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Effects of fish meal replacement by maggot meal in diets for Nile Tilapia fingerling (*Oreochromis niloticus* Linnaeus, 1758) in Burkina Faso

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Abstract
In Burkina Faso, the availability of other local protein sources that can replace fishmeal in diets for *Oreochromis niloticus* is a concern of stakeholders involved in aquaculture sector. This study consisted of evaluating the growth performance of *Oreochromis niloticus* juveniles fed with diets containing maggot flour. It was conducted at Burkina Faso from April to June 2022. To test the effect of maggot flour on the growth of *O. niloticus*, 3 diets noted as R1, R2 and R3 were made of 100% fishmeal, 50% fishmeal + 50% maggot meal and 100% maggot meal respectively. These diets were used to feed 3 batches of juveniles (5 g) in duplicate group for 60 days. Each batch consisted of 15 fish per happa of 1m^2. After 60 days, results on zootechnical performances showed that juveniles of *Oreochromis niloticus* fed with diet 3 (36.70±9.32 g) had high growth performance compared to those fed with other diets (21.38 g±4.11 for diet 1 and 26.04 g±5.31 for diet 2). Statistically, the obtained results with diet 3 were found to be different from those obtained with diet 2 and different from those obtained with diet 1.

Keywords: Juveniles, *Oreochromis niloticus*, protein, growth, Burkina Faso

1. Introduction

The greatest challenge of the millennium is meeting the food and nutritional needs of a growing world population in a context of climate change, economic uncertainty and increasing competition for natural resources (FAO, 2016) [17]. Aquaculture, especially fish farming is constantly growing around the world (Dupont, 2009) [14]. However, these spectacular advances in aquaculture are less noticeable in some parts of the world. This is the case for sub-Saharan Africa where the sector continues to occupy a minor place despite its natural potential. Burkina Faso has a surface water potential estimated at more than 200,000 hectares (in rainy season) and around 50,000 hectares (in the low water period) for fish production. Despite this, fish farming is yet to reach a remarkable dimension economically (FAO, 2008) [15]. According to statistics from the General Directorate for Fishery Resources (DGRH) and Customs, domestic fish production was 29,752 tons (of which 752 tons come from aquaculture) in 2020 compared to 146,995 tons of imported fishery products. This clearly shows a great demand for fish products. Faced with this situation, the only credible alternative to increase domestic production remains fish farming. Among the species which contribute to the success of fish farming worldwide, tilapia could be prominently considered. Thus, it was classified as the third highest group of fish in the world after cyprinids and salmonids (Al Dilaimi, 2009) [4]. This could be explained by the fact that tilapia is easy to be raised in a closed environment, in particular because of their omnivorous food habit; their easy reproduction in captivity; their great tolerance to high stocking density; few pathological problems; their relatively rapid growth; their broad ecological valence and their ability to withstand stress (FAO, 2010) [16]. With regards to all these assets, tilapias could play an important role for aquaculture development in Burkina Faso.

In aquaculture, feed is the most budget consuming factor and can reach 60 to 70% of operating expenses during a production cycle (Houngbo *et al*., 2019) [23].

