

Evaluation of Growth Performance of Nile Tilapia *Oreochromis niloticus niloticus* Fed *Piophilidae* Maggot Meal (Magma meal) Diets

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Abstract: A relatively new approach is the use of insects as a source of animal protein in fish nutrition. Houseflies larvae utilise decaying organic waste to produce animal protein and the larvae can be used to produce a meal (magma meal). Interestingly study of the use of magma meal as substitute for fish meal in fish diets have increased in recent times. In the present work, a feeding trial was conducted to evaluate the potential of housefly maggot meal (magma meal) as a protein source for Nile tilapia (*Oreochromis niloticus niloticus*). The results of the present study revealed that all the experimental diets were accepted by *O. niloticus niloticus*. This implies that the different experimental feed ingredients did not affect the palatability of the diets. The good overall growth performances and no mortality obtained in both experimental group of this study confirm the suitability of chosen nutritional composition for tilapia. FCR values below 1 have been reported here, indicating the most efficient utilisation of food by *Oreochromis niloticus niloticus*. The fish fed on maggot diet exhibited a higher K value compared to those fed on commercial diet. The results suggested that dietary maggot meal promoted the growth of Nile tilapia and enhanced nutrient utilization which is reflected in improved length gain, weight gain, FCR, and SGR. Progressive increment in length gain, weight gain and SGR were observed in maggot meal based diet, recording better growth than commercial based diet, concluding that maggot diet has the best performance. Based on the result obtained from the experiment, it is hereby recommended that 100% maggot meal can be included in the diet of *O. niloticus niloticus* to reduce cost and maximize profit.

Keywords: Housefly Maggot Meal, Nile Tilapia, Aquaculture, Feed Technology

1. Introduction

Feed Technology is one of the least development sectors of aquaculture particularly in developing countries [1]. Selection of feed ingredients for use as a fish feed will play a major role in matching its ultimate nutritional in addition to economic success. Fish feed generally constitutes 60–70% of the operational cost in aquaculture system [2]. The need to minimize feed cost through the use of newer and cheaper sources of feed ingredients, has already been considered. Several feed ingredients have been investigated in an attempt to find substitutes for fish meal in the diets of tilapia [3], including animal proteins and plant proteins sources [4]. These feeds are cheaper than fish meal and enjoy high availability in certain regions of the world. The use of these ingredients in farmed tilapia diets have led to reduced feed efficiency and growth. Also, the competing demand for these

fish feed stuff has made feed production expensive [5][6].

A relatively new approach is the use of insects as a source of animal protein in fish nutrition [7]. Family philidae belonging order diptera have recently gained a wide attention as their larvae, used as substitute for fish meal in fish diets [8,9,10]. Houseflies larvae utilise decaying organic waste to produce animal protein and the larvae can be used to produce a meal (magma meal). Interestingly study of the use of maggot meal (magma meal) as substitute for fish meal in fish diets have increased in recent times [8, 9,10]. Maggots have high protein content with an amino acid profile superior to that of soybean and groundnut cake [8,9,10,11]. Based on cost effectiveness, availability and crude protein content, the housefly larvae grown on animal waste seem to have an immense potential as a good protein source for fish. The percentage of crude protein ranges between 39-55%, lipid 12.5-21%, and crude fiber 5.8- 8.2%. Magma meal is also rich in

phosphorus, trace elements and B complex vitamins [12].

Growth performance is important fishery management tool. Its importance is pronounced in assessing the relative well being of the cultured fish. It is a critical variable determining the success in fish culture. Nutrition is one of the most important factors influencing the ability of cultured fish to exhibit its genetic potential for growth. They are also greatly influenced by factors such as behaviour of fish, quality of feed, daily ratio size, feed intake or water temperature [13].

In the present work, a feeding trial was conducted to evaluate the potential of housefly maggot meal (magma) as a protein source for tilapia (*O. niloticus niloticus*) fingerlings. The effect of magma, however, has not been fully investigated in fish production. This study therefore, attempts to evaluate the potential of housefly magma as an alternative dietary protein sources for Tilapia (*O. niloticus niloticus* L.) fingerling by substituting maggot meal with fishmeal in the experimental diets. Growth parameters and feed conversion were examined.

