similar superscript are not significantly different from one another ( $P > 0.05$ ). \* Coefficient of variation (CV, %) = (standard deviation)/ (mean) × 100.

### 3.2 Growth Performance and Survival Percentage

Results of growth performance and survival percentage of catfish fed on the three different feeds are shown in Table (4). There was no significant difference in the initial length and body weight of the fish between treatments. Survival percentage was within the range 55-75%, with insignificant differences ( $P > 0.05$ ) among treatments. Results of the growth performance parameters of catfish fry fed the three feeds showed that final weight (g/ fish) was significantly ( $P \leq 0.05$ ) higher in catfish fed 50% artificial diet + 50% fresh housefly maggots (6.03±0.08), followed by fish fed fresh housefly maggots alone (4.62±0.27), followed by fish fed artificial diet alone (3.15±0.68). Specific growth rate (%/day) was also significantly ( $P \leq 0.05$ ) higher in catfish fed 50% artificial diet + 50% fresh housefly maggots (5.31±0.10), followed by fish fed fresh housefly maggots alone (4.86±0.03), followed by fish fed artificial diet alone (4.18±0.24). The same trend was observed with total weight gain, percentage weight gain, daily growth rate and relative growth rate. But, final length and condition factor were not significantly ( $P > 0.05$ ) between treatments. The results indicated that the catfish fed 50% artificial diet + 50% fresh housefly maggots grow better in weights compared to those fed on fresh housefly maggots alone and artificial diet alone, but, catfish fed fresh housefly maggots alone grow better than catfish fed artificial diet alone under the experimental conditions.

**Table 4.** Average of the growth performance and survival percentage of catfish fed on the three different feeds for 60 days (mean± SE)

parameters	Artificial diet	Fresh house-fly maggots	Diet + maggots
Initial length, cm/ fish	3.3±0.1 <sup>a</sup>	3.3±0.1 <sup>a</sup>	3.3±0.1 <sup>a</sup>
Final length, cm/ fish	8.10±0.70 <sup>a</sup>	8.75±0.15 <sup>a</sup>	9.75±0.25 <sup>a</sup>
Initial weight, g/ fish	0.25±0.02 <sup>a</sup>	0.25±0.02 <sup>a</sup>	0.25±0.02 <sup>a</sup>
Final weight, g/ fish	3.15±0.68 <sup>b</sup>	4.62±0.27 <sup>ab</sup>	6.03±0.08 <sup>a</sup>
Total weight gain, g/ fish	2.90±0.66 <sup>b</sup>	4.37±0.25 <sup>ab</sup>	5.78±0.06 <sup>a</sup>
Percentage weight gain, %	91.79±1.18 <sup>b</sup>	94.58±0.11 <sup>ab</sup>	95.84±0.26 <sup>a</sup>
Daily growth rate, mg/ day	48.32±11.02 <sup>b</sup>	72.74±4.10 <sup>ab</sup>	96.24±0.94 <sup>a</sup>
Specific growth rate, %/day	4.18±0.24 <sup>b</sup>	4.86±0.03 <sup>ab</sup>	5.31±0.10 <sup>a</sup>
Relative growth rate, %	1142.87 ±177.76 <sup>b</sup>	1742.95 ±32.86 <sup>ab</sup>	2314.19 ±151.58 <sup>a</sup>
Condition factor, g/cm <sup>3</sup>	0.59±0.03 <sup>a</sup>	0.69±0.01 <sup>a</sup>	0.66±0.05 <sup>a</sup>
Survival percentage, %	55.00±5.00 <sup>a</sup>	75.00±5.00 <sup>a</sup>	75.00±5.00 <sup>a</sup>

**Notes:** Values are mean of three replicates. (a and b) Average in the same row having different superscripts are differ significantly ( $P \leq 0.05$ ). Mean values with the same superscript are not significantly different ( $P > 0.05$ ).

