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RESEARCH ARTICLE

EFFECTS OF DIFFERENT TYPES OF COMMERCIAL FEED ON THE ZOOTECHNICAL PERFORMANCE OF LARVAE OF THE "BRAZIL" STRAIN OF TILAPIA OF THE NILE *OREOCHROMIS NILOTICUS* (LINNAEUS, 1758).

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ABSTRACT

The objective of this study is to evaluate the influence of different types of commercial feed on the zoo technical performance on Brazil strain larvae of Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) in breeding conditions in Côte d'Ivoire. The study focused on four commercial foods, Ivograin, Skretting, Raanan and Real with 17%, 48%, 48%, 48% and 60% protein respectively. The average larvae 17.38 ± 1.92 mg were fed rations of 50% (1st week), 40% (2nd week), 30% (3rd week) and 25% (4th week) of their total biomass for 28 days.The results showed that the best zootechnical performance was obtained with the Skretting feed, followed by the Raanan feed. The final average weights achieved were 1020.44 ± 24.66 mg; 1615.55 ± 86.34 mg; 1478.44 ± 232.30 mg; 969.99 ± 369.29 mg respectively with Ivograin, Skretting, Raanan and Real. Larvae fed Ivograin feed had a high survival rate than those fed Skretting, Raanan and Real feeds. On the other hand, the nutrient quotient was significantly higher in larvae fed Ivograin and Real compared to other foods. The economic analysis showed that the cost of the feed distributed to larvae and the cost of the feed to produce the kilogram of fry were relatively higher with Skretting feed compared to Raanan, Ivograin and Real feed.

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INTRODUCTION

In many African countries, fish is the main source of inexpensive and nutritionally valuable protein and animal fat (Asté *et al*., 2012) In Côte d'Ivoire, national demand for fishery products is estimated at 300,000 tonnes(MIRAH, 2014). However, aquaculture production is insufficient. It increased from 1200 tonnes in 2000 to 866 tonnes in 2005, then to 1700 tonnes in 2010 and 3720 tonnes in 2013 (FAO, 2015).To meet these needs in fish products, the Ivorian State imports fish on a massive scale. According FAO (2011), these imports cause a considerable outflow of foreign currency in the order of 130.5 billion CFA francs. Thus, to reduce these imports, the Ivorian government has made the fisheries resources sector, particularly aquaculture, a new development policy(Asté *et al*., 2012). To this end, the Ivorian authorities imported a strain of tilapia Nile *Oreochromis niloticus* from Brazil in 2014, in an effort to solve the problem of the size of the fish produced and increase fish production in Côte d'Ivoire.

According Lazard (2009), *O. niloticus* is a very hardy fish with appreciated flesh and rapid growth. Its reproduction and breeding are easy. He has a relatively plastic diet. However, one of the constraints for this species is the availability of fry due on the one hand to the lack of control of production techniques and on the other hand to the feeding based exclusively on high-quality protein-rich feeds. The use of low-protein feeds by some fish farmers results in long production times and low larval growth of Cichlidae *O. niloticus*. In addition, very little work has been done to report the zootechnical performance of *O. niloticus* specimens weighing less than 2g (Bamba *et al*., 2007). Therefore, it seems appropriate to evaluate the zootechnical performance of larvae fed quality protein-rich feeds over a period of 28 days for application in the production of fry in captivity. This study therefore aims to evaluate the effect of different types of commercial feed on the zootechnical performance of larvae of the Brazil strain of Nile tilapia *O. niloticus* in farming conditions in Côte d'Ivoire.

MATERIALS AND METHODS

Larval production: The experiments were carried out in a private fish farm (Aqualand), located about 40 kilometres from Abidjan in Côte d'Ivoire. Average larvae weights of 17.38 ± 1.92 mg were obtained from the Brazil brood stock of *O. niloticus* with an average body weight of 215 ± 12.90 g for females and 442.5 ± 132.25 g for males. The stocking density of the spawners was two females to one male (Chimatiro and Costa-Pierre, 1996). The larvae were collected three (3) weeks after loading the spawners in a 28 m² breeding happa installed in a 350 m² pond. To harvest the larvae, the surface of the breeding catch was narrowed to collect all the larvae produced. The larvae, once gathered at the surface of the water, were collected using two 1 mm mesh vacuum nets and poured into buckets containing water.