2. Material and Methods

2.1. Study Location

The present study was conducted at Zoology Department, Faculty of Science, Al-Azhar University (Assiut branch) to study the effect of *Piophil casei* Maggot Meal (Magma) diets on the growth performance of Nile tilapia (*Oreochromis niloticus niloticus*).

2.2. Experimental Design

A total of 60 healthy Nile tilapia (*Oreochromis niloticus niloticus*) were used in the present work. Nile tilapias (average initial weight 28-41 gm and length 11-13.4 cm) were collected from the river Nile at Assiut, Egypt. Fishes were acclimated in the laboratory for at least 21 days. During the time of acclimatization fishes were fed on a commercial pellet diet twice per day. The compositions of such diet are provided in Table 1. After acclimatization, fishes were divided into two groups. Each group consisted of three replicates of 10 fish per 70 -L aquarium. The first group fed on commercial diet (Diets 1) and the second group fed on maggot diets (Diets 2) (Table 1).

The experiment lasted for 12 weeks. Each aquarium was supplied with dechlorinated tap water, continuously aerated using an air compressor. Dissolved oxygen (5.6 mg/L), pH (7.9), total NH₃-N (0.097 mg/L), and temperature (25.5 °C) were monitored daily in each aquarium during the experimental period. Experimental tanks were regularly cleaned and the faecal matters were siphoned out daily.

2.3. Sources of Ingredients and Diets Preparation

Soy bean meal, wheat bran, Rice bran, Mix Oil, Premix, di-calciumphosphate, and Fish meal were obtained locally from the market. Maggot meal used for this study is locally prepared in the lab during the progress of the experiment using the larval stage of Skippers (fly larvae) of *Piophil casei*.

The larvae were collected from classic made cheese mesh by floating method. The home made cheese was mixed with running water and the larvae floated out to be collected with a sieve. Maggots were harvested, washed, killed in tepid water and dried for 36 hours at 60 °C in an oven. Dried samples were milled using pestle and mortar. Maggot powder was added to components of experimental fish food according to the following recommended amounts. Two test diets were formulated. Diet 1 (commercial diet) was formulated with the highest inclusion level of fishmeal and without magma. Diet 2 (maggot diet) was formulated with the highest inclusion level of magma and without fishmeal (Table 1). All dry diet components, including vitamins and minerals mixture, were thoroughly mixed with oil. Water was added and the feed pressed into pellets of 1 mm diameter. The wet pellets were dried for 3 days at room temperature and stored at -2 °C until use.

Table 1. Formulation of experimental diets.

Diets	Diet 1 %	Diet 2 %	Gram
Fish meal 65%	20	----	200
Magma	----	20	200
soy bean	35	35	350
wheat bran	20	20	200
Yellow corn	14	14	140
Rice bran	5.5	5.5	55
Mix Oil	3	3	30
Premix	2	2	20
di-calciumphosphate	0.5	0.5	5
Total	100%	100%	1000

2.4. Growth Performance Parameters

All growth parameters were determined at four weeks intervals. After the feeding trial, the growth parameters including weight gain (WG), length gain (LG), condition factor (K), specific growth rate (SGR), feed conversion rate (FCR), Gonadosomatic index (GSI), and survival rate (SR), were individually determined using the following equations:

1- Weight Gain WG (g) = final fish weight (g) – initial fish weight (g).

2- Length Gain LG (g) = final fish length (mm) – initial fish length (mm).

2- Specific growth rate (SGR %) = $\log FW - \log IW / t \times 100$.

Where FW is the final weight of fish (G).

Where IW is the initial weight of fish (G).

t = total number of experimental days.

3- Feed conversion ratio (FCR) = feed intake (g) / weight gain (g).

4- Survival rate = Number of live fishes x 100/Total initial number of fish

6- Gonadosomatic index (GSI) = Ovary or testis weight (g) X 100/ fish weight (g).

7- Condition factor (K value) = $100 \times \text{Weight} / L^3$

2.5. Statistical Analysis

All data were subjected to one-way analysis of variance (ANOVA). The significance of difference between means

was determined by Duncan's multiple range test ($P < 0.05$) using SPSS for Windows (Version 12). Values are expressed as means \pm SE.