### 3.3 Feed Efficiency Parameters

As shown in Table (5). Results of the feed efficiency parameters of catfish fed the three feeds showed that feed intake, protein intake and energy intake were significantly highest ( $P \leq 0.05$ ) in fish fed 50% artificial diet + 50% fresh housefly maggots and fish fed fresh housefly maggots alone, followed by fish fed artificial diet alone. While, feed conversion ratio (FCR), protein efficiency ratio and energy efficiency ratio were not significantly ( $P > 0.05$ ) different between the three treatments. But the improvement in FCR recorded in African catfish fry fed 50% artificial diet + 50% fresh housefly maggots and fish fed fresh housefly maggots alone.

**Table 5.** Average of the feed utilization efficiency parameters of catfish fed on the three different feeds for 60 days (mean± SE)

parameters	Artificial diet	Fresh housefly maggots	Diet + maggots
Feed intake, g/ fish/ period	3.84±0.51 <sup>b</sup>	5.48±0.25 <sup>a</sup>	6.61±0.07 <sup>a</sup>
FCR, g feed/ g gain	1.36±0.14 <sup>a</sup>	1.26±0.02 <sup>a</sup>	1.15±0.01 <sup>a</sup>
Protein intake, g/fish	1.56±0.20 <sup>b</sup>	3.21±0.15 <sup>a</sup>	3.29±0.04 <sup>a</sup>
Protein efficiency ratio	1.83±0.19 <sup>a</sup>	1.36±0.01 <sup>a</sup>	1.76±0.01 <sup>a</sup>
Energy intake, Kcal/ fish	18.88±2.43 <sup>b</sup>	26.31±1.20 <sup>a</sup>	32.15±0.34 <sup>a</sup>
Energy efficiency ratio	0.15±0.016 <sup>a</sup>	0.17±0.002 <sup>a</sup>	0.18±0.001 <sup>a</sup>

**Notes:** Values are mean of three replicates. (a and b) Average in the same row having different superscripts are differ significantly ( $P \leq 0.05$ ). Mean values with the same superscript are not significantly different ( $P > 0.05$ ).

**Notice:** Feed intake was on dry matter basis (3.84g equal to 4.27g on wet weight), (5.48g equal to 21.43g on wet weight) 6.61g equal to 3.68g artificial diet +12.94g maggots on wet weight).

## 4. Discussion

The high dependence of aqua feeds on prohibitively expensive

fishmeal protein has taken its toll on the aquaculture industry. Fishmeal is the most expensive component of fish feeds and several studies have advocated its replacement with plant sources. Plant protein alternatives have their nutritional deficiencies<sup>[8]</sup> and also their use by humans and other animals make it imperative for a search for other alternatives<sup>[15]</sup>. Recently, there are several reports on the evaluation of unconventional protein sources in fish feeds, but the use of maggot (housefly larvae) meal that has a comparable nutritive value, especially amino acid profile, with fishmeal<sup>[25]</sup>, holds a promise in fish nutrition. Maggot meal has been found to be rich in protein and essential amino acids<sup>[26]</sup> and has successfully replaced fishmeal in catfish diets<sup>[27,28]</sup>.

In the present study, African catfish (*Clarias gariepinus*) fry fed on three feeds, artificial feed only, fresh (wet) housefly maggots (*Musca domestica*) only and 50% artificial feed with 50% fresh housefly maggots. Results obtained for growth performance such as final weight, total weight gain, daily growth rate and specific growth rate showed that there were significantly ( $P \leq 0.05$ ) higher in catfish fed 50% artificial diet + 50% fresh housefly maggots, followed by fish fed fresh housefly maggots alone, followed by fish fed artificial diet alone.

Response of catfish to feed was more aggressive with fed on fresh housefly maggots than artificial feed during the feeding trial, probably this is due to the predation behavior of African catfish as the fresh housefly maggots satisfy this natural instinct. The higher growth performance of catfish fed on 50% artificial diet + 50% fresh housefly maggots, this is due to two reasons: the first is that fresh housefly maggots provide satisfying instinct in predators, and the second is that artificial diet contains various ingredients (fish meal, soybean meal, yellow corn, soybean oil, yeast, starch and vitamins and minerals mixture) that contain all the necessary growth promoting factors from protein, energy, vitamins and minerals.