Experimental feeds and larval feeding: The test feeds used as a basis for this experiment were provided by four (4) industrial manufacturers. These are the test feeds Ivograin, Raanan, Real and Skretting with 17%, 48%, 60% and 48% protein respectively. The bromatological composition of these four experimental feeds is presented in Table 1. Larvae were fed rations of 50%, 40%, 30% and 25% of their total biomass respectively during the 1st, 2nd, 3rd and 4th week of feeding. Daily food rations were served manually in 6 meals at 8:00, 10:00, 12:00, 14:00, 15:00 and 16:00.

Experimental set-up and constitution of experimental lots: The tests were conducted in a private fish farm (Aqualand) for 28 days in twelve (12) catchers with a surface area of 1 m² each and a mesh size of 1 mm. These happas were installed in a 350 m² pond. The pond is supplied with water by gravity from a water retention lake. It is equipped with a buried Polyvinyl Chloride pipe system, the opening of which is covered with a 1 mm mesh mosquito net. The larvae obtained were counted and distributed in breeding structures. Before the loading of the happas, the initial average weight of each individual was determined. This consisted of random sampling and weighing 3 samples of 200 larvae. Larval biomass (17g) was assessed by the product of the average weight and number of larvae of each happa. From this biomass, twelve batches of larvae in three batches per feed were formed to carry out the loading. For each batch, a stocking density of 1000 individuals/m² was used.

Water quality of the livestock and evaluation of zootechnical parameters: Water quality (dissolved oxygen, pH, transparency and temperature) was monitored twice a day between 6 am and 30' and 7 am and between 3 pm and 30' and 4 pm. This operation was performed before feeding and repeated 3 days a week (Ouattara *et al.,* 2005). Weight growth control fisheries were conducted every seven (07) days on 25% of the high population. During these fisheries, all larvae of each happa were weighed together using a YP Series and YP 3002 electronic scale (accuracy 0.01 g; range 300 g) to determine the total biomass of each treatment. These control fisheries have made it possible to readjust the feed ration in proportion to the total biomass. At the end of the experiment, first all fish were counted to assess the survival rate. Then, 30 individuals randomly selected from each happa were measured for length (total and standard) using a 50 cm long ichthyometer and individual weight according (Tigoli *et al*., 2017). On the basis of these data, the various zootechnical performance parameters (survival rate, food conversion ratio, weight gain, average daily gain, condition factor) on the one hand, and financial profitability on the other hand, were evaluated as follows:

Zootechnical parameters

$$\text{Survival rate (SR) (\%)} = \frac{\text{Number of fish harvested}}{\text{Number of fish stocked}} \text{x } 100$$

$$\text{Weight gain (WG)} = \text{Final weight (g)} - \text{Initial weight (g)}$$

$$\text{Average daily gain (ADG)} = \frac{\text{Weight gain (g)}}{\text{Culturing day}}$$

$$\text{Condition factor (CF)} = \frac{\text{Fish weight (g)}}{\text{Standard length}^3\text{ (mm)}} X100$$

$$\text{Foodconverion ratio (FCR)} = \frac{\text{Total feed given (g)}}{\text{Total weigth gained (g)}}$$

Production parameters and financial profitability of food Statistical analysis

$$\text{Quantity of feed used (g)} = \text{Daily ration x Breeding time in days}$$

$$\text{Cost of feed used (fcfa)} = \text{Amount of feed used x Cost per kg of feed}$$

$$\text{Net biomass (kg)} = \text{Final biomass} - \text{Initial biomass}$$

$$\text{Food cost of production per kg of fry} = \frac{\text{Cost of food used}}{\text{Net biomass}}$$

The zootechnical (survival rate, nutrient quotient, final weight, weight gain, daily weight gain, condition factor) and physico-chemical parameters were subjected to the analysis of variance using a criterion (ANOVA 1). This test was followed by the Tukey multiple comparison test for parameters with variability ($p < 0.05$) to identify specific differences between batches taken in pairs. As for the survival rate, it was subject to a contingency table. These analyses were performed using STATISTICA 7.1 software.