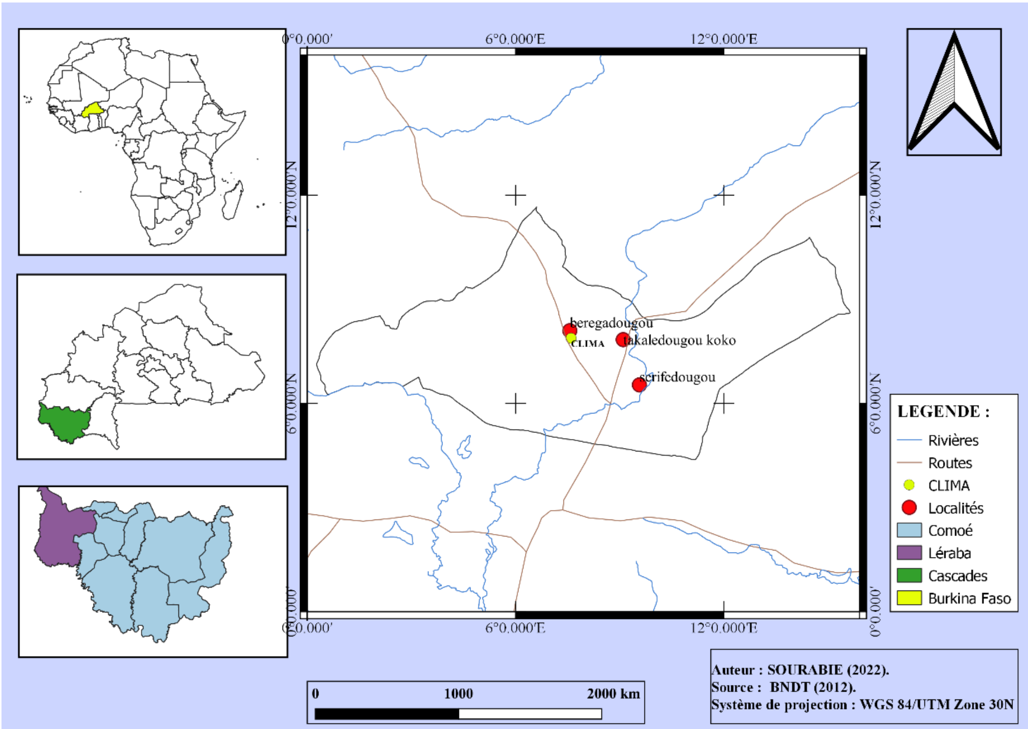
In addition to the high cost of the feed, there is sometimes their unavailability due to the fact that most feed or ingredients are imported. This is partly explained by the cost of the fishmeal which the major ingredient in fish is feed manufacturing. To overcome this issue, it is necessary to find other local alternative protein sources which can replace fishmeal in the feed. Thus, Agro-industrial by-products of plant origin were already used to substitute a significant part of this ingredient in feed for fish farming (Sarr *et al*., 2015) [30]. Nevertheless, the nutritional profile of some of these ingredients, in particular plant ingredients, do not meet *all* the nutrients requirement for most farmed fish species, which means that they can only be incorporated in their feed to a limited extent (Hoc, 2014) [22]. Indeed, apart from their imbalanced essential amino acid profile, most plant ingredients contain antinutritional factors (ANFs) which limit their digestibility by fish (Yuan *et al*., 2011; Burel and Médale, 2014; Nunes *et al*., 2014) [35, 11, 28]. In this context, insects have been considered as a new protein source which could be produced locally to feed the fish. Several studies have shown that fly larvae could be potentially used to replace fishmeal in diets for fish (Hardouin *et al*., 2000; Teguia *et al*., 2002; Mensah *et al*., 2007; Bouafou, 2011, Agbohessou *et al*., 2021) [20, 31, 26, 3, 9]. Therefore, these larvae can stand for a fitting solution to reduce the production cost for fish farmers.

2. Material and methods

2.1 Material

2.1.1 Presentation of the study site

Experiments to evaluate the effect of maggot flour on the growth of *Oreochromis niloticus* were conducted at the Lasalian Center for Initiation to Agricultural Professions (CLIMA). This center is located at about 4 kilometers away from Beregadougou city, on the Beregadougou-Orodara axis, more precisely on the former fish farm of the Ministry of Agriculture. CLIMA is located between the following geographical coordinates: 10°46' north latitude and 4°44' west longitude (map 1).



Map 1: Location of the CLIMA site

2.1.2 Technical equipments for fish feed manufacturing

The production of fish feed required the use of bowls for mixing the ingredients, a mill for grinding the coarse ingredients, a sieve for sifting the crushed ingredients, a scale for weighing ingredients, a granulator for the manufacture of pellets, tarpaulins for sun drying of the pellets, bags for packaging the feed.

2.1.4 Technical equipment for rearing *Oreochromis niloticus*

Monitoring the culture water quality required the use of a pH meter to record water pH and temperature (figure 1B), an oximeter to measure the oxygen in water (figure 1C), a Secchi disk to measure the transparency of the water (figure 1A), 1m^2 happas for raising fish, landing nets for catching fish during sampling, plastic buckets for handling operations, an electronic scale for recording individual weights of the fish and for weighing the feed.

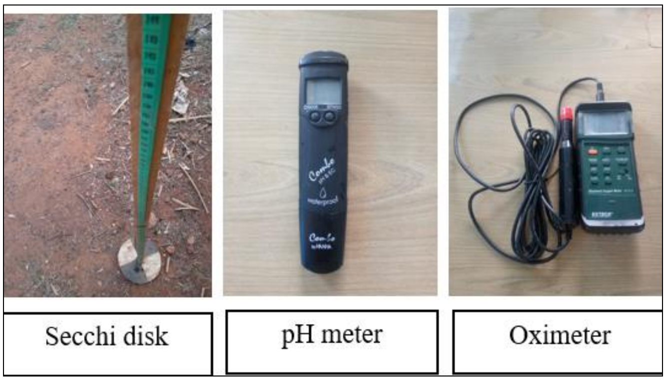


Fig 1: Materials for measuring physicochemical parameters

2.2. Methodology

2.2.1. Diet formulation

In order to test the effect of maggot meal on fish growth, fish feed were formulated by considering partial and total substitution of fish meal by that of maggots. Table I shows the experimental diets used in this study.

Table I: Composition of experimental diets

Ingredients	Incorporation rate %		
Fish meal	R1	R2	R3
	35	17.5	0
Maggot meal	0	17.5	35
Roasted soybeans	20	20	20
Corn flour	8	8	8
Rice flour	4	4	4
Wheat bran	20	20	20
Cottonseed oil	3	3	3
Vitamin premix	2	2	2
Mineral premix	2	2	2
Baobab powder	3	3	3
Molasses	2	2	2
Garlic	1	1	1
Total	100	100	100

Legend: R1: Feed with 100% fishmeal; R2: Feed with 50% of maggot flour and 50% fishmeal; R3: 100% Maggot flour.

