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Comparative growth performance and survival of hatchery-reared African catfish fry (*Clarias gariepinus* Burchell 1822) fed on live and artificial diets

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Abstract

Background: Feed determines to a large extent, the sustainability in aquaculture since the survival and growth of the fish fry depends on the quality of feeds. The comparative growth performance and survival in *Clarias gariepinus* fry fed with live and artificial feeds were carried out.

Methods: Four hundred and eighty healthy fries collected from a commercial hatchery were randomly divided into four experimental groups of 40 fry with three replicates for each group, and fed with four different feeds (three live feeds and one artificial feed) to differentiate each group; Artemia Lush® (AL), Artemia Inve® (AI), Dried-ground Shrimp (S), and artificial feed Durante® (D) for three weeks. The proximate composition of feed samples was analyzed, Physico-chemical parameters and microbiological analysis of water in experimental tanks were analyzed on a weekly basis. The fish were assessed for growth performance and survival on a weekly basis.

Results: There was a significant difference of $P < 0.05$ in all proximate compositions of the feeds analyzed, there was no significant difference ($P > 0.05$) in the Physico-chemical parameters of water in the experimental tanks within twenty-one days. The final weight, final length, specific growth rate, and survival of fry fed with live feeds Artemia were similar to artificial feed Durante®, but the economic analysis was reduced in artificial feed compared to live feeds while fry fed with Dried-ground Shrimp had poor growth and survival rate.

Conclusion: The feeding of live and artificial feeds to *Clarias gariepinus* fry within the first twenty-one days produced a similar growth response and survival rate but an artificial diet required reduced cost than live diets, while dried-ground shrimp should not be recommended for feeding *Clarias gariepinus* fry.

Keywords: Artemia, artificial feeds, growth, survival, fry, *Clarias gariepinus*

Introduction

Fertilization, hatching, and early survival of larvae are vital for the successful aquaculture of the African catfish^[8]. The knowledge of the nutritional requirements of the fish is necessary to ensure healthy and optimal growth, particularly in the larval stage. *C. gariepinus* is generally classified as an omnivore or predator as no consistent pattern on its food composition has emerged. Introducing a good starter compound feed type to the larval fish at a particular larvae developmental stage is a key challenge in intensive fish culture^[23, 29] and it is only possible at a developmental stage when the digestive system can assimilate and digest the compound feed^[27]. Although the fish may have basic developmental phases, the complexity of the development of the digestive tract and timing may defer as the larvae mature, characterizing varying nutritional requirements at different stages and periods in different fish species^[15, 20]. First feeding, when the fish begins taking feeds is the most critical period as delays or early feeding may affect fry growth and survival^[14]. In some cultured species, dry feeds have been successfully introduced as starter feeds at first feeding without using live feeds^[18, 22]. Additionally, the type of weaned feed the larvae are fed will influence their growth and survival because of the different nutritional content in the diet formulations. The suitability of first feed sources for fry rearing is very important in the light of the need for good growth and high survival rates^[4] and the high cost of importing encapsulated artemia has necessitated the search for other first feed sources with fish culturists using several materials to rear the larvae of *Clarias gariepinus*^[3].

However, *Artemia* is not cost-effective in most developing countries. So many works have been done on several feeds to look at their suitability as an alternative to *Artemia* in fish larvae, concerning survival and growth.

Therefore, this study focused on comparative growth performance and survival of hatchery-reared *Clarias gariepinus* fry fed on different diets.

Materials and Methods

Handling of experimental Fish

Ethical clearance and valid approval were obtained from the University of Ibadan, Animal Care and Use Research Ethics Committee before the commencement of the experiment. Fry used in this study were handled according to the Canadian Council on Animal Care's Guide to the Care and Use of Experimental Animals [13].

Study Area

The research work was carried out in the Fish and Aquatic Animal Medicine unit of the Department of Veterinary Medicine, University of Ibadan, Oyo State, Nigeria. Ibadan, the capital of Oyo State, lies between longitude 3^o54'59.99 E and latitude 7^o23'28.19 N.