RESULTS

Physico-chemical characterization of water in Breeding structure: The mean values of the abiotic variables (water temperature, dissolved oxygen, pH, and transparency) are presented in Table 2. The average temperature recorded in the various happas ranges from 29.16°C (H_2) to 29.38°C (H_4). The concentration of dissolved oxygen in happas is high (4.38 mg/l) in H_2 and low (4.17 mg/l) in H_4. The average value of transparency was minimal (30.20 cm) in H_1 and maximal (30.39 cm) in H_4. The average pH values obtained ranged from 7.16 (H_2) to 7.38 (H_4). However, statistical analysis of the results shows that there is no significant difference ($p > 0.05$) between abiotic variables from one structure to another.

Evaluation of zootechnical parameters: The data on zootechnical parameters at the end of the 28 days of breeding are summarised in Table 3. At the end of this trial, the final average weights (Figure 1) achieved by individuals were 1020.44 ± 24.66 mg; 1615.55 ± 86.34 mg; 1478.44 ± 232.30 mg;

Table 1. Bromatological composition of foods experimental Ivograin, Skretting, Raanan and Real used to feed Nile *O. niloticus* tilapia larvae

Components	Feeds			
	Ivograin	Skretting	Raanan	Real
Crude protein	17 %	48 %	48 %	60 %
Metabolisable energy	2997.35 kcal/kg	-	-	-
Crude fibre	3.8%	-	-	-
Crude fat	4.51%	9 %	5 %	7 %
Starch		13 %		
Orne	-	-	12.5 %	-
Crude fibre	-	2.5 %	2.5 %	-
Phosphorus	5.45 g/kg	1.1 %	-	-
Phosphate	-	-	1.3 %	-
Calcium	35.07 g/kg	-	1.7 %	7 %
Sodium	0.17 %	-	-	-
Lysine	-	2.4 %	1.5 %	-
Methionine + cysteine	-	-	1.7 %	-
Copper	-	8 mg/kg	-	-
Digestible energy	-	15.5 MJ/ kg	-	-
Vitamin A	7500 mg/kg	7500 IU	9000 IU/kg	-
Vitamin E	1500 mg/kg	500 mg/kg	120 IU/kg	-
Vitamin D3	1500 mg/kg	1125 IU	-	-
Vitamin C	-	-	300 mg/kg	-
Ash	12.62 %	7 %	9 %	-
Humidity	-	-	-	10
Chlorides	-	-	-	2

Table 3. Environmental variables measured in happas H_1, H_2, H_3 and H_4 during the breeding of Nile O. niloticus tilapia larvae. The values represent the means and standard deviations of triplicates. The values that are assigned the same alphabetical letter are not significantly different ($p < 0.05$) for each row of the table

Physico-chemical parameters	H_1	H_2	H_3	H_4
Temperature (°C)	29.19 ± 0.02^a	29.16 ± 0.03^a	29.22 ± 0.11^a	29.38 ± 0.46^a
Dissolved oxygen (mg/l)	4.19 ± 0.02^a	4.17 ± 0.03^a	4.22 ± 0.12^a	4.38 ± 0.46^a
pH	7.19 ± 0.02^a	7.16 ± 0.03^a	7.22 ± 0.11^a	7.38 ± 0.46^a
Transparency (cm)	30.20 ± 0.02^a	30.27 ± 0.19^a	30.24 ± 0.13^a	30.39 ± 0.45^a

Values in the same row sharing the same superscript are not significantly different (p> 0.05). Data are represented as means ± standard error