2.2.2. Determination of the chemical composition of experimental diets

After manufacturing, samples of each diet were taken. The nutritional values (crude protein, lipid, ash, fiber and moisture content) (Table II) are determined at the INERA laboratory in Farako-bâ. The chemical composition of foods was determined by Near Infrared Spectrometry (NIRS). It is based on the absorption of radiation by organic matter. As this absorption is linked to the chemical composition of the sample, it can be estimated simply by measuring the absorption of light by the sample.

Table 2: Chemical composition of diets

Chemical composition	Diets		
	R1	R 2	R 3
Proteins (%)	38.14	39.21	44.26
Lipids (%)	10.18	10.50	7.92
Fibers (%)	4.78	5.43	7.49
Moisture (%)	7.73	8.01	10.28
Ash (%)	8.5	8.47	11.81

2.2.3 Experimental design

The experiment is carried out in a 54 m^2 tank in which juveniles of *Oreochromis niloticus* with an average individual weight (IW) of 5 g were stocked. It consisted of three treatments corresponding to three formulated diets (R1, R2 and R3) (figure 2). These diets were used to feed a duplicate group of fish, thus giving 6 batches of fish numbered as follows: A1 and A2 for fry fed with 100% fishmeal; B1 and B2 for fry fed 50% maggot meal and 50% fish meal; C1 and C2 for fry fed with 100% maggot meal. Each batch consists of 15 fish and distributed in happas of 1 m^2. After stocking, the feeding frequency was three (03) times a day (8 a.m., 11 a.m. and 4 p.m.). The daily ration is adjusted for each sampling (every 10 days) in order to take into account the evolution of the biomass according to the feeding table established by Toguyeni (1996) (Table III). Fish were individually weighed using an electronic balance, the average weight of the fish per treatment is determined and the ration for ten days is again calculated and those for 60 days.

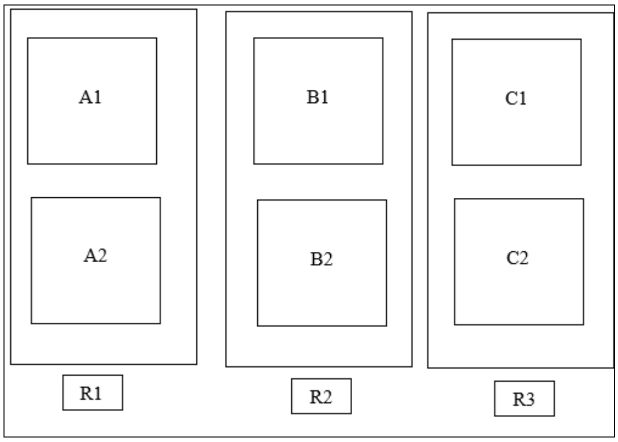


Fig 2: Experimental set up

Table 3: Daily ration rate of *Oreochromis niloticus* (Toguyeni, 1996)

Age or body weight	Feeding rate
11-31 days PF	30%
Batching (31 days PF) à 2g	16%
2-6 g	12 %
6-45 g	8 %
45-100 g	4 %

Legend: PF: Post Fertilization

2.2.4. Zootechnical parameters

To evaluate the effect of maggot meal on the growth performance of *Oreochromis niloticus*, the zootechnical parameters were calculated based on three indices: these parameters are the survival rate, the growth index and the feed conversion ratio

2.2.4.1. Survival rate (SR)

It corresponds to the percentage of survived fish at the end of the experiment. Its formula is as follows:

$$SR_{(\%)} = 100 \times \frac{N_{pf}}{N_{pi}}$$

Where Npi and Npf = number of fish at the beginning and at the end of the experiment, respectively

2.2.4.2. Growth performances

- Average Final Weight (AFW in g)

$$AFW = \frac{Bf}{Nf}$$

Where Bf = Final biomass and Nf = Final number of fish

- **Daily weight gain (DWG)**

The Daily Weight Gain (DWG), also called daily individual growth (DIG), is an index used to assess the daily weight gain of farmed fish. It is determined based on the equation below:

$$DWG_{(g/d)} = \frac{AFW - AIW}{Rearing\ time(d)}$$

Where AFW and AIW = Average initial weight and Average final weight

- Specific growth rate (SGR)

It is used to assess the weight gained by the fish each day, as a percentage of its final weight. It is calculated according to the following formula:

$$SGR_{(\%/d)} = \frac{100 \times (\ln AFW - \ln AIW)}{\Delta t}$$

With Ln: Natural logarithm

2.2.4.3. Feed conversion and utilization

- **Protein Efficiency Ratio (PER))**

It indicates the weight gain per unit of consumed protein, which gives a measure that determines whether the protein source of the food meets the requirements of the species correctly. Its formula is:

$$PER = \frac{AFW - AIW}{IP}$$

With PI (Ingested Protein) = Total weight of food distributed × protein level of the food