Stocking Density

Hatchery reared fry obtained from hormonally-induced spawns of mature African catfish *C. gariepinus* broodstocks were used in this study. A total of 480 pieces of three days old African catfish fries of 2.98 ± 0.04mg weight and 2.91 ± 0.09mm length were collected from the University of Ibadan fish farm, transported under hygienic conditions to the Department of Veterinary Medicine (Fish and Aquatic Animal Medicine Unit). The fries were stocked in a 6L experimental plastic tank containing 4 liters of water (100ml of water per fry) and divided into four groups of forty fishes, each in three replicates. The weight was obtained by the use of a Rohrer-sensitive electric weighing balance. A wet filter paper was placed in the balance and set the reading to zero, twenty-five larvae were collected randomly from the hatchery at the end of endogenous feeding and placed at the zero-weight filter paper, and the weight was taken, and the average was determined. This was repeated five times, and the average of the results of the five sets was taken as the weight of the individual larvae in the hatchery. Five fries from each set were measured using a transparent millimeter calibrated ruler and a magnifying hand lens. The average lengths of each of the groups of fish were taken and the mean of the five-set was taken as the length of each fry.

Feeding

The feed samples collected were identified as follows: Group 1 *Artemia* Lush® (Decapsulated or Shell Free *Artemia*), Group 2 *Artemia* Inve® (Decapsulated or Shell Free *Artemia*), Group 3 Dried-ground Shrimp, and Group 4 *Durante*® (artificial feed). The microbiological and proximate analyses of all the feed samples were carried out. The feeding commenced 12 hours after stocking and they were fed 10% of their body weight per day for 21 days.

Physico-Chemical Parameters of water

The fifty percentage of water in each experimental fish tank was changed every 48 hours to avoid the death of fries due to poor water quality (Tucker 1985). Water quality parameters namely temperature, pH, Dissolved Oxygen, Ammonia,

Nitrite, and Total Hardness was measured on days 7, 14, and 21, using mercury in a glass thermometer calibrated in degree centigrade (0-100 °C). The thermometer was immersed in the experimental water column and allowed to stand for five minutes. The reading was taken immediately after the thermometer was removed from the water, an average of three measurements was taken per tank. pH, Dissolved Oxygen, ammonia, and nitrite were measured using a digital pH meter, Dissolved Oxygen meter, chemical titration for ammonia, and nitrite using an ELISA reader (ELX 800 from Biotek) for the optical density of color development for ammonia and nitrite.

Growth Parameters

Length

The length was measured using a transmitted millimeter calibrated ruler and a magnifying hand lens. The initial fry length was 2.91 ± 0.09mm and measurements were repeated at days 7, 14, and 21 while the weight was determined by using an electric sensitive weighing balance. The initial fry weight before stocking was 2.98 ± 0.04mg, and weighing was repeated at 7, 14, and 21 days post-feeding.

Survival Rate

The survival rate was determined using the formula.

$$\% \text{ survival rate} = \frac{\text{final number of fry stocked} \times 100}{\text{The Initial number of fry stocked}} \quad (7)$$

Specific Growth Rate (SGR) Specific Growth Rate (SGR):

$$\text{This was calculated using: } \text{SGR} = \frac{\ln W_t - \ln W_o}{T} \quad (7)$$

Where

W₁ = Final body weight

W₀ = Initial body weight

T = Time (days)

Condition Factor (K)

The Condition Factor (K): this was calculated using the formula:

$$K = \frac{W \times 100\%}{L^3} \quad [30]$$

W= Weight (g) and L = Length (cm)

$$\frac{\text{Final weight} - \text{Initial weight}}{\text{GrowthPeriod}}$$

Statistical analysis

Statistical analysis was carried out on all data using the SPSS VERSION 12 for windows. Data were pooled by treatment and presented as mean ± standard deviation (SD). The proximate composition of feed and Physico-chemical parameters of water in experimental was analyzed by one-way analysis of variance (ANOVA). The Turkey Post hoc test was used to 95% confidence level to produce specific information

on which means are significantly different from each other.

