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Effect of Feed Formulas with ACHETA Domesticus on Some Zootechnical Parameters of Catfish (Clarias Gariepinus)

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Abstract
To assess the effect of feed formulations with Acheta domesticus on some zootechnical parameters of catfish, Clarias gariepinus, an in vivo study was conducted in a fish farm at Zamakoe in the Center Region of Cameroon. For this purpose, a total of 240 larvae weighing in average 20 g were divided into twelve (12) batches, corresponding to six treatments (06) with 2 duplicates each. These rations were: T100, T80, T60, T40, T20 and T0, formulated on the basis of the level of substitution of "gouessant", a commercial feed. A completely randomized design was used for the distribution of the larvae. They were fed three times a day (08:00 h, 13:00 h and 18:00 h) at a rate of 6.5 % of their body weight during the first three weeks and then afterwards, 5 % until the end of the experiment, which lasted for four weeks. Data on survival rate, weight gain, Apparent Conversion Rate and the specific growth rate, were collected daily. Additionally, data on financial profitability were carried out. It was found that the highest average values of the survival rate were observed with T0 (85.00%) and T100 (85.00%) and the lowest average value was observed for T40 (75%). The best daily weight earning during this experiment was recorded with T0 (2.01 g) and the lowest value was recorded at the level of T20 (1.36 g). The highest cost was incurred with the T0 feed (616.57 FCFA) significantly higher than the T100 feed (124.48 CFA). The use of these feeds generated a gain in total final biomass of 1259.97 g with the T100 feed against 1003.33 g for the T20 feed. In conclusion, with the current state of knowledge, we consider the T100 diet constituted as a viable alternative to commercial feed since it is relatively cheaper, easy to formulate and yields good results.

Keywords: Acheta Domesticus, Clarias Gariepinus, Fish Feeding, Zamakoe, Zootechnical Parameters

Introduction

In aquaculture, feed represents a significant part of the cost of fish production [1]. The economic interest of this part of farming is therefore highly dependent on the availability and cost of feed [2, 3]. Thus, reducing feed-related costs, and in turn, controlling the cost of production of farmed fish, is one of the priorities in aquaculture [4]. One of the main raw materials in fish feed is fishmeal (Fagbohoun 2017). Fishmeal has high protein content, with balanced essential amino acids (EAA), it is an excellent source of essential fatty acids (EFA), and has good digestible energy [5].

Fishmeal is very expensive thus, the current use of feed based mainly on this product has considerably increased production costs [6]. The high cost of fishmeal and the irregularity of its quality have directed research towards alternative sources of protein which may not be directly usable for human consumption [7, 8]. In Africa, the possibility of incorporating insects into fish feed has been proven [9]. Insects are part of the natural diet of several species of fish, their production requires only a small area and few resources, and no arable land [10]. They produce food at a low environmental cost [11]. Insects are very rich in protein (60%), fat and minerals [12]. They have also a short life cycle with very rapid growth and are capable of bioconversion [13]. In addition, insect-based fish food products could have a similar market to fishmeal and soy [14]. Thus, the use of insects as food in aquaculture would probably become widespread over the next decade [15].

Among the insects targeted throughout the world in the diet of fish, are crickets of the family Grillidae [16]. There are 900 species of crickets and the house cricket (Acheta domesticus L.) is probably the most produced species for commercial purposes [17]. This species is used throughout the world for animal consumption [18]. In addition to being an excellent source of protein (up to nearly 70% of dry matter), A. domesticus is also rich in minerals (e.g., calcium, iron, and magnesium) (3–10%), fat, and essential fatty acids (15–40%) [12, 19]. More so, the protein conversion efficiency of the A. domesticus has been demonstrated to be superior to that of chickens, pigs, sheep and cattle [20].