- **Feed Conversion ratio**

It is a coefficient used to characterize the efficiency of feed utilization.

$$FCR = \frac{\text{Quantity of feed distribued (g)}}{\text{final weight (g)} - \text{initial weight (g)}}$$

I.3. Data processing and Analysis

The Excel office 16 spreadsheet was used to type data for the physicochemical parameters and the zootechnical parameters. Statistical analysis was performed using XLSAT 2007 software. The Shapiro-Wilk test is used for data normality test. Then, the effect of diets on *O. niloticus* was tested by comparing zootechnical and food utilization parameters, using One-way analysis of variance (ANOVA). The physico-chemical parameters of the culture water were also analyzed by one-way analysis of variance (ANOVA). Fisher's LSD (Least Significant Difference) test was used to show differences among treatment means at 5% significance.

3. Results

3.1. Daily variations of the physico-chemical parameters of the culture water

Table IV shows the daily variation of the physico-chemical parameters of the culture water in the rearing tank. The pH recorded in the morning varied from 7.70±0.29 to 8.37±0.84 and that in the evening from 8.41±0.41 to 9.28±0.99. The analysis of variance showed that there is no significant difference among treatments regarding pH means. Temperature was significantly different among treatments. It varied from 26.27 °C±1.29 to 29.35 °C±0.21 in the morning and from 30.25 °C±1.44 to 33.53 °C±0.9 in the evening. As for dissolved oxygen, it varied from 5.66 mg/l±0.81 to 7.83 mg/l±0.21 in the morning and from 7.01 mg/l±0.19 to 8.28 mg/l±0.95 in the evening. Dissolved oxygen was significantly different among treatments in the morning. On the other hand, in the evening, there was no significant difference for dissolved oxygen among treatments during the experiment. Water transparency varied from 29.33 cm±8.73 to 43.25 cm±12.81. The analysis of variances does not reveal any significant differences at 5% significance level among treatment means.

Table 4: Daily average variations of the physico-chemical parameters of the culture water

Variables		Decades					
		1	2	3	4	5	6
pH	Morning	8,28±0,64 a	7,70±0,29 a	8±0,49 a	8,35±0,69 a	8,19±0,7 a	8,37±0,84 a
	Evening	8,63±0,57 a	8,41±0,41 a	8,8±0,58 a	9,25±0,4 a	8,85±0,63 a	9,28±0,99 a
T (ºC)	Morning	26,27±1,29 a	28,76±0,49b	29±0,34 b	28,97±0,53 b	29,35±0,2 b	29,08±0,3 b
	Evening	30,25±1,44a	33,53±0,9c	31,8±0,56b	31,11±1,11ab	31,62±0,2 ab	31,25±0,64 ab
DO (mg/l)	Morning	7,83±0,21b	7,2±0,82 b	5,66±0,81a	7,59±0,43 b	6,82±1,27 ab	6,57±1,24 ab
	Evening	8,28±0,95 a	7,4±0,26 a	7,01±0,19 a	7,88±0,52 a	7,47±0,93 a	7,44±1,22 a
Trans (cm)	Morning	38±8,83a	29,33±8,73a	32,66±8,32a	38,5±10,47a	36±12,12a	43,25±12,81a

The means followed by the same letter are not significantly different at the alpha threshold = 0.05.

3.2 Zootechnical performance of juveniles

3.2.1. Survival rate

Figure 3 shows the survival rate of juveniles. At sixty days of experiment, the survival rate varied between 99.52% for diet 1, 98.57% for diet 2 and 100% for diet 3. Statistical analysis did not reveal any significant difference (p>0.05) of this parameter among experimental diets.

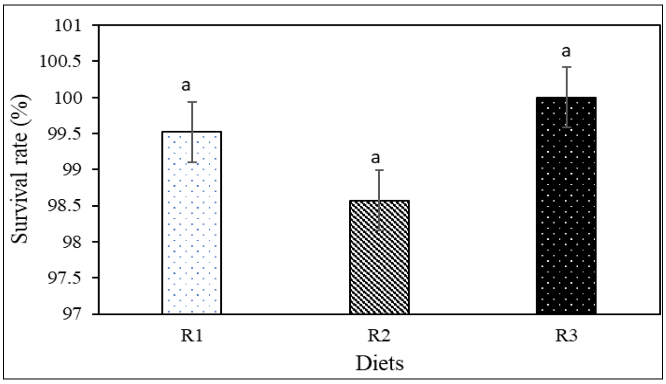


Fig 3: Juvenile survival rate

The means followed by the same letter are not significantly different at the alpha threshold = 0.05.