Results

The proximate composition of the four experimental diets (Artemia Lush®, Artemia Inve®, Shrimp®, and Durante®) are shown in Table 1. There was a significant difference in all the parameters measured at $P < 0.05$,

Physico-Chemical Parameters of Water in the Experimental Tanks

The summary of the Physico-chemical parameters of the experimental waters during the periodic water change within the twenty-one days is shown in Table 2. There was no significant difference ($P > 0.05$) in the values of temperature, pH, total hardness, nitrite, ammonia and dissolved oxygen of the water in all the experimental tanks.

Microbiological Analysis of Water in the Experimental Tanks

The result of the microbiological analysis is shown in Table 3, with total aerobic count and total coliform counts noticeably present in the experimental waters, while Vibrio count, fungal, and Escherichia coli were absent.

Growth Response in *Clarias gariepinus* fry fed Experimental diets within 21 days

The growth responses of fries to the experimental diets are shown in Figures 1 to 5. The fish fed with Artemia Lush®, Artemia Inve®, and Durante® consistently had higher final weight values than that of Ground Shrimp within the experimental period (Figure 1). Similarly, in final length, larvae fed with Artemia Lush®, Artemia Inve®, and Durante® consistently had higher final length values than that of Dried-ground Shrimp within the experimental period (Figure 2).

The condition factor K differs among the fries fed with different feeds. The condition factor in the fish fed with Dried-ground Shrimp rose and peaked at week 2, later it declined at week 3, while the fish fed with Artemia Lush®, Artemia Inve®, and Durante® were within the same range in all experimental periods (Figure 3).

The specific growth of *C.gariepinus* fries obtained in this study increased in all the diets except in Dried-ground shrimp as the experimental period increased. However, the highest values for both live and artificial feeds were observed in the experimental period of week 3 (Figure 4).

The fries of *C.gariepinus* survived more under exposure to Artemia Lush®, Artemia Inve®, and Durante® diet than Dried-ground shrimp. The survival rate in *C.gariepinus* fries fed with all the diets decreased as the experimental period increased (Figure 5).

Table 1: Proximate Composition of experimental Feeds

Nutrient Content	AL	AI	S	D
Crude Protein (%)	49.50±0.05 ^a	58.19±0.05 ^a	59.43±0.05 ^a	50.38±0.05 ^a
FAT	9.40±0.05 ^a	11.40±0.05 ^a	7.7±0.05 ^a	9.90±0.05 ^a
Moisture	10.88±0.02 ^a	10.40±0.02 ^a	18.38±0.02 ^a	8.90±0.02 ^a
Fibre	8.27±0.02 ^a	2.90±0.02 ^a	4.08±0.02 ^a	6.68±0.02 ^a
Ash	7.50±0.02 ^a	8.38±0.02 ^a	7.31±0.02 ^a	3.90±0.02 ^a
Energy (Cal/g)	253.17±0.04 ^a	363.61±0.04 ^a	277.93±0.04 ^a	296.11±0.04 ^a

Mean within the same row with same superscript are significantly different ($P < 0.05$).

Table 2: Physico-chemical parameters in the experimental tanks.

Physicochemical Parameters	Week 1	Week 2	Week 3	Standard Values for Fish Farming APHA 1989, Boyd and Tucker 1992
Temperature	27.47±1.14 ^b	27.63±1.13 ^b	27.50±1.17 ^b	26°C – 32°C
pH	7.25±0.30 ^b	7.25±0.30 ^b	7.30±0.30 ^b	6.5 – 8.5
Total Hardness (ppm)	120.0±2.5 ^b	120.3±2.5 ^b	120.0±2.5 ^b	50 – 150
Nitrite (ppm)	0.01±0.02 ^b	0.01±0.02 ^b	0.01±0.02 ^b	0.05 max
Ammonia (ppm)	0.55±0.22 ^b	0.60±0.22 ^b	0.60±0.02 ^b	2.0 max
Dissolved Oxygen (ppm)	7.0±1.10 ^b	6.5±1.10 ^b	6.8±1.10 ^b	5.0 min

Mean within the same row with same superscript are not significantly different at ($p > 0.05$)

Min. = minimum, max. = maximum.

Table 3: Microbiological Analysis of Water in Experimental Tanks.