The difference obtained in the growth performance parameters of catfish fed on housefly maggot when compared to artificial diet, this may be attributed to maggot meal is animal protein ingredients are high protein content<sup>[5]</sup>, good sources of amino acids<sup>[29]</sup>, fatty acids<sup>[30]</sup>, minerals<sup>[27]</sup>. Moreover, Spinelli et al<sup>[31]</sup> indicated that the amino acid profile of maggot meal contains on the same number and outstanding level of amino acids found in fish meal. Also, Ipinmoroti et al.<sup>[12]</sup> mention that the wet maggot's composition showed the presence of amino acids similar to fishmeal. Also, maggot meal is rich in phosphorus, trace elements and B complex vitamins<sup>[32]</sup>. In addition, the improvement in growth and feed efficiency recorded in African catfish (*Clarias gariepinus*) fry fed maggot-supplemented diet suggest that maggot contain all the

necessary growth promoting factors, this opinion was supported by Mustapha and Kolawole<sup>[11]</sup> for *Oreochromis niloticus*. As well as, Mustapha and Kolawole<sup>[11]</sup> mention that the reason for the superiority of 100% fresh maggot diet over other diets was attributed to the relatively large amount of soft tissue contain in the whole diet. Also, Adesulu and Mustapha<sup>[33]</sup> indicated that the maggot meal may be superior to other protein sources in fish diets, it may contribute to this that the maggots easily digestible. This result agree with the report of other authors who have observed a better performance of fish fed diets containing maggot meal over those solely fed on fish meal diets meal. Thus, this is a reflection of the nutritive quality and acceptance of this biomaterial<sup>[34]</sup>. The result also corroborates previous observation that maggot meal, like other animal protein sources is well accepted and utilised by fish<sup>[35]</sup>.

From results of this study, the use of housefly maggot with artificial feed to fed African catfish appear to be advantageous especially as it produced higher growth performance when compared to the use of housefly maggot only and artificial diet only in feeding. This is similar to that observed by Ipinmoroti *et al.*<sup>[12]</sup> utilised housefly maggots (*Musca domestica*) at different levels (0, 25, 50, 75 and 100%) to replace fishmeal in the diets of catfish (*Clarias gariepinus*) juveniles. And they observed that 75% of wet maggot gave better growth and feed utilisation and conversion of feed to flesh. Also, Okore *et al.*<sup>[2]</sup> reported that, supplementing conventional fish feed with *Musca domestic* maggots for *Clarias gariepinus* juveniles. The percentage of the conventional feed to maggot inclusions were 70% to 30%, 55% to 45%, 35% to 65%, and 100% conventional feed. The result shows that a combination of 55% compounded ration and 45% maggot gives the best growth performance. And concluded that using housefly maggot directly as supplementary feed for *Clarias girepinus* at appropriate ration will enhance its growth and haematological performance. In another research conducted by Mustapha and Kolawole<sup>[11]</sup> indicated that fresh maggot meal can be successfully used to replace fishmeal partially or completely from 50% up to 100% in the diet of *Oreochromis niloticus* fingerlings for optimal growth and nutrient utilization. The results were in partial agree with Mustapha<sup>[36]</sup>, the best growth performance was recorded for fingerling fed with diet containing 75% oven dried maggot meal, followed by 50% maggot inclusion and the least growth performance was exhibited by fingerlings fed diet containing 100% oven dried maggot meal as the protein source.

On the other hand, Arong and Eyo<sup>[6]</sup> studied the effects of the combination of housefly maggot meal with commercial feed on the growth rates, survival

rate and feed utilization of the African catfish (*Clarias gariepinus*). Fish were fed maggot meal (100%), maggot meal with commercial feed (50:50), and commercial feed (100%). Although commercial feed was the best growth performance and feed utilization, the combination of maggot meal with commercial feed as supplementary feed will reduce the cost of fish production.