3.2.2. Growth performances

3.2.2.1. Evolution of the average individual weight of juveniles

The results of the evolution of the mean Individual Weight (IW) of the fish are shown in figure 4. Thus, after 60 days of experiment, the mean Individual Weights of the fish increased from 5 to 21.38 g±4.11 for diet 1, from 5 to 26.04 g±5.31 for diet 2 and from 5 to 36.70 g±9.32 for diet 3. The analysis of variance reveals that IW was significantly different among the three experimental diets ($p<0.05$). Juveniles fed with Diet 3 showed a significant individual weight ($p<0.05$) compared to the other two diets after the first sampling. At the fifth sampling, three groups were found to be statistically different. The first group (diet 1) was statistically different from the second group (diet 2) and different from the third group (diet 3) with $p<0.05$. This result shows that *O. niloticus* juveniles fed diet 3 made of maggot flour had the best average weights (36.7 g).

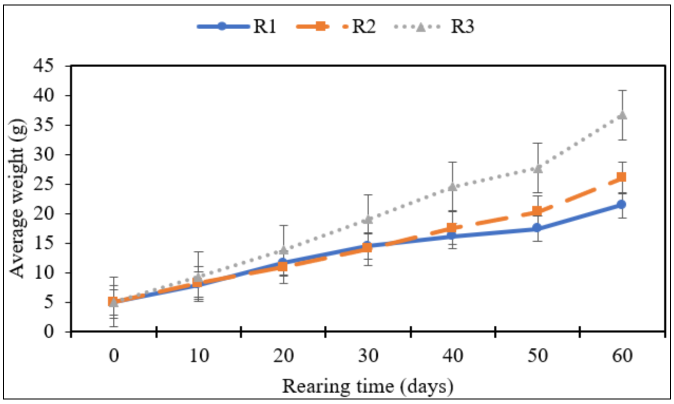


Fig 4: Evolution of the average individual weight of juveniles

3.2.2.2. Daily Weight Gain and Specific Growth Rate

Table V shows the Daily Weight Gain and Specific Growth Rate. Concerning the Daily Weight Gain (DWG), the fry fed with diet 3 had the highest average of weight gain (0.53±0.20 g/d) and those fed with diet 1 the lowest average of the same parameter (0.27±0.10 g/d). The Daily Weight Gain of fish fed with diet 3 was significantly different from those fed with diet 1 and diet 2 ($p<0.05$). The Specific Growth Rates (SGR) was 0.34%/d for fish fed with diet 1 and 0.47%/d for those fed with diet 3 and no significant difference ($p>0, 05$) was observed among the three diets.

Table 5: Daily Weight Gain and Specific Growth Rate

Growth parameters		Diets	
	R1	R2	R3
DWG (g/d)	0.27±0,10^{a}	0.35±0,11^{ab}	0.53±0,20^{b}
SGR (%/d)	0.34±0,27^{a}	0.39±0,24^{a}	0.47±0,32^{a}

The means in the same row followed by the same letter are not significantly different at the alpha threshold = 0.05.

II.2.3. Food conversion and utilization

Table VI indicates the feed conversion and utilization. Concerning the Protein Efficiency Ratio (PER), the analysis shows that there is no significant difference among treatments ($p>0.05$). The ratio ranged from 0.054±0.04 and 0.07±0.045 for diet 1 and diet 3, respectively. As for the Feed Conversion Ratio (FCR), values varied from 6.95±5.02 to 4.94±3.28 for diet 1 and diet 3, respectively. The analysis reveals no significant difference among all diets.

Table 6: Feed conversion and utilization

Variables		Diets	
	R1	R2	R3
PER	0.054±0,04^{a}	0.061±0,036^{a}	0.07±0,045^{a}
FCR	6.95±5,02^{a}	5.01±2,22^{a}	4.94±3,28^{a}

The means in the same row followed by the same letter are not significantly different at the alpha threshold = 0.05.

4. Discussion

4.1. Physico-chemical parameters of culture water

The physico-chemical parameters, condition for life in aquatic environments are essential for the metabolism of species. In general, the water pH values recorded during this experiment were relatively high. This would be as a result for the culture water quality. Indeed, the low frequency of water renewal in the rearing tank led to a rapid deterioration of the water quality. These results were comparable to those obtained by Sarr *et al*. (2015) [30] and those of Bahnasawy *et al*, (2009) [5] who found that *O. niloticus* had good growth with a pH ranging from 7 and 9. Abou *et al*. (2007) [1] also showed that the species *O. niloticus* can survive in extreme water conditions with a pH between 5 and 11. According to Boyd and Tucker (1998) [10], temperature is a crucial factor for fish growth. The temperature values recorded in our study were relatively high. This would be due to the period of the year in which the experiment was carried out (from April to June). Indeed, this period is part of the hot dry season of which temperatures are high. The obtained temperature values were comparable to the optimum temperature for the growth of *O. niloticus* which is between 26-30 °C according to Ndour *et al*. (2011) [27]. These results are also close to those obtained by Sarr *et al*. (2013) [29] who obtained values between (13.5-33 °C) and (24-35 °C). However Ballarin and Hatton (1979) demonstrated that *O. niloticus* cannot tolerate a long period of temperature between 10 and 15 °C. As for dissolved oxygen concentrations, it was generally high and differ from those obtained by Sarr *et al*. (2015) [30] who obtained values between 4.4 to 6.1 mg/l. Indeed, low dissolved oxygen level was recorded in the morning and high values in the evening. This variation could be explained by photosynthesis which almost does not occur at night while respiration is continuous, thus causing a significant consumption of oxygen and a production of carbon dioxide from night to dawn. The turbidity of the culture water experienced strong variations during the experiment. These high values would be due to the presence of the fish species *Clarias gariepinus* excluding happas in our rearing tank and the very low frequency of water renewal, which was realized once a week. Our results were found to be different from those obtained by Sarr *et al*., (2015) [30] who recorded turbidity values ranging from 19.1 to 25 cm. Turbidity values ranging from 19.8 to 22.4 cm were also found by Bamba *et al*., (2017) [8] and these results were different from those observed in our study.