Physicochemical Parameters	Week 1 (cfu/ml x 10 ⁵)	Week 2 (cfu/ml x 10 ⁵)	Week 3 (cfu/ml x 10 ⁵)
Total Aerobic Counts	1.2	1.1	1.3
Total Coliform Counts	1.4	1.2	1.3
Fungal Counts	0	0	0
Vibrio Counts	0	0	0
<i>Escherichia coli</i>	0	0	0

Table 4: Summary of cost benefit analysis of African Catfish rearing

Parameters / Diets	AL	AI	S	D
Cost of feed used for production of one kilogram of fish* (US\$ Kg-1)	2.40	2.60	1.80	2.00
Cost of expenses related to the production of one kilogram of fish (US\$ Kg-1)	0.50	0.50	0.50	0.50
Total cost of production of one kilogram of fish (US\$ Kg-1)	2.90	3.10	2.30	2.50

* Cost of feed used for production of one kilogram of fish = Feed Conversion Ratio × Cost of feed per kilogram.

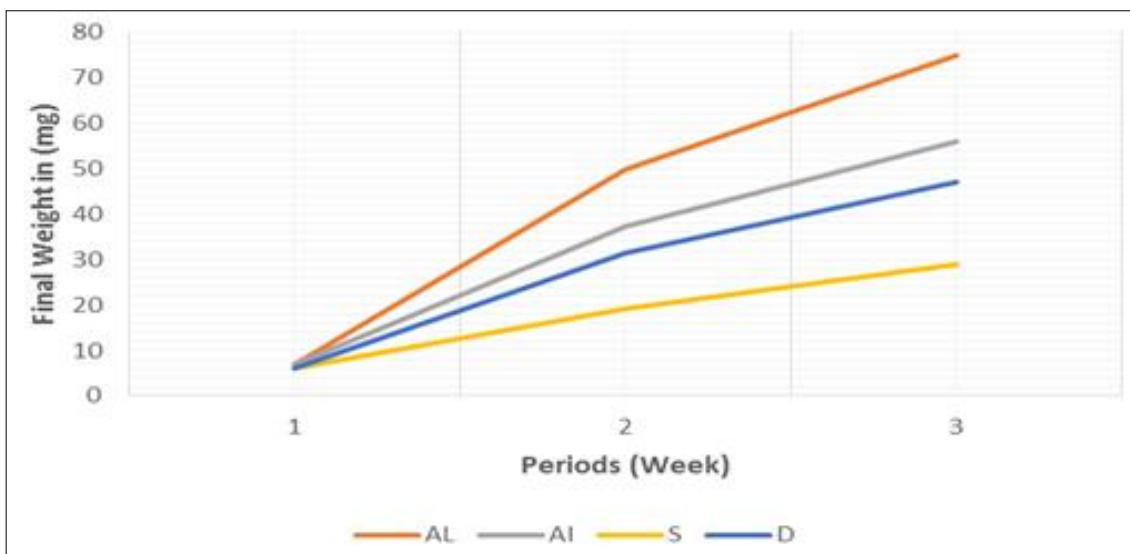


Fig 1: Changes in final weight of *Clarias gariepinus* fed on different diet

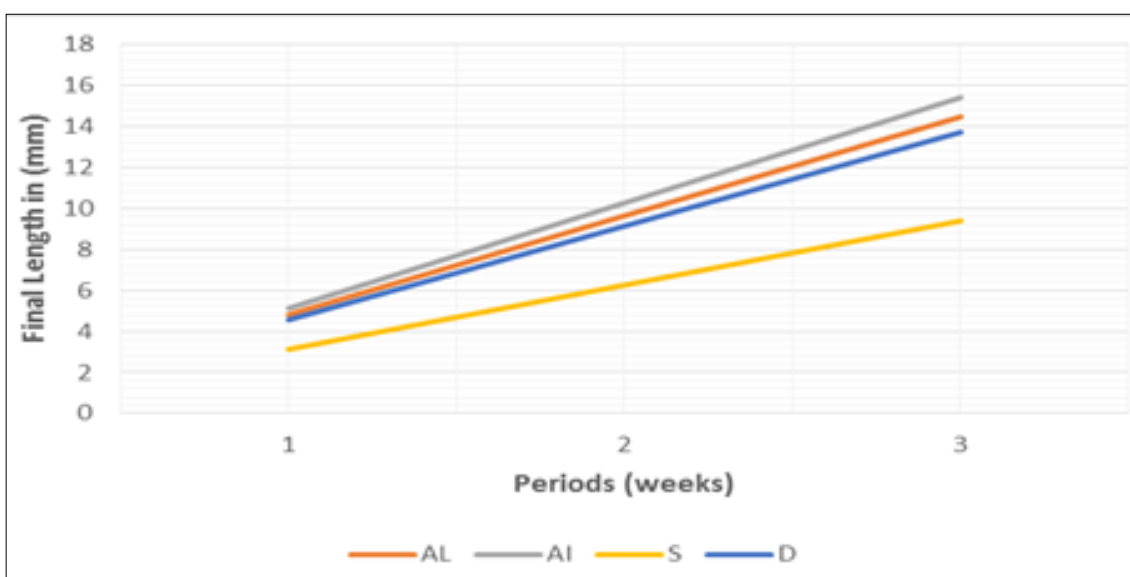


Fig 2: Changes in final length of *Clarias gariepinus* fed on different diets

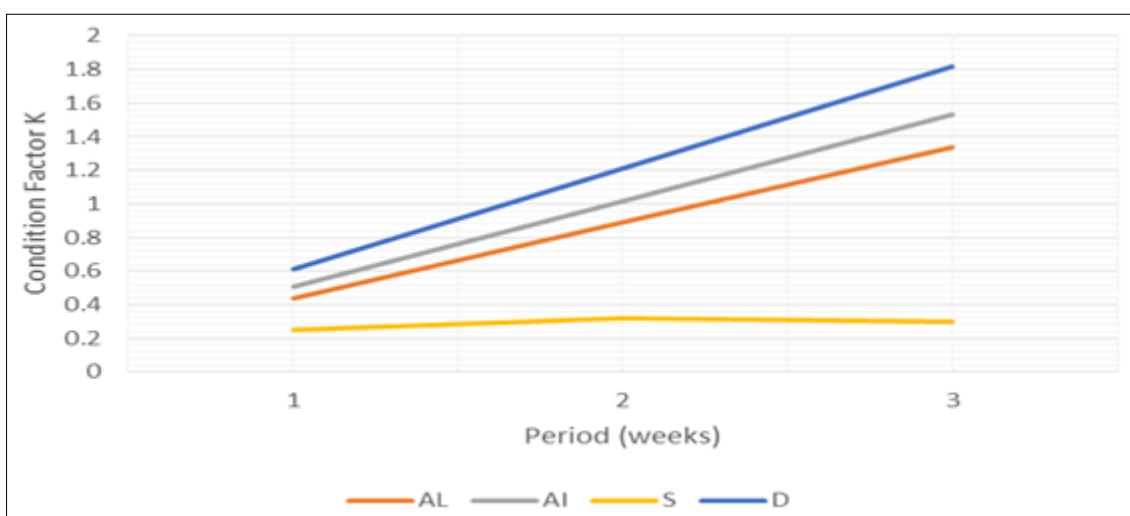


Fig 3: Changes in Condition factor K of *Clarias gariepinus* fed on different diets