Table 4. Zootechnical parameters of larvae of Nile tilapia *O. niloticus* subjected to different food treatments for 28 days

zootechnical parameters	Ivograin	Skretting	Raanan	Real
Initial average weight (mg)	17.38 ± 1.92^a	17.38 ± 1.92^a	17.38 ± 1.92^a	17.38 ± 1.92^a
Survival rate (%)	99.13 ± 0.23^a	95.2 ± 0.72^b	94.27 ± 1.41^b	$90{,}53 \pm 0{,}50^c$
Food conversion rate	0.60 ± 0.03^b	$0{,}39 \pm 0{,}05^a$	0.38 ± 0.02^a	$0{,}38 \pm 0{,}02^a$
Final average weight (mg)	1020.44 ± 24.66^a	1615.55 ± 86.34^{bc}	1478.44 ± 232.30^{ac}	$969{,}99 \pm 369{,}29^a$
Weight gain (mg)	$1003.44 \pm 24{,}66^a$	1598.55 ± 86.34^{bc}	1461.44 ± 232.30^{ac}	$952{,}99 \pm 369{,}29^a$
Average daily gain (mg/j)	35.83 ± 0.88^a	57.08 ± 3.08^{bc}	52.19 ± 8.29^{ac}	$34{,}03 \pm 13{,}19^a$
Condition factor	1.73 ± 0.08^{ab}	1.76 ± 0.01^b	1.61 ± 0.04^a	$1{,}68 \pm 0{,}02^a$

Values in the same row sharing the same superscript are not significantly different (p> 0.05). Data are represented as means ± standard error

Table 5. Economic parameters of larvae of Nile tilapia *O. niloticus* fed with different experimental feeds

Production and cost parameters	Foods			
	Ivagrain	Skretting	Raanan	Real
Initial biomass (kg)	0.00869	0.00869	0.00869	0.00869
Final biomass (kg)	0.506	0.769	0.696	0.439
Net biomass (kg)	0.497	0.760	0.687	0.430
Cost per kg of food (FCFA)	312	312	1420	630
Amount of feed distributed (g)	299.7	302.39	302.39	231.26
Cost of food distributied (FCFA)	93.5	703	703	145.6
Food cost of production per kg of fry (FCFA)	188	925	551	338

and 969.99 ± 369.29 mg respectively for Ivograin, Skretting, Raanan and Real foods. As for weight gain, the values recorded were 1003.44 ± 24.66 mg ; 1598.55 ± 86.34 mg ; 1461.44 ± 232.30 mg and 952.99 ± 369.29 mg Ivograin, Skretting, Raanan and Real respectively. Regarding daily weight gain, larvae fed Ivograin, Skretting, Raanan and Real obtained 35.83 ± 0.88 mg, 57.08 ± 3.08 mg, 52.19 ± 8.29 mg and 34.03 ± 13.19 mg respectively.

In terms of nutrient quotient, the mean values observed in individuals were 0.60 ± 0.03 mg, 0.39 ± 0.05 mg, 0.38 ± 0.02 mg and 0.38 ± 0.02 mg respectively for Ivoigrain, Skretting, Raanan and Real foods. The survival rates recorded varied significantly ($p < 0.05$) from one food to another. The highest value (99.13 ± 0.23%) of this parameter was recorded in larvae bound to the Ivograin feed and the lowest value (90.53 ± 0.50%) in individuals fed the Real feed.

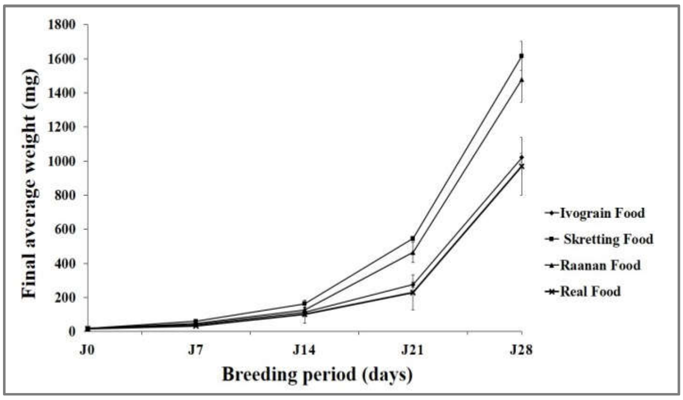

Figure 1. Evolution of the average weight of larvae of the Brazilian strain of tilapia of the Nile *Oreochromis niloticus* subjected to different diets according to the days of breeding.