3. Results

3.1. Water Quality Parameters

Means of Water quality parameters in the tanks during the experimental period are presented in Table 2.

Table 2. Range and average values of water quality parameters during the experiment.

Items	NH ₃ mg/L	pH	T °C	D O mg/L
Ranged	0.097 : 0.095	7.18 : 7.25	28 : 30	5 : 7.60
Average	0.0097 \pm 0.0028	7.8 \pm 0.14	25.5 °C \pm 2.12	7

3.2. Growth Performance Parameters

The fish actively consumed all rations of the diet, and there was progressive increase in growth of the juvenile in both diets. The mean values of growth performance parameters, feed utilization efficiency and survival rate data of the *O. niloticus niloticus* fed on different experimental diets are summarized in Table 3.

3.2.1. Body Length Gain

Averages length gain (cm) of commercial diet- fed (Diet 1) and maggot – fed (Diet 2) fish in monthly interval are presented in Table 3. It was found that length gain was non-significantly ($P > 0.05$) higher in Diet 2 fish compared to Diet 1.

3.2.2. Weight Gain

Diet 1 recorded an average weight gain of 8.5 g while Diet 2 recorded 19.16 g weight gain (Table 3). For both experiential diets the weight gain was significantly ($P < 0.01$) increase with the exposure time recording the maximum values at the end of the experiment (after 3 months).

3.2.3. Average Specific Growth Rate

Specific growth rates (SGR) exhibited clear fluctuations ranging from 0.14 to 0.22 in commercial diet- fed fish and from 0.24 to 0.58 for in maggot – fed fish with overall mean values of 0.18, 0.36 for diet 1 and diet 2, respectively (Table 3). Tilapia fed on maggot diet exhibited better SGR than tilapia fed on commercial diet.

3.2.4. Feed Conversion Ratios

Averages of feed conversion ratio (FCR) of Nile tilapia fed on commercial diets and maggot diets at the end of the experiment are presented in Table 3. Comparisons were conducted separately every month during the experiment using Mann Whitney U-tests. The values of FCR were nearly higher in fish fed on commercial diet compared to those fed on maggot diets during the first and the third month of the experiment. According to the current results a significant ($P < 0.05$) difference was recorded between FCR of commercial diet- fed fish and maggot – fed fish. In general and at the end of the experiment fish fed on maggot diets showed the best (lowest) FCR compared to those fed on commercial diets.

3.2.5. Average Condition Factor (K)

The averages values of condition factors (K) in Nile tilapia fed on Diets 1 and Diets 2 during the experiment are presented in Table 3. From that table it is obvious that the higher K values were recorded in fish fed on Maggot diets. The detected differences between the experimental diets was not significant ($P > 0.05$).

3.2.6. Gonadosomatic Index GSI

Average values of GSI of Nile tilapia fed on both experimental diets are presented in Table 3. Nile tilapia fed on commercial diets exhibited higher GSI than those fed on maggot diets. Such differences between the selected experimental diets were not significant ($P > 0.05$).

3.2.7. Survival Rate

No mortality was observed (Table 3) during the whole time of the experiments, neither in commercial diet- fed fish nor maggot – fed fish (SR= 100%)

Table 3. Growth performance parameters (mean \pm SD) of Nile tilapia (*Oreochromis niloticus niloticus*) fed on commercial diet and maggot diet for three months.

