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Research Article

Effects of Artemia replacement by maggot meal in the larval rearing of *Clarias gariepinus* in Benin (West Africa)

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ABSTRACT

In order to reduce the high cost of aquaculture feed, domestic fly larvae (maggots) have been transformed into maggot meal (FA) for the replacement of Artemia in the larval rearing of *Clarias gariepinus*. Larvae of *Clarias gariepinus* with an initial average weight of 3 ± 0.05 mg were obtained 5 days after artificial propagation. One control and four experimental regimens of 100%, 75%, 50%, 25% and 0% of Artemia (58.1 ± 0.5% isoprotein) were administered in this study. Three days after artificial propagation, the larvae were acclimatized alternately with artemia and AF every 1 h for 1 day. Then, they were divided into 15 basins each containing 300 larvae per 100L of water and subjected to a ration of 50% of their total biomass distributed in five daily meals for 24 days. At the end of the experiments, the growth parameters (final average weight and weight gain) were better at the control diet (T1) followed respectively by T2 (25% Artemia) and T3 (50% Artemia) regimes.). All diets have guaranteed good larval survival. The protein and ash content of the larval carcasses decreased with increasing levels of maggot meal in diets while those with the lowest lipid content were recorded in larvae fed 25% and 50% FA and the highest in larvae fed 75% and 100% AF. The results revealed that the substitution of Artemia for AF had no adverse effects on the larvae and that the best rates of Artemia substitution by FA in the larvae were 25% and 50%, respectively. These rates made it possible to make the largest profit margins.

INTRODUCTION

Food is essential in fish farming because the cost of nutrition represents 60 to 70% of production costs in the aquaculture system (Djissou *et al.*, 2016). Artemia has for decades been considered the primary source of protein for larval rearing of fish and crustaceans due to its high protein content, palatability and digestibility for most fish. Freshwater and marine (Djissou *et al*., 2015). However, the constant price fluctuation of Artemia flour and its variation in developing countries is affecting the profitability of aquaculture (Atsé *et al.*, 2009). To improve aquaculture production, ensure food security and reduce the level of poverty in developing countries, cheap and locally available food is needed (Munguti *et al.*, 2006). Maggots are bio-degraders of organic matter and have been the subject of several studies that have shown the possibility of their use in animal husbandry as a source of animal protein (Mensah *et al.*, 2007). Many reports on the evaluation of unconventional protein sources in fish feeds have revealed that maggot meal has a nutritional and biological value comparable to that of fishmeal, particularly crude protein, crude fat and contains 17 amino acids including several essential amino acids (Olele (2011), Moreki *et al.*, (2012).) Maggot flour is also rich in phosphorus, trace elements and vitamins (Bouafou, 2011). In the larval feed of *Clarias gariepinus* would provide a good opportunity for low-cost food development especially for developing countries where Artemia meal is not available locally (Yapoga *et al*., 2012). The production of maggot is fast and its processing in the form of fish feed is also easy and accessible to all, unlike Artemia which is a commercial food (Rumpold and Schluter, 2013). According to Djissou *et al.*, (2016), the cost of producing one kilo of maggot meal is less than the cost of a kilo of fishmeal and much lower than the price of one kilo. kilo of Artémia demonstrating the cost-effectiveness of Balogun *et al.*, (1989) maggot meal. Atsé *et al*., (2014) state that the use of maggot meal enriched with 4% iron, 4% chlorine, 4% phosphorus and 2% vitamin and many other elements in a diet containing 35% of crude

protein. The combination of Artemia-maggot meal is mainly to provide fish with a more appropriate and balanced diet (Adebayo and Akin, 2014). This study aims to determine the substitution effect of Artemia flour by maggot meal in the larval rearing of *Clarias gariepinus.*

MATERIALS AND METHODS

Maggot production and larval rearing were conducted at the Abomey-Calavi Wetland Research Laboratory station. The larvae of *Clarias gariepinus* with an initial average weight of 3 ± 0.05 mg were obtained 10 days after artificial propagation of *Clarias gariepinus* (Burchell, 1822) spawners reared at the LRZH station according to the method of Ducarme and Micha (2003).The maggots used were produced at the (LRZH) station from a combination of chicken viscera substrate and soybean meal (Djissou *et al*., 2015). 3 kg of this combination of ratio 2: 1 were placed in 18 circular plastics placed in a box away from sunlight, rain and predators (lizards, birds, rats etc.) at an average temperature of 28 ° C. The maggots produced were weighed, boiled for a few minutes (to reduce the microbial load), dried in the sun on an improved drying device that is made of solid wood with stainless wire mesh that can rotate on trestles with a temperature that fluctuates between 26 to 30 ° C (Dossou-Yovo *et al*., 2010). This device prevented the installation of any other flies that would be attracted by the smells of exposed maggots.