Out of 51.4 million tonnes of world aquaculture production in 2002, the production of Clarias spp. amounts to 199,129 tonnes [21, 22]. Moreover, endemic to Africa, Clarias gariepinus Burchell, the African Catfish, remains one of the most suitable species for African aquaculture, because of its resilience to climatic variation and salinity as well as its flexibility to food quality. These attributes account for the wide geographical distribution of the fish on the African continent [23]. Clarias gariepinus is a major warm water aquaculture species in Africa and Asia (Khan and Abidi 2011). It is an excellent intensive culture species due to its tolerance to poor water quality; its ability to sustain strong, high-density growth; to its resistance to the diseases [24]. Clarias gariepinus is a species present in many fish farms in Cameroon [25].

The objective of this study was to evaluate the performance of fish (Clarias gariepinus) in a controlled environment using feeds based on Acheta domesticus

Materials and Methods

Formulation of pellets

The current study required as ingredients, cassava flour, corn bran, weat bran, peanut cake, cotton seed cake purchased at the small market in Ngaoundéré, capital of the region of Adamaoua Cameroon were dried in an oven at 105°C for 24 hours, then sorted in order to separate the raw material from the debris (pebbles, sand, paper, physical particles), crushed and sieved using a 900µm mesh sieve. Crickets (Acheta domesticus) were caught in the Adamaoua region, dried, and then ground into flour using a blade and hammer mill. Table 1 shows the mix plan for fish pellets. Eighteen (18) formulas of pellets for fish were obtained by combining six (06) ingredients according to a mixing plan generated by the expert Design software, represented by Table 1. Each of the mixtures was immersed in a volume of water according to the ratio (1/3). The paste obtained was subjected to an extruder to extract the hydrated pellets. The various hydrated pellets were dried for 24 hours in a memmert oven at a temperature of 105 °C.

Table 1: Mixing Plan for Fish Pellets

Pellets	Weat bran	Cassava flour	Corn bran	Peanut cake	Cotton seed cake	Acheta domes-ticus powder	Total
(g)							
1	0.80	11.25	11.25	0.85	0	0.85	25
2	9.55	0	11.25	0.85	0.85	2.5	25
3	6.25	0	11.25	2.5	2.5	2.5	25
4	10	0	11.25	2.5	0	1.25	25
5	11.25	1.65	11.25	0.85	0	0	25
6	9.58	0	11.25	0	2.5	1.67	25
7	5	5	11.25	1.25	1.25	1.25	25
8	3.75	7.5	11.25	2.5	0	0	25
9	0	9.58	11.25	2.5	1.67	0	25
10	8.35	4.55	11.25	0	0.85	0	25
11	2.09	4.16	11.25	2.50	2.50	2.50	25
12	5.625	5.625	11.25	0	0	2.500	25
13	8.35	4.55	11.25	0	0.85	0	25
14	10.45	0	11.25	1.65	1.65	0	25
15	0	8.75	11.25	0	2.50	2.5	25
16	3.75	6.65	11.25	0.85	2.50	0	25
17	6.875	2.5	11.25	1.875	1.875	0.625	25
18	0	7.95	11.25	2.5	0.80	2.5	25

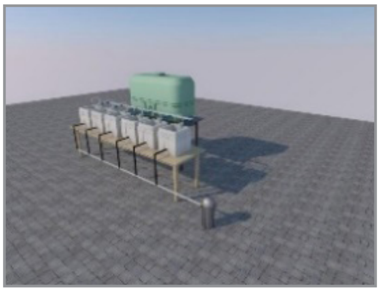
Description of the Study Area

The fish farm for the present study was located at Zamakoe Village in the Mbalmayo Council Area of the Nyong -et -So'o Division, Centre Region, Cameroon. Zamakoe is located near the Ngalan village as well as Nkolnkokand loted between 3e and 34e degrees of northern latitude and between 11e et 30e degrees of longitude Est. Zamakoe has a population of 968 inhabitants according demographic projection from the third general population and housing census 2005. It includes 4 unevenly distributed seasons, two dry (December-February and July-August) and two rainy (March-June and September-November). The vegetation is that of the dense forest, strongly modified by man due to the advancement of urbanization and farming.