parameters	Experimental diets	Months			Total
		1 st Month	2 nd Month	3 rd Month	
Length gain(Lg)	Commercial diet	1.17 \pm 0.93	2.43 \pm 0.87	3.13 \pm 0.55	2.82 \pm 1.48 ^{NS} ($P > 0.05$)
	Maggot diet	1.95 \pm 0.65	4.18 \pm 0.43	5.67 \pm 0.97	3.85 \pm 1.18 ^{NS} ($P > 0.05$)
Weight gain(Wg)	Commercial diet	3.58 \pm 4.48	10.2 \pm 3.2	11.72 \pm 3.3	8.50 \pm 5.00 ^{**} ($P < 0.01$)
	Maggot diet	15.7 \pm 5.41	16.4 \pm 8.61	25.38 \pm 5.1	19.16 \pm 7.65 ^{**} ($P < 0.01$)
Specific growth rate(SGR)	Commercial diet	0.14 \pm 0.16	0.22 \pm 0.06	0.15 \pm 0.035	0.18 \pm 0.10 ^{**} ($P < 0.01$)
	Maggot diet	0.58 \pm 0.17	0.24 \pm 0.11	0.25 \pm 0.04	0.36 \pm 0.20 ^{**} ($P < 0.01$)
Feed conversation ratio(FCR)	Commercial diet	0.72 \pm 0.68	0.92 \pm 0.39	0.87 \pm 0.24	0.83 \pm 0.43 [*] ($P = 0.05$)
	Maggot diet	0.68 \pm 0.3	1.15 \pm 1.1	0.46 \pm 0.1	0.78 \pm 0.60 [*] ($P = 0.05$)
Gonadosomatic index(GSI)	Commercial diet	2.03 \pm 0.21	4.02 \pm 2.3	4.7 \pm 2.69	3.60 \pm 2.20 ^{NS} ($P > 0.05$)
	Maggot diet	4.03 \pm 2.6	1.81 \pm 0.17	1.95 \pm 0.33	2.60 \pm 1.75 ^{NS} ($P > 0.05$)
Condition factor(K)	Commercial diet	1.44 \pm 0.19	1.09 \pm 0.09	0.97 \pm 0.04	1.16 \pm 0.23 ^{NS} ($P > 0.05$)
	Maggot diet	1.54 \pm 0.07	1.4 \pm 0.12	0.93 \pm 0.07	1.30 \pm 0.28 ^{NS} ($P > 0.05$)

4. Discussion

The growth performance and feed utilization efficiency of *O. niloticus niloticus* were affected by different environmental factors such as water quality parameters including water temperature, pH, nitrogen waste, and dissolved oxygen concentration. However, the average values of all water quality parameters recorded during the experiment were not significantly different ($P>0.05$) and were within a suitable range for the normal growth performance of *O. niloticus niloticus*. The average values of pH ranged from 7.18 to 7.25 and dissolved oxygen concentration ranged from 5-7.6 mg/l. Moreover, the initial body size of the fish recorded at the beginning of the experiment were homogenous and were not significantly different ($P>0.05$).

Throughout the experiment, water quality in all treatments remained within the favourable range required by tilapias [14] indicating that these feed could be utilized in the tilapia farming pond. Water quality parameters such as temperature, pH, dissolved oxygen, and available nitrogen as shown in Table 2 were found to be very similar in all the tanks and hence their effects on growth of the experimental fish were ignored in evaluating the efficiency of the feeds.

The results of the present study revealed that all the experimental diets were accepted by *O. niloticus niloticus*. This implies that the different experimental feed ingredients did not affect the palatability of the diets. The reason might be due to the processing technique employed in this study which might have reduced some of the anti-nutrient factors in the feed ingredients. The good overall growth performances and no mortality obtained in both experimental group of this study confirm the suitability of chosen nutritional composition for tilapia. The same results were previously reported by [3].

FCR is a measure of an animal's efficiency in converting feed mass into body mass. Comparisons here were conducted separately every month during the experiment using Mann Whitney U-tests. The values of FCR were significantly higher in commercial diet than those for fish fed on maggot diet. According to De Silva [15] the FCR for fish fed well prepared diets ranges between 0.46 and 1.15. Ogunji [16] concluded that FCR 1.19 indicated the most efficient utilisation of feed by *Oreochromis niloticus* fingerlings. FCR values below 1 have been reported here, indicating the most efficient utilisation of food by *Oreochromis niloticus niloticus*. The results suggested that dietary maggot meal promoted the growth of Nile tilapia and enhanced nutrient utilization which is reflected in improved length gain, weight gain, FCR, and SGR. The lower growth rate was recorded in the commercial diet fed fish may be attributed to the low feed conversion efficiency. Growth response by Nile tilapia fed maggot meal based diets showed that the maggot meal in the diets gave an improvement in growth and feed conversion efficiency. Progressive increment in WG, LG and SGR were observed in maggot meal based diets, recording better growth

than commercial based diet. The improving growth response observed here in fish fed on maggot diet, may be caused by the high level of crude protein in maggot meal [17]. This agreed with Ogunji [18] who observed a better performance of diets containing maggot meal over those fed 100% fish meal. Fish fed maggot diets recorded the lower FCR (0.78). This is an indication that it has lower feed to flesh conversion.