Experimental device

15 open-cast concrete above-ground circular tanks were used to carry out this experiment with a total of 4500 larvae. Each basin was filled with approximately 100 L of water and 300 larvae. The circuit was supplied with water from a borehole made at the laboratory site. Each basin has a water inlet and a central PVC water evacuation device equipped with a fine mesh net to prevent the escape of the la rvae. Each basin has been covered half of its surface with a rack to prevent direct penetration of the sun that can allow t he development of algal chlorophylls may cause possible m ortality.

Experimental diets

The diets used consist of artemia, maggot and mixtures of both for experimentation. Dried maggots are crushed into powder with an electric grinder and stored in the refrigerator.5 diets were formulated including a control (T1) not containing maggot meal and 4 experimental diets (T2 to T5) consisting of a mixture of artemia and / or maggot meal at different proportions (Table 2) with T5 diet not containing artemia at all.

Larvae of *C. gariepinus* were fed with a ration ration of 50% of their total biomass. Food rations were distributed five times (7h, 10h, 13h, 16h, and 19h) for 25 days. The density of loading was 3 individuals / L of water or 300 larvae per basin with a partial renewal rate of water of 3L / min. Water temperature, pH, TDS, dissolved oxygen and conductivity were measured every 48 hours before feeding in the morning and evening after feeding with a multi parameter. In the control fishery (every 72h), natural death was determined by the presence of dead larvae floating in the pools (Haylor, 1991), but missing larvae were thought to have succumbed to complete cannibalism (Hecht and Appelbaum, 1988). Undigested food particles and wastes were siphoned twice a week with a fine mesh dip net before feeding the larvae. Then all the larvae were counted and weighed to adjust the ration. At the end of the experiment, 30 larvae were collected per basin, dried with the freeze-dryer and crushed for the bromatological analysis of the carcasses.

Table 2: Composition of experimental diets containing gradual rates of maggot meal in replacement of artemia.

	T1 (0%) control	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Farine d'asticot	-	25	50	75	100
Artémia	100	75	50	25	-
Total	100	100	100	100	100
Protéines brute	58,0	57,6	58,2	58,3	58,4

Growth performance and feed efficiency

Nutrient growth and utilization parameters were calc ulated for each treatment as follows:
Weight gain (GP) = final biomass - initial biomass; average daily gain (g / d) = weight gain / duration; Specific Growth (TCS) = [ln (final average weight) - ln (initial average weight)] × 100 / number of days; Survival Rate (TS) = (final number of larvae / initial number of larvae) × 100; Food Conversion Rate (TCA) = Quantity of food distributed (g) / weight gain; the Consumption Index (IC) = ingested food / weight gain; Cannibalism rate (TC) (%) = (number of missing larvae / initial number of larvae) ×100; Mortality rat e (TM) (%) = (number of dead larvae / initial number of lar vae) × 100.

Biochemical analyzes

The biochemical analyzes (proteins, lipids, moisture and ash) were performed in duplicate according to the standard AOAC (1990) methods and concerned the homogenized carcasses of 20 individuals taken per basin after 2 days from the end of the experiment. 60 individuals per diet. Crude proteins (% N x 6.25) by the Kjeldahl method, lipids by the hot method (Soxhlet type), ashes by incineration of the samples in a mold oven at 550° C for 12 hours.

Statistical analyzes

For the statistical analysis of the results, the biometric data for each repetition are considered as an observation. These results are compared statistically by the one-way analysis of variance (ANOVA) using the Statviews software (version 5.01) after prior checking of the homogeneity of the variances and the normality of the data to be analyzed. When ANOVA was significant, Fisher's LSD test was used for the multiple comparison of averages. For these comparisons, the 5% level of significance is retained.