Bioassays

Experimental Structures

Based on a 3D representation developed using AutoCad and ArchiCad software (Figure 1a), an installation consisting of a set of six (06) bins corresponding to six treatments connected to pipes, end fittings, elbows and taps were constructed (Figure 1b and c). The assembly in the simple assembly is supplied with water from a water storage tank (Figure 1c). The latter is filled with water from a borehole by means of a pump.



(a)

(b)

(c)

Figure 1: Experimental Devices (a) 3D Structure, b) Installation, c) Water Storage Tank

Preparation of Rations and Treatments

To achieve this, six (06) feed formulations corresponding to six (06) treatments were produced. Control treatments contained only a pure commercial feed (T0 « Le GOUESSANT ») while those based on pellet formula seven (table 1) included: T20, T40, T60, T80 and T100. These included pellets substituted respectively with 20%, 40%, 60%, 80% and 100% of the control rations. To these mixtures we added a fish cure antibiotic + brand and livestovit (as vitamins. In addition to this, salt was also given to the fish to stimulate their appetite. The fish samples for the experiment were Clarias gariepinus fry with an average weight of 20 g, purchased from a local fish farmer and stocked at a density of 20 fry per tank giving a total of 240 larvae for the experiment.

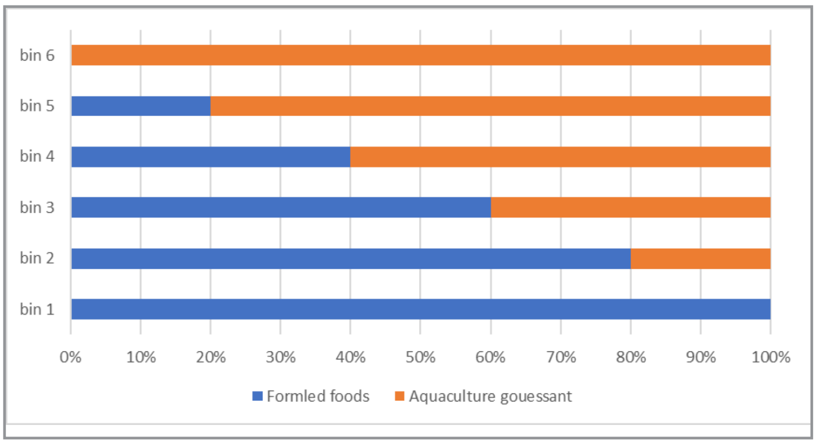


Figure 2: Mixing Proportions

Ration and Feeding Time
The work was done in 20-litre transparent plastic tanks operating with recycled water. The larvae were transferred to the experimental tanks after acclimatizing for 4 days. In total, 240 larvae weighing 20 g each were used. The larvae were distributed at a density of one larva by litter and fed three (03) times a day (morning at 08:00 h GMT+1, 13:00 h and evening at 18:00 h) for 28 days at 6.5% of their body weight, during the first three weeks and 5% thereafter until the end of the experiment [26]. Each morning, food particles not ingested by the larvae and their faeces were siphoned off using a flexible hose prior to food distribution [27].

Water Quality Control
Water is essential to the life of fish because it is the element that must meet all their needs; its temperature is therefore a crucial element because it regulates the growth and activity of fish. The temperature of the media was measured using a manual thermometer, and the pH of the medium was measured using a manual pH meter. Each morning, the water is renewed in the opened bins with a tap.

Growth Control
Control of fry growth was carried out every three days. To achieve this, three (03) larvae were randomly sampled per tank and weighed individually using a DAHONGYING brand scale. Af-ter each control fishing, the fish were returned to the cleaned bins, then the total biomass and the number of larvae were determined. At the end of the experiment, all the larvae per tank were counted and weighed.