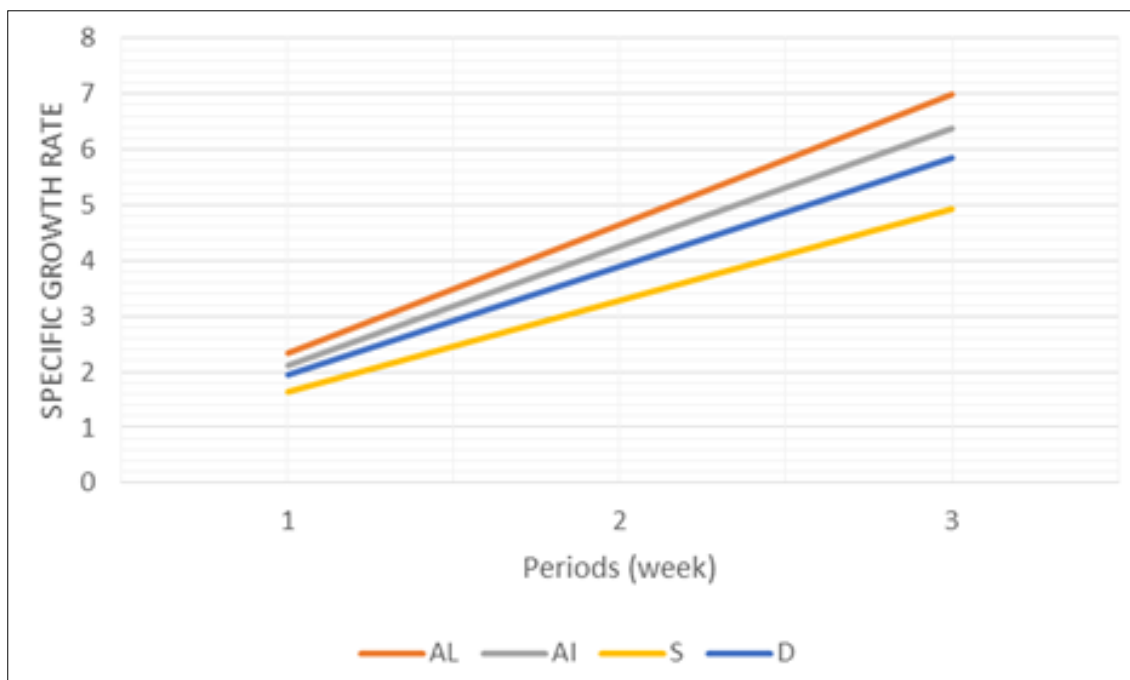


Fig 4: Changes in Specific Growth Rate of *Clarias gariepinus* fed on different diets

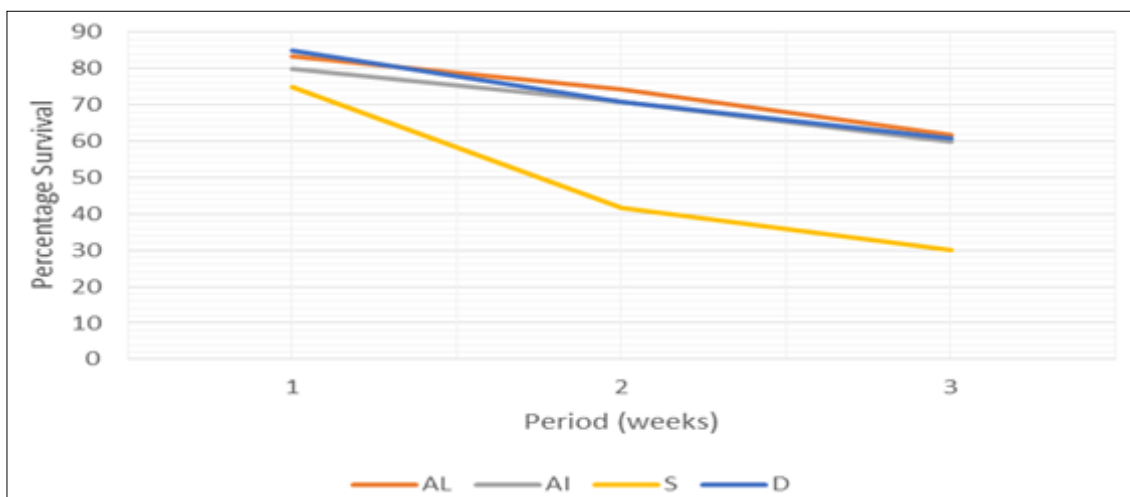


Fig 5: Changes in Survival Rate of *Clarias gariepinus* fed on different diets

Discussion

The proximate composition of the experimental diets used in this study was within the range recommended for fish growth and survival of catfish culture [24, 33], except in the moisture content, in which Shrimp had a significantly higher value.