RESULTS AND DISCUSSION

Throughout the period of the experiment, the average values of the physicochemical parameters of the waters of

the breeding tanks are 26.67 ± 0.48 ° C for the temperature, 5.47 ± 0.13 for the pH, 04.84 ± 0.19 mg / L for dissolved oxygen, 168.86 ± 9.42µs / cm for conductivity, 0.09 ± 0.01 g / L for salinity and 83.16 ± 4.76 for total dissolved solids (TDS).The zoote-chnical data obtained at the end of the experiment (Table 3) show that the mean final weights vary from 492 ± 78 mg for the batch fed with the T5 diet to 857 ± 110 mg for the one that received the T1 control diet. Fisher's LSD test shows that there is no significant difference (P> 0.05) between the mean final weights of experimental diets with the exception of the T2 diet with the best final average weight (Pmf = 736 ± 69 mg). With regard to the calculated specific growth rates (TCS), the same trend was observed with a significant difference between the control diet and the experimental regimes (P <0.05) with the best experimental diet TCS obtained with T2 diet (12.37 ± 0.12% / day). But Fisher's LSD test shows that there is also no significant difference (P> 0.05) between TCSs respectively obtained in T2 (12.37 ± 0.12) and in T3 (11.96 ± 0.36). The consumption indices recorded with the T1 (0.87) and T2 (1.36) regimens are better than the other expe rimental regimes (T3 to T5) with a significant difference (P <0.05).

The approximate composition of the larval carcasses is shown in Table 4. The rate of incorporation of maggot meal into the different diets did not affect the larval moisture and crude protein content, unlike the ash content and lipids (P <0.05). The lowest levels of lipids in the larval carcass are recorded with the larvae fed with 25% and 50% of the maggot meal while the higher ones are obtained with the larvae fed with 75% and 100% of the meal. maggots. It should be noted that the protein content in the carcass of the larvae gradually decreases with the increase in the rate of incorporation of maggot meal into the diets.

The mean values of temperature, oxygen and pH recorded in the waters during the test were 26.67 ± 0.11 ° C, 4.69 ± 0.10 mg / L and 5.47 ± 0.13. These values, similar to those obtained by Agadjihouèdé *et al.,* (2012) on the survival and growth of *C. gariepinus* and *Heterobranchus longifilis* larvae fed on zooplankton are within the tolerance range for better growth of *C. gariepinus* larvae (Baras and Jobling 1999).

In this study, the best growth and utilization performance of the food was obtained with the control diet (100% Artemia) because of its high nutritional value due to its protein, amino acid and lipid content. . The best specific growth rate obtained with the control diet in this study (14.48% / d) is lower than those obtained by Anvo *et al*., (2016) and Vandecan *et al.,* (2010) and Umar *et al.* (2018) fed larvae of *C. gariepinus* to Gemma commercial feed with TCSs of 17.44 and 31.9% / day, respectively. This difference in growth observed can be explained by the quality of the food used but also by the duration of the experiment. Growth is exponential during larval rearing (14 days) before being linear for the next phase.

All experimental diets satisfied the food protein requirements of *C. gariepinus* larvae by 55% according to Uys and Hecht (1985). Although the experimental diets have an isoproteic composition, the T2 diet (25% maggots + 75% Artemia) led to the second best performance of growth and use of the food followed by the T3 diet (50% maggots + 50% Artemia) besides the control food (100% Artemia) .However, experimental diets (T4 and T5) with high rates of incorporation of maggot meal could not satisfy these parameters in terms of final average weight, weight gain, specific growth rate and consumption index.

These results are similar to those obtained by Ossey *et al.,* (2014) and Anvo *et al*., (2016) with larvae of *C. gariepinus* fed respectively on maggot meal and caterpillar (Cyrina but yrospermi) where the best zootechnical performances are ob tained with an incorporation rate of 25%. Overall, the result s of this study showed acceptance of all experimental diets by *C. gariepinus* larvae, reflecting the palatability of the experimental regimes formulated for *C. gariepinus* larvae. However, poor growth and feed utilization was achieved with diets containing high levels of maggot meal (75 to 100% in T4 and T5) compared to T1, T2 and T3 diets. These performances are explained by the absence of a stomach in the larvae whose role is to digest the food and therefore not proteolytic activities. In fact, *Clarias gariepinus* larvae clearly prefer live food, in this case Artemia nauplii or living zooplankton (Ducarme and Micha, 2003), which favors their predatory instinct. On the other hand, the mixing of artemia and maggot meal at high rates could affect the palatability of the larvae. These results do not corroborate those obtained by Vodounnou *et al.* (2015) and Ahmed *et al*., (2015) who demonstrated that maggot meal in fish diets improved acceptability and promoted growth. In reality, it is not the protein content of diets that promotes growth but especially essential amino acids they contain. When the latter do not meet the needs, this results in the reduction of the growth and the efficiency of the use of the food.