Zootechnical Performance
Growth performance evaluation parameters of Clarias gariepinus were determined. These differ-ent zootechnical parameters were calculated from the results obtained to assess the growth of fish respectively and the effectiveness of food use during the experimentation. This is the survival rate (SR) expressed in percentage (%); Daily Weight Gain (DWG) expressed in grams per day (g.d-1); Body Mass Gain (GMG), Specific Growth Rate (SGR) expressed in gram percentage per day (g%. D-1); and the cost of distributed foods (CF).

Survival Rate (SR)
The study of the mortality of our fry was carried out every three days as follows:
- Determination of total biomass;
- Identification and removal of dead fry;
- Subtraction of the number of dead from the total number of fries.

This survival rate makes it possible to know the effect of the different treatments on the monitor-ing of the fish.
Survival rate (SR) % = (Number of individuals at the end of the experiment / Initial number of individuals) × 100.

Average Daily Weight Gain (DWG) or Daily Growth Rate (DGR)
It is used to assess the growth rate of farmed fish by daily weight gain.
• **Daily Growth Rate (DGR) =** (Pmf - Pmi) / Duration of the experiment
• **Pmi: Initial weight; Pmf:** Final average weight.
• **Body Mass Gain (BMG):** = Final weight (g) – Initial weight (g)
• **Specific Growth Rate (SGR):** It is used to assess the weight gained by the fish each day, as a percentage of its live weight.
• **Specific Growth Rate (SGH) =** 100 × (ln Pmf – ln Pmi) / Experiment

Table 2: Cost of One Kilogram of Different Ingredients Used for the Formulation of Pel-lets (1kg)

Ingredients	Kilogram Cost (FCFA)
Cassava flour	200
Cotton seed cake	200
Peanut cake	200
wheat bran	300
Corn bran	100
Acheta domesticus powder	_
Total	1000

Cost of Feed distributed
Cost of feed administered = Quantity of feed administered × Price of feed
Table 1 presents the different ingredients used for the formulation of our pellets

Statistical Analysis
Data processing was done using Excel 2010 and SPSS Statistics version 20 software.
- Data were expressed as mean ± standard deviation.
- Data were analyzed by one-way ANOVA at the threshold α = 0.05.
- Multiple comparisons of means were performed with Duncan's test.

Results and Discussions

Physicochemical Parameter
In fish farming, physico-chemical parameters play an important role in the growth of individuals. Thus, the physical and chemical factors of the environment are among the parameters that could influence the growth of fry (DiMaggio et al 2014). During the experiment, two factors were measured: Temperature and pH.

Study Environment Temperature and pH
The temperature of all treatments combined ranged between

20°C and 23°C. These values correspond to those belonging to the survival tolerance interval of the African catfish Clarias gariepinus. But this species has an optimum growth temperature between 28 and 30°C [28]. Our work is not in line with that of Baras and Jobling (2002) who placed the temperature range for good growth of Clarias gariepinus between 24°C and 33°C. However, Clarias gariepinus can live in very turbid waters and tolerate temperatures of 8 to 35°C [29]. These temperature differences have just confirmed the fact that the species Clarias gariepinus has a wide range of temperature tolerance [30].

The pH value obtained in the experimental tanks is between 6.7 and 7.1. This value is found in the recommended pH range of 6.5 to 9 by Kanangire 2001 for optimal growth of African catfish Clarias gariepinus.). Our work is also in line with that of who place the pH range for maximum growth of Clarias gariepinus between 6.5 and 8.