In contrast to the present finding [19,20,21] concluded that high levels of fishmeal replacement with other animal or plant proteins have frequently led to growth reduction of fish. This phenomenon is usually related to a deficiency or absence of one or more essential amino acids in those animal and plant protein sources. Moreover, insufficient amounts of certain essential amino acids in any given diet can cause fish to suffer cataracts (methionine and tryptophan) and scoliosis (tryptophan) [22].

Jhingram [23] reported that maggots are easily digested by fish and this has been attributed to its relatively high crude fiber content, which according to Fagbenro and Arowosoge [24] plays a significant role in feed digestion. It has been reported that the biological value of maggot meal is equivalent to that of whole fish meal [9]. This fact is strengthened by the results obtained in the present study.

The condition factor K is an index reflecting interactions between biotic and abiotic factors in the physiological condition of fish. It shows the fish welfare during the various stages of life cycle. K has been used to compare growth conditions of fish. A high K reflects good environmental quality; while a low K reflects poor environmental quality. The fish fed on maggot diet exhibited a higher K value compared to those fed on commercial diet.

No mortality was observed during the whole time of the experiments, either in commercial feed nor in maggot feed (SR= 100%). The present results, in accordance with Ogunji et al., [3] who reported that the good overall growth performances and no mortality obtained in each experimental group. This confirm the suitability of chosen nutritional composition for tilapia juvenile. As an agreement with the present result [11].

The observed differences of the evaluated growth performance parameters between the two experimental diets imply that maggot meal can successfully replace the entire fishmeal portion of the fish diet. Other authors have observed a better performance of fish fed diets containing maggot meal over those solely fed on fish meal diets [11]. This is a reflection of the nutritive quality and acceptance of this biomaterial [25]. The result also corroborates previous observation that maggot meal, like other animal protein sources was well accepted and utilized by fish [26, 27]. In contrast to the present result Ogunji et al., [20] concluded that higher magmeal inclusion in diets decreased carp growth performance significantly and also the body lipid concentration. Since the amino acid dietary composition meets the requirement for carp, such reduced growth performance when magmeal completely substitute fishmeal

may be due to inefficient utilization of magmeal protein by carp resulting from low digestibility. Fasakin *et al.*, [10] reported that the reduction in growth performance of African Catfish fed full-fat maggot meal may be, among other reasons due to low protein digestibility of magmeal. There is justification to believe that maggots can help to improve of fish growth, considering recent findings of [28,29,30,31]. Testia and Miller [32] had reported that maggots are a good source of protein, essential amino acids and fatty acids.

High levels of fishmeal replacement with housefly maggot meal have been associated with low body weight gain in both fish and chickens [3,33]. The latter studies indicated that housefly maggot meal should only partially substitute fishmeal in the diets of omnivorous fish species such as catfish [3, 33]. Some authors reported replacement of fishmeal with housefly maggot meal at 50% or less provided the optimum level in chicken feed [34, 35]. These earlier studies contrast with the present study which showed increased substitution of fishmeal by Skippers maggot meal improved the growth, survival and feed efficiency of tilapia with the total replacement diet giving the optimal results. Although palatability of the maggot meal was not directly tested, these results and our observations in the lab indicated that there was no rejection by the fish.

5. Conclusion

In conclusion, it could be said that maggot diet has the best performance in term of F'CR, WG, LG, SGR, and K. Based on the result obtained from the experiment, it is hereby recommended that 100% maggot meal can be included in the diet of *O. niloticus niloticus* to reduce cost and maximize profit. Considering production cost, availability, biological value, growth and nutrient utilization, maggot meal is a viable alternative protein source to fish meal in Nile tilapia diets. Maggot larvae can be mass-produced in a short period of time (less than one week) from agricultural waste and replacement of fishmeal with maggot meal in tilapia feed should directly reduce the production costs. Utilization of maggot meal will thus pave way for cheaper and nutritionally rich aqua feeds. This is the key to the development of a productive and sustainable aquaculture in developing countries. Further studies should be conducted to improve and refine maggot meal production and to determine the potential of maggot meal as a component feed for other commercially important fishes.

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