In addition, the consumption index values recorded in this study at the diets containing maggot meal are higher than those obtained (1.02-1.18) by Ossey *et al*., (2014) but similar to those obtained by Otchoumou *et al.,* (2012) on *Heterobranchus longifilis.* But our consumption index values obtained are considered to be better (1.5-2) for good growth in fish farming (Craig and Helfrich 2002, Hwangbo *et al.,* 2009 and Djissou *et al.,* 2016).

Biochemical analysis of the carcass of *C. gariepinus* larvae showed that the crude proteins were not significantly influenced by the different regimes to which the larvae were subjected. The protein content gradually decreases with the gradual substitution of Artemia by maggot meal. Conversely, crude lipid levels increased with maggot incorporation rates in experimental diets. These results show that beyond 50% incorporation of maggot meal into the larval diet of C. gariepinus, proteins are used as a source of energy for swimming and maintenance the metabolism instead of being used for the growth.

CONCLUSION

The present study shows that larval rearing of *C. gariepinus* can be achieved by combining Artemia flour and maggots. The best combinations for obtaining good growth and use of the food are respectively 75% Artemia, 25% maggot meal and 50% Artemia, 50% flour. maggots. The results revealed that the substitution of Artemia for AF had no adverse effects on the larvae and that the best rates of Artemia substitution by FA in the larvae were 25% and 50%, respectively. These rates made it possible to make the largest profit margins.

Table 3: Growth performance of the larvae of *C. gariepinus* subjected to different treatments

Paramètres	T1	T2	T3	T4	T5
Pmf (mg)	857±110^{a}	736±69^{b}	671±86^{bc}	575±59^{c}	492±78^{c}
TS (%)	61,33±1,9^{a}	56,33±2,34^{a}	60,67±0,67^{a}	60±1,58^{a}	61,22±2,57^{a}
GP (g)	854±110^{a}	733±69^{b}	692±86^{bc}	624±59^{c}	589±78^{c}
GMQ (g/j)	34,16±4,4^{a}	29,32±2,76^{abc}	28,83±3,44^{c}	24,96±2,36^{bc}	23,56±3,12^{ab}
TCS (%/j)	14,48±0,3^{a}	12,27±0,12^{b}	11,96±0,36^{bc}	10,70±0,21^{c}	9,88±0,17^{d}
IC	0,87±0,16^{a}	1,36±0,22^{a}	1,80±1,07^{b}	2,08±0,75^{b}	2,22±0,48^{b}
Tcani (%)	30,44±1,54^{a}	33±6,17^{a}	28,22±0,84^{a}	29,88±2,55^{a}	31±2,46^{a}

Values represent means and standard deviations of three repetitions. Values that do not have the same letter are significantly different (Anova, P <0.05) for each row of the table

Table 4: Biochemical composition of *C. gariepinus* larvae fed with experimental regim represent means and standard deviations of three repetitions.

	Initial	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Humidité (%)	78.33	73.45±0.11^{a}	74.05±0.16^{a}	74.14±0.20^{a}	74.38±0.22^{a}	74.89±0.33^{a}
Cendre (%)	2.45	03.87±0.30^{a}	03.67±0.26^{b}	04.16±0.37^{c}	05.12±0.14^{d}	05.20±0.21^{d}
Protéine (%)	11.99	15.05±0.13^{a}	14.79±0.22^{a}	14.63±0.18^{a}	14.33±0.21^{a}	14.20±0.12^{a}
Lipide (%)	4.07	05.62±0.14^{a}	05.24±0.10^{a}	05.10±0.09^{a}	06.02±0.07^{b}	06.29±0.06^{b}

Values that do not have the same letter are significantly different (Anova, p <0.05) for each row of the table.

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