The values of the condition factor recorded in this study range from 1.61 to 1.76. The statistical analysis carried out shows that there is a significant difference ($p < 0.05$) between these values.

Evaluation of production costs: Data on the costs per kilogram of food, quantities of food used, costs of food distributed and food costs of production per kilogram of fry are recorded in Table 4. The costs per kilogram of food vary from 312 to 2325 CFA francs for the food used. The Skretting feed is the most expensive and the Ivograin feed the least expensive. Regarding the amount of feed distributed during the experiment, individuals in the H_1, H_2, H_3 and H_4 breeding facilities consumed between 231.26 and 302.39 g of feed. The Skretting feed used in the H_2 structure was the most distributed compared to the Real feed used in the H_4 structure. The feed costs to produce the registered kg of fry range from 188 to 925 CFA francs for the feed used. The kilogram of fry produced with Skretting feed has a high cost price while the kilogram of fry produced with Ivograin feed has a low cost price. As for the costs of the feed distributed during the study, the costs obtained vary from 93.5 to 703 CFA francs for Ivograin, Skretting, Raanan and Real feeds. The Skretting feed is more expensive than the Real feed which is less expensive.

DISCUSSION

Survival rates obtained in larvae fed Ivograin, Skretting, Raanan and Real feed range from 90.53 to 99.13%. The average survival rate recorded in this study was 94.78%. This allows us to say that the food used has not negatively affected the survival of individuals. In addition, deaths generally occurred a few days after the control fisheries. These could therefore be related to the stress caused by the manipulations. According (FAO, 1990), a better survival rate in *O. niloticus* breeding is above 90%. Thus, it can be stated that the survival rate observed in Niletilapia *O. niloticus* larvae in this study is excellent. This value is higher than those obtained by Tigoli *et al*. (2017) in fry of the Bouaké (90.83%) and Akosombo (91.16%) strain. This difference could be due to the breeding structures used. Indeed, the study on Bouaké and Akosombo fry was conducted in basins and the present study in ponds. Differences in growth performance between larvae can be attributed to the feed used. The Skretting feed gave better results than Ivograin and Real feeds. These used foods differ in their energy, fat and starch content (energy source). Therefore, the growth differences observed between larvae fed with Skretting and those fed with Ivograin and Real may be related to the low fat levels in Ivograin (4.51%) and Real (7%) compared to Skretting which contains 9% fat. In addition, digestible energy is absent in Ivograin and Real foods, unlike Skretting, which contains 13% starch and 15.55 MJ/kg digestible energy. Indeed, according Du *et al.* (2005), an increase in lipid and energy contents in food can lead to an economy in protein utilization in fish and allow an increase in their growth performance. In addition, Person-Le Ruyet et Bergot (1999) indicate that larvae require high-fat foods for rapid growth. In addition, Sargent *et al*. (2002) reported that lipids are very important compounds in the formulation of diets for aquaculture operations, whether to meet energy or structural needs. In addition to the aspects discussed, another cause of this performance gap between Skretting and Ivograin and Real could be explained by the imbalance in the content of essential amino acids in the composition of these foods, particularly lysine. Indeed, according to Dabrowski *et al*. (2007), deficiency in one or more amino acids limits protein synthesis and affects fish growth. The best performance obtained with the Skretting feed can be related to the presence of lysine (2.4%) in this feed. On the other hand, Real and Ivograin foods do not contain this amino acid. The best growth performance observed with REAL despite the high protein content (60%) compared to Skretting with 48% protein would result from the higher degree of convertibility by fish of the ingredients incorporated in these two foods. In other words, the Skretting food would be more digestible and easily assimilated by fish. According Sklan *et al*. (2004), the digestibility of a food depends on the nature of the ingredients used. These same authors indicate that ingredients may appear to be excellent sources of nutrients, but of low nutritional value, due to the variability of their digestibility, absorption coefficients and the availability of nutrients such as amino acids and minerals. According Ouattara (2004), the ingredients contained in food have an influence on the zootechnical performance of fish. In addition, Shiau (1997) reported that food digestibility and convertibility increase with increasing fat content.