In this study, housefly maggot (*Musca domestica*) had crude protein of 58.60% which is higher than 22.97%<sup>[37]</sup>, 33.29%<sup>[6]</sup>, 42.00%<sup>[38]</sup> and 47.45%<sup>[12]</sup>, these variations observed in the chemical composition of maggot meal in the present study with other studies may be attributed to the methods used in processing of housefly maggots.

In fish nutrition studies, amount of feed consumed and feed conversion ratio (FCR) are very useful indices that are used to evaluate feed acceptability, production economics and fish performance in terms of growth<sup>[6]</sup>. The result of this study showed that feed intake and protein intake were significantly highest ( $P \leq 0.05$ ) in fish fed 50% artificial diet + 50% fresh housefly maggots and fish fed fresh housefly maggots alone, followed by fish fed artificial diet alone. While, FCR and protein efficiency ratio (PER) were not significantly ( $P > 0.05$ ), but the improvement in FCR recorded in African catfish fry fed 50% artificial diet + 50% fresh housefly maggots and fish fed fresh housefly maggots alone. This clearly indicates that the maggots used in the present study as supplementary feed could be consumed and utilized efficiently by catfish in the absence of artificial feed. This confirms the suitability of maggots as supplementary diets for *Clarias gariepinus*. This result corresponds with Okore *et al.*<sup>[2]</sup> mention that the best FCR was observed in *Clarias gariepinus* fed 55% conventional feed with 45% maggot. The results were in partial agree with Mustapha and Kolawole<sup>[11]</sup> indicated that the FCR decrease with increasing maggot level from 25% to 100% and PER decreased as the dietary maggot inclusion level increased. FCR was not significantly different between the maggot levels from 50% to 100% in the diet of *Oreochromis niloticus* fingerlings. On the other hand, Arong and Eyo<sup>[6]</sup> mention that the best FCR was obtained in catfish fed commercial feed.

In the present study, survival percentage was within the range 55-75%, with insignificant differences ( $P > 0.05$ ) among treatments, but the higher survival percentage (75%) recorded in African catfish fry fed 50% artificial diet + 50% fresh housefly maggots and fish fed fresh housefly maggots alone. These results agree with the observation of Okore *et al.*<sup>[2]</sup> confirmed that the highest survival rate was observed in *Clarias gariepinus* fed 55% conventional feed with 45% maggot. Also, Fatureti and Ifili<sup>[39]</sup> who indicated that the feeding of *Clarias*

*gariiepinus* fingerlings on maggot diets made for high survival. The results were in partial agree with Arong and Eyo <sup>[6]</sup> confirmed that the survival rate was not influenced by experimental feed as catfish fed on 100% commercial feed, 100% maggot meal, and maggot meal with commercial feed (50:50), but the highest survival recorded in African catfish fed commercial feed.

In the present study, water quality parameters such as temperature, pH, dissolved oxygen, total ammonia, un-ionized ammonia, nitrite and nitrate were not significantly ( $P>0.05$ ). Similar water quality characteristics were observed in all aquaria and were within the range recommended for optimal growth of freshwater fishes <sup>[40]</sup>. Also, the absence of negative effect of water quality parameters on catfish growth confirm that the combination of housefly maggots with artificial diet as a suitable feed combination to be used in culturing *Clarias gariiepinus* <sup>[6]</sup>.

## 5. Conclusion

Findings of this study has shown that growth performance and feed utilization indices were significantly better ( $P\leq 0.05$ ) in African catfish fry fed 50% artificial diet + 50% fresh housefly maggots, followed by fish fed fresh housefly maggots alone, followed by fish fed artificial diet alone under the experimental conditions. Use of the 50% fresh (wet) housefly maggots with 50% artificial diet in African catfish fry feeding had positive effect on growth performance and reduce of the feed cost.

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