Zootechnical Performance

Table 2 shows Zootechnical performance. This table shows the survival rates recorded at the level of the various treatments during the experiment. The highest average values were observed at T0 (85%) (average of two treatments fed with the T0 ration) and T100 (85%) (average of two treatments fed with the T100 ration) and the lowest average value was observed at T40 (75%) (average of two treatments fed with the T40 ration). There were not significant differences between these treatment groups. These average values obtained for the survival rate in the treatments agree with that obtained by, for whom a survival rate of 90% is generally accepted in breeding [31]. On the other hand, these same survival rates are shown to be higher than that obtained by Djoko in the developed marshes (0.27%), by in the simulated ponds (21.47 to 39.3%) and (21.67 31.77%) for polyester pools, and that observed by (between 55 and 63%) in tanks with non-permanent water renewal. Furthermore, the results of the work reported by Pouomogne (2013) on the survival rate of Clarias gariepinus fingerlings after eight weeks of rearing was 75% with a feed containing 20% protein, 82% at 25% of protein, and 100% at 30 - 35 - 40 - 45 - 50% of protein at a temperature varying between 27.5 and 28° C., with a pH lying between 7.5 and 7.8. The good survivals recorded in all the treatments are certainly due to the fairly good conditions of the rearing environments [32]. In view of the values obtained, it appears that major problems have not been recorded in terms of mortality. The few deaths counted during the experiment do not seem to be related to food. Mortality would therefore be due to the stress of handling.

Table 3: Zootechnical Performance

RA-TION	T100	T80	T60	T40	T20	T0	SEM	P
SR (%)	85^{a}	80^{a}	80^{a}	75^{a}	82.5^{a}	85^{a}	1.66	0.66
DW(g)	1.80^{c}	1.63^{b}	1.80^{c}	1.91^{cd}	1.36^{a}	2.01^{d}	0.62	<0.001
BMG (g)	54.16^{d}	49.16^{b}	54.16^{c}	57.5^{de}	40.83^{a}	60.41^{e}	0.62	<0.001
SGR	4.36^{c}	4.13^{b}	4.36^{c}	4.51^{cd}	3.70^{a}	4.63^{d}	0,086	<0.001

SR: Survival rate, DW: Daily weight, BMG: Body mass gain, SGR: specific growth rate

Table 2 shows that the average daily weight gain at the end of this experiment varied overall between 1.36 for the T20 ration (average of two treatments fed with the T20 ration) and 2.01 for the T0 ration (average of two treatments fed with the T0 ration). There were significant differencees between these treatment groups.

The daily individual weight gain values recorded in the present study are higher than those obtained by with Moringa leaves (0.19 g/d) in Clarias gariepinus but remain lower than the 3 g/d obtained by. This difference in daily weight gain between these two studies could be due to the different sources of proteins used in these studies [33, 34].

Table 3 shows that the average body mass (ABM) gains observed over 28 days of the treatments at the end of this experiment gave the values of 54.16; 49.16; 54.16; 57.5; 40.83 and 60.41 respectively for food T100, T80, T60, T40 and T20, T0. T0 and T40 foods had the highest gmc, followed by T100 and T60 foods. Foods T80 and T20 presented the lowest values. There were significant differences between these treatment groups.

Table 3 shows that the average specific growth rate (SGR) in grams Clarias gariepinus observed for 28 days of the treatments at the end of this experiment gave the values of 4, 36; 4.13; 4.36; 4.51; 3.70 and 4.63 respectively for food T100, T80, T60, T40 and T20, T0. T0 and T40 foods gave the highest specific growth rates (SGR), followed by T100 and T60 foods. Foods T80 and T20 presented the lowest values. There were significant differences between these treatment groups [35]. These values of the specific growth rate corroborate the values of 4.14 and 5.80%/d obtained by in Clarias gariepinus for the soy incorporated respectively at 30 and 60% and of 5.43 and 4.32% for cotton incorporated respectively at 30 and 60%. Our values also agree with those of 4.26; 4.05 and 3.85%/d obtained respectively for food at Azolla (0%, 30%, and 50%) [36]. These figures remain higher than those (1.4 %/day - 2.46 %/day) recorded in populations of O. niloticus with an initial weight of 30 g [37, 38]. In this study, the initial weight was 20 g. This difference observed between the two studies could be explained by the difference in initial body weight. It has been proven in fish, as in other livestock, that the specific growth rate decreases with increasing age, weight and size [39]. The significant growth performance observed during this study would also result from a high degree of convertibility by the fish of the ingredients used in the formulation of the food based on agricultural by-products [40].