The growth difference observed between larvae fed with Skretting and those fed with Ivograin may be due to protein levels. The Skretting food, which contains 48% protein, is richer in protein than the Ivograin food, which contains 17% protein. According Tigoli *et al*. (2017), larval growth improves with increasing protein levels. Jauncey and Ross (1982) point out that the proportion of protein in the diet is of primary importance. The condition factor is a good indicator to characterize the physiological and nutritional state of fish. The recorded condition factor values range from 1.61 to 1.76 for individuals in breeding structures H_1, H_2, H_3 and H_4. The fish in the H_2 structure would be more overweight and in good condition than those in the other structures. Mamadou *et al*. (1996) indicate that the higher the condition factor, the larger the fish, and thus the better the conditions. The average value observed in this study (1.69) is close to those obtained (1.90 and 1.85 on average) by Tigoli *et al*. (2017), in the evaluation of the effect of the hormone (17-a-methyltestosterone) on the zootechnical performance of the "Bouaké" and "Akosombo" strains of Nile *O. niloticus* tilapia. Regarding the nutrient quotient, the values recorded vary between 0.38 and 0.60. The Raanan feed was very well valued by the larvae compared to the Ivograin feed. However, the values obtained reveal a good yield of the tested foods. Indeed, according to Morissens *et al*. (1990) a good nutrient quotient must be below 3; he is qualified as bad when he is above 3.5; when it is between 3 and 3.5 it is considered satisfactory.

Relatively to the cost of production related to food, the economic analysis of the results shows that Skretting food has a relatively higher cost compared to Ivograin, Raanan and Real food. However, the final average weight obtained in larvae compelled to feed the Skretting is higher than that of larvae that have consumed the other foods. The use of the Skretting food makes it possible to obtain good growth performance and increase the biomass produced, but above all to reduce the larval production time. The cost differences observed in this study can be explained, on the one hand, by the price and availability of the ingredients used in the composition of food and, on the other hand, by the means (financial, material and labour) deployed by each company for food production. With regard to water quality, analysis of the mean values of the recorded abiotic variables, compared to those obtained by Mélard (1999) (pH = 6 to 9, dissolved oxygen ≥ 3 mg/l and temperature ≥ 2 5 °C), showed that the water in the experimental pond has an acceptable quality for good fish productivity.

Conclusion

This study focused on the analysis of the zootechnical performance of larvae of the Brazil strain of Nile tilapia *O. niloticus* fed with different types of commercial feed. This work highlighted the importance of using high quality protein-rich feeds in the diet of *O. niloticus* in the larval breeding phase by happa implanted in a pond for application in the intensive production of fry in captivity. The analysis of the results of the zootechnical parameters at the end of the experiment revealed that individuals fed Skretting feed showed best growth performance, followed by the fish constrained Raanan feed, then of the fed specimens. with Ivograin and Real foods. In contrast to zootechnical parameters, the costs per kilogram of feed and feed costs to produce the kilogram of fry are relatively high with Skretting feed, followed by Raanan feed, then Real and Ivograin feed. However, these results allow us to indicate that the Skretting feed that has induced good growth performance is potentially better for the intensive production of best quality fry and the reduction of production time.

List of abbreviation

ADG: Average Daily Gain
ANOVA: Analysis of Variance
FAO: Food and Agriculture Organisation
CF: Condition Factor
CFA: French Colonies in Africa
FCR: Food Conversion Ratio
H: Hapa
IU: International Unit
MIRAH: Ministry of Animal and Fisheries Resources
SR: Survival Rate
WG: Weight Gain

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