4.2. Juvenile survival rate

Fish fed with diet 3 did had no mortality while those fed with diets 1 and 2 had mortality which was observed at a low rate. This could be explained by the good adaptability of *O. niloticus* and also by the best rearing conditions during periods of experiments. The observed mortalities would be due to the stress which may arise from the fish handling during sampling. These results were in line with those observed by Trahinta (2019) [34] who recorded a survival rate of 99% during evaluation of the growth performance of male *O. niloticus* reared in breeding tanks.

III.3. Growth performances

The analysis of the fish growth based on the average weights of the fish fed with the 3 diets during the experiment showed significant differences. Fish fed with diet 3 containing 100% maggot meal had better growth compared to those fed with diets 1 and 2. This showed that fish fed with diet containing maggot flour exhibited the best performance compared to fish fed with other diets. This would as results of the nutritional quality of the maggot flour used in the diets formulation. With regards to the chemical composition of the three formulated diets, diet 3, prepared with maggot meal, contains the highest protein content and protein is the main nutrient used by fish for growth. Studies of Hardouin and Mahoux (2003) [21] also showed that dried and ground larvae contained 4349 Kcal/kg of metabolizable energy, 59.65% protein, 19% lipids and 7.26% minerals. These results were different from those reported by Coulibaly *et al*. (2021) [12] who found that fish (juvenile stage) fed with industrial feed containing fish meal up to 71.40 g had better growth than those fed with a mixture of maggot meal and fish meal up to 56, 91 g. Our results were also different from those recorded by Guedegbe (2014) [19] who highlighted a better growth for fry fed with feed made of 46.75 g of fish meal than those fed with 38.75 g of maggot meal.

The daily weight gain was higher for fish fed with diet 3 compared to those fed with diets 1 and 2. This could be explained by the high protein level of diet 3. This was confirmed by Hardouin and Mahoux (2003) [21] who showed the high energy, protein, lipid and essential amino acid content of dried and ground maggot larvae. These results were found to be different greatly from those observed by Dibala *et al*. (2018) [13] who obtained values ranging from 0.99 g/d to 1.36 g/d. Indeed, these authors used fish of which the mean initial individual weight was 110 g±7.

The specific growth rates (SGR) recorded in our study was low in all treatments. However, fish fed with diet 3 exhibited the highest SGR compared to those fed other diets. This could be explained by the high nutritional value of diet 3 and the presence of essential amino acids in the dried and crushed larvae of the maggots which can favor the fish growth. Our findings were similar to those obtained by Bamba *et al*. (2008) [7] (0.31 to 0.45%/d) by using agricultural by-products to feed *O. niloticus*. However, these results were different from those recorded by Gbaï *et al*. (2014) [18] (0.75%/d) who conducted a comparative study of the growth and survival of *Sarotherodon melanotheron* X *Oreochromis niloticus* hybrids, *O. niloticus* and native tilapias from the Ivorian lagoons.

4.4. Feed conversion and utilization

With regards to the Protein Efficiency Ratio, the highest value was recorded for fish fed with diet 3, compared to those fed other diets. This difference could be explained by the fact that the maggot flour used as protein source in diet 3 adequately meets the need of *O. niloticus* for growth when compared to the fishmeal used in diet 1 and the mixture of these two protein sources used in diet 2. Further, the dried and ground maggot larvae contain 9 out of the 10 essential amino acids required for fish growth (Langar, 1996; Médale *et al*., 2013) [24, 25]. These essential amino acids cannot be synthesized by the fish body and must therefore be supplemented in diets. Hardouin and Mahoux (2003) [21] demonstrated the presence of these amino acids in dried and ground larvae. These amino acids are: Threonine, Methionine, Isoleucine, Leucine, Valine, Phenylalanine, Histidine, Lysine and Arginine. Our results were widely different from those obtained by Bamba *et al*., (2017) [8] who recorded values which ranged from 1.25 to 1.61. Indeed, in this experiment lasted for 180 days, authors used fish of which the initial weight was 33.3 g.