Financial Evaluation of Production

Economic Values of Food Introduced by Container

Table 4 below shows the average cost and quantity of feed used in treatments. Average cost and quantity of feed table shows that the average quantities of food distributed for the entire experiment vary between 531.6 g (T100%) and 408.9 g (T80%). Knowing the quantity and the economic value of our various ingredients, we deduced that the cost of the feed distributed to the larvae was higher with the T0 feed (616.57 FCFA) compared to T100% feed (124 .48 FCFA) which is the lowest value. The gradual use of our pellets led to a decrease in the prices of formulated feeds (124.48; 172.83; 267.74; 372.88 and 439 31 FCFA respectively T100, T80, T60, T40 and T20) compared to the reference food T0 (616.57 FCFA) [41-45]. We previously determined that producing one kilogram of fish with the T100 feed costs 144.50 FCFA against 242.00 FCFA with the T80 feed; 336.00 FCFA with T60; 480.50 with T40; 641.50 with T20 and 702.50 FCFA for T0. The use of these feeds generated a gain in total final biomass of 859.97 g with feed T100; 705.80g with T80; 748.30 g with T60 and 761.61 g with T40 versus 603.33 g for T20 food and 969.16 g with T0. The T100 feed performed well in terms of growth and yield. And this same food was the cheapest in terms of cost. It was more advantageous and accessible than the T0 food (control). The economic results that we obtained corroborate the studies of IGA-IGA Robert (2008) in Gabon who demonstrated that feed made from local ingredients had similar performance and were economically more profitable than manufactured commercial feeds [46-50].

Table 4: Average Cost and Quantity of Feed Used

Batches	T100	T80	T60	T40	T20	T0	SEM	P
Initial bio-mass (g)	400	400	400	400	400	400	0.00	_
Final bio-mass (g)	1259.97^{bc}	1105.80^{ab}	1185.80^{abc}	1161.61^{abc}	1003.33^{a}	1369.16^{c}	38,52	0.08
Gain of total final bio-mass (g)	859.97^{ab}	705.80^{ab}	748.30^{ab}	761.61^{ab}	603.33^{a}	969.16^{b}	41.60	0.06
Diet costs per batch (FCFA)	124.48^{a}	172.83^{a}	267.74^{ab}	372.88^{ab}	439.31^{ab}	616.57^{b}	55.98	0.12
Pellet costs per batch (FCFA/g)	124.48^{e}	76.01^{d}	60.97^{d}	43.09^{c}	20.65^{b}	0.00^{a}	69,13	0.43
GOUES-SANT cost (FCFA /g)	0.00^{a}	96.82^{ab}	206.77^{ab}	329.79^{abc}	418.66^{bc}	616.57^{c}	65.34	0.05
Production of one-kilogram fish cost (FCFA / Kg)	144.50^{a}	242.00^{a}	336.00^{ab}	480.50^{ab}	641.50^{b}	702.50^{b}	64,45	0.05

SEM: Average standard error

Conclusion

At the end of this study, in which the feeds formulated with A. domesticus were tested in an experiment in a controlled environment on catfish (Clarias gariepinus), it appears that the zootechnical parameters of our farmed fish are a function of the substitution of classic commercial foods with our pellets. In view of the characteristics of growth, we can, in the current state of knowledge, consider the T100 diet (food with 100% of our pellets) constituted as being the most interesting. It would be more accessible to average fish farmers, followed by T40 made up of 40% of our feed, which has growth performance close to T100 [51-53].

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