Analysis of the Feed Conversion Ratio showed that feed made of maggot meal was more effective for fish than feed made of fish meal or 50% fish meal and 50% maggot meal. Indeed, the lower the Conversion Ratio, the greater the mass gain that the feed can provide for the fish. These results could be explained by the nutritional quality of diet 3 because it contained higher protein content than other diets (Table II) and by the presence of essential amino acids susceptible for fish growth. The values obtained during our study were much higher than those obtained by Thabet (2017) [32] which were around 2.25 and 2.51 and those obtained by Dibala *et al*., (2018) [13] (2.7 to 3.03). On the other hand, our results corroborated with those obtained by Coulibaly *et al*., (2021) [12] with a consumption index of 4.73 for fish fed with diets containing 75% maggot protein. These good growth performances of *O. niloticus* fed with maggot flour showed that maggots could be a good animal protein source for boosting its growth. It can therefore replace fishmeal in small fish farms in developing countries.

Conclusion

Three diets containing 0%, 50% and 100% maggot meal, respectively, were tested in the growth of *O. niloticus* juveniles. In view of the zootechnical parameters, the results revealed that the fish fed with diet containing 100% maggot meal showed the best growth performance and survival rate. This showed that feed containing the maggot meal is better valued by the fish. The observed performances for fish fed with diet 3 highlighted the possibility of using dried maggot meal as a total replacement of fish meal. Thus, this new protein source will make it possible to optimize fish production and the development of cost effective feed for all fish farmers.

References

1. Abou Y, Fiogbé ED, Micha JC. A preliminary assessment of growth and production of Nile tilapia, *Oreochromis niloticus* L., Fed Azolla-based-diets in Earthen Ponds. Journal of Applied Aquaculture. 2007;19(4):55-69.
2. Agbohessi PT, Degila BDD, Elegbe HA, Pelebe ROE, Okewole J, Houndji AMB, *et al*. Optimization of fish productivity in ponds by the combination of fasting and co-culture in *Clarias gariepinus* and *Oreochromis niloticus*. Journal of Applied Biosciences. 2018;130:13138 – 13147 ISSN 1997-5902.
3. Agbohessou PS, Mandikia SNM, Gougbédjib A, Megidoc RC, Limab LW, Corneta V, *et al*. Efficiency of fatty acid-enriched dipteran- based meal on husbandry, digestive activity and immunological responses of Nile tilapia *Oreochromis niloticus* juveniles. Aquaculture. 2021;545:737193.
4. Al Dilaimi A. Determination of optimal dietary lipid intake in Nile tilapia (*Oreochromis niloticus*) fry. University of Oran; c2009. p. 78.
5. Bahnasawy MH, El-Ghobashy AE, Abdel-Hakim NF.

Culture of the Nile tilapia (*Oreochromis niloticus*) in a recirculating water system using different protein levels. Egyptian Journal of Aquatic Biology and Fisheries. 2009;13(2):1-15.

6. Ballarin JD, Hatton JD. Tilapia: A guide to their biology and culture in Africa. Stirling University; c1979. p. 174.
7. Bamba Y, Ouattara A, Costa KS, Gourène G. Production of *Oreochromis niloticus* with foods based on agricultural by-products. Science & Nature. 2008;5(1):89–99.
8. Bamba Y, Ouattara S, Ouattara N, Doumbia L, Ouattara A, DA Costa KS, Gourène G. Incorporation of copra and cocoa and groundnut cuticles in Nile tilapia feed (*Oreohromis niloticus*, Linnaeus, 1758) reared in a pond: effect on growth and biochemical composition. African Agronomy. 2017;29(2):121-134.
9. Bouafou KGM. Bibliographic review on maggots and their use in animal feed. Journal of Animal & Plant Sciences. 2011;12(2):1543-1551.
10. Boyd CE, Tucker CS. Pond aquaculture water quality management. Kluwer Academic Publishers, Boston. 1998. p. 44-48.
11. Burel C, Médale F. Protein sources in animal feed: what about the utilization of plant-proteins in fish feed.In: Peyronnet, C (Ed.), OCL, Oilseeds and Fats. Crop. Lipids 2014;21:D406.
12. Coulibaly ND, Kondombo C, Imien HL. Effects of partial substitution of fishmeal by maggot meal on the growth of Nile tilapia (*Oreochromis niloticus* Linnaeus, 1758). Journal of Animal & Plant Sciences; c2021. p. 20717024.
13. Dibala CI, Yougbaré MC, Konaté K, Coulibaly ND, Dicko MH. Production of Nile tilapia (*Oreochromis niloticus*, linneaus, 1758) with vegetable protein feeds. Journal of Applied Biosciences. 2018;128:12943-12952.
14. Dupont G. The rapid development of aquaculture should continue. The world; c2009.
15. FAO. General view of the Burkina Faso national fisheries sector. FID/CP/BFA; c2008. p. 19.
16. FAO. The state of world fisheries and aquaculture 2010. Rome; c2010; p. 244.
17. FAO. Commission on Genetic Resources for Food and Agriculture. CGRFA/WG-An GR-7/16/2. 2016;2:12.
18. Gbaï M, Yao K, Atse YNABC. Comparative study of the growth and survival of *Sarotherodon melanotheron* X *Oreochromis niloticus* hybrids, *O. niloticus* and indigenous tilapias from the Ivorian lagoons (*S. melanotheron* and *Tilapia guineensis*). Livestock Research for Rural Development. 2014;26(1):1-8.
19. Guedegbe OAUG. Effect of substitution of fishmeal by sun-dried maggot on growth of male monosex fry of *Oreochromis niloticus* (Linnaeus, 1758) fish. Professional License Diploma in Animal Production and Health, Department of Animal Production and Health, University of Abomey-Calavi; c2014. p. 71.
20. Hardouin J, Dongmo T, Ekoue SK, Loa C, Malekani M, Malukisa M, *et al.* Technical breeding guide n°7 on maggots [On line]. Office for the exchange and distribution of information on mini-livestock (B.E.D.I.M.), ed. J. Hardouin, BEDIM. 2000; 8 p.
21. Hardouin J, Mahoux G. Zootechnics of insects – Breeding and use for the benefit of man and certain animals. Office for the Exchange and Distribution of Information on Mini-breeding (BEDIM), in: agronomic press of Gembloux; c2003. p. 164.
22. Hoc B. Development of insect farms intended to produce aquaculture inputs. Gembloux Agro-Bio Tech, University of Liège. 2014; http://www.gembloux.ugl.ac.be/entomologiefonctionnelle-etevolutive/personnel/entomologistes/ir-bertrand-hoc/
23. Houngbo SBE, Zannou A, Houssou P, Biaou G. Competitiveness of local fish feed manufacturing units in Benin. Tropicultura; c2019. p. 0771-3312.
24. Langar H. Study of the protein efficiency of some experimental diets in young wolf fry (dicentrarchus labrax) using the nitrogen and energy balance method. INSTM Bulletin. 1996;23:2.
25. Médale F, LE Boucher R, Dupont-Nivet M, Quillet E, Aubin J, Panserat S, *et al*. Plant-based foods for farmed fish. INRA Prod. Anim. 2013;26(4):303-316.
26. Mensah GA, Pomalegni SCB, Koudjou AL, Cakpovi JCG, Adjahoutonon KYKB, Agoundo A, *et al*. Fly maggot meal, a highly valued source of protein in the diet of Muscovy ducks. Workshop: Natural and Agronomic Sciences, University of Abomey-Calavi, Faculty of Sciences and Cultures, Abomey Calavi, Benin; c2007.
27. Ndour I, Le Loc'h F, Thiaw OT, Ecoutin JM, Laë R, Raffray J, *et al*. Study of the diet of two species of Cichlidae in contrasting situations in an inverse tropical estuary in West Africa (Casamance, Senegal) J. Sci. Halieut. Aquat. 2011;4:120-133.
28. Nunes AJP, Sá MVC, Browdy CL, Vazquez-Anon, M. Practical supplementation of shrimp and fish feeds with crystalline amino acids. Aquaculture. 2014;431:20–27.
29. Sarr SM, Kabré AJT, Niass F. Diet of yellow mullet (*Mugil cephalus*, Linneaus, 1758, Mugilidae) in the Senegal River estuary. Journal of Applied Biosciences. 2013;71:5663-5672.
30. Sarr SM, Thiam A, Faye EH, Sene M, N'diaye M. Production of Tilapia fingerlings (*Oreochromis niloticus*) with 3 foods based on agro-industrial by-products in northern Senegal. Int. J Biol. Chem. Science. 2015;9(5):2598-2606.
31. Teguia A, Mpoame M, Okourou MJA. The production performance of broiler birds as affected by the replacement of fish meal by maggot meal in the starter and finisher diets. Tropiculture. 2002;4:187-192.
32. Thabet R. Comparative study of Nile Tilapia "*Oreochromis niloticus*" farming between fresh and geothermal waters in Tunisia. Final thesis, Aquaculture option, Higher Institute of Fisheries and Aquaculture of Bizerte – Tunisia, Agrocampus ouest, CFR Rennes; c2017. p. 72.
33. Toguyéni A. Sex-linked differential growth in Tilapia (Pisces: Cichlidae), *Oreochromis niloticus* (Linnaeus, 1758): contribution of genetic, nutritional and behavioral factors, and the search for an endocrine relay. Single doctoral thesis, University of Rennes 1, Rennes; c1996. p. 250.
34. Trahinta BN. Evaluation of zootechnical performance of male Tilapia *Oreochromis niloticus* reared in rearing tanks. Professional License Diploma in Animal Production and Health, Department of Animal Production and Health, University of Abomey Calavi (UAC), January 2019, Abomey-Calavi, Benin; c2019.p. 51.
35. Yuan YC, Gong SY, Yang HJ, Lin YC, Yu DH, Luo Z. Effects of supplementation of crystalline or coated lysine and/or methionine on growth performance and feed utilization of the Chinese sucker, *Myxocyprinus asiaticus*. Aquaculture. 2011;316:31-36.