The values for the water quality in twenty-one days observed in this study were within the range recommended for aquaculture practice [6, 38], except in the static period that the ammonia and nitrite were present in quantities that are threatening to fish health [9, 41]. The presence of ammonia and nitrite could be due to leftover feed decay, and biological activities of the fish larvae and micro-flora within the period of the non-water exchange [19, 40]. After a long time, the presence of ammonia and nitrite has can negatively affect the survival, growth, and mortality in fish fries [38].

The microbiological activities of the various experimental water tanks observed in this study (Table 3) confirmed the presence of varying quantities of the following bacteria: - Total aerobic bacteria and total coliform bacteria. Though not all micro-flora present in fish is found in the fish environment, meanwhile, there is a relationship between the

micro-flora in the fish environment and the fish body [6]. In this study, varying quantities of the above-mentioned bacteria were found in the experimental tanks of all the diets, and this result is in agreement with the report of Anifowose *et al.*, [6] and Daboor *et al.*, [14].

The total aerobic count was higher in all the experimental tanks and this could be as a result of their presence in the water source (Borehole) [28]. The organic matter deposited as a result of uneaten feeds and metabolic activities enhanced their presence and total aerobic bacteria can grow to a level that may be detrimental to the fish and the fish consumer if the ponds are not properly managed [16]. The presence of total coliform bacteria of water tanks observed in this study was fair in qualities and this could be as a result of fish excreta, and favored by the enabling environment [10, 21].

Growth studies on catfish rearing have indicated differences in the performance of various starter feeds for African catfish. Studies emphasized incorporating live feeds as starter feeds for catfish larvae in the weaning protocol for better growth performance [2, 32, 40]. This study illustrated the successful weaning of the catfish fries exclusively on live and artificial

feeds. Three weeks of feeding period with four different feeds on *C. gariepinus* fry showed Durante®, Shrimp, and Artemia affected the growth and survival rates differently within the experimental period. Fish feed, including the larval feed has different components; one of the crucial components is protein. The protein level of any given feed affects the fish growth differently, with the best growth could be as a result of an increase in the protein level of the feed. Though feeds, either live or artificial, have different effects on fish larva concerning growth response^[14]. The growth performance of *C. gariepinus* larvae fed on artificial feed Durante® was better than those fed on Artemia Inve in terms of final weight gain. Artemia Lush® and Inve® fed larvae had higher length gain, weight gain, and growth rate than Shrimp and artificial feed Durante® fed larvae, even though Shrimp and Durante® have higher protein content than Artemia Lush®. The report of Ezechi and Nwuba^[17] stated that an increase in dietary protein could lead to an increase in growth, and it is also in agreement with the report of Ukwe *et al.*,^[37] who stated that Artemia with less protein (48.55%) content had better growth than Aqualis with the higher protein content of (53.74%). This could be as a result of the fact that Artemia as a live feed has its protein properly utilized for growth, as evident in its high protein efficiency ratio^[5, 25], it could also be a result of the fact that the live exogenous enzymes that come with live feeds facilitated digestion in the fry since their digestive system at this stage is poorly developed^[31]. The higher energy content of artificial feed Durante® can also be a factor why Artemia with lower protein content did better than Durante® because the larvae tend to eat less quantity of the feed to be satisfied^[37, 39]. The result of this experiment conforms to the report of Bukola *et al.*,^[11] The fry fed with dried-ground shrimp had the lowest length gain, weight gain condition factor K, and Specific growth rate (Figure 1, 2, 3, 4) despite the feed having the highest crude protein contents of 59.43% (Table 1). This may be attributed to the poor digestibility of dried-ground shrimp, the shell of which has a high level of chitin, and the undigested shrimp diet supplied no nutrient to the fry with the possibility of starvation. The percentage survival was highest in Artemia Lush® fed larvae than in artificial feed Durante® and dried-ground shrimp (Figure 5), and this could be as a result of the stress due to water contamination. Tivkaa and Sampson, Uddin and Al-Harbi^[34, 36] reported that the bacteria flora of pond water was a reflection of the bacteria composition of the skin, gills, and stomach of the *Clarias gariepinus*. In the same vein, Adedeji and Okocha^[1] reported that pond water could be a source of contamination of the catfish cultured in them and it can lead to mortalities.

The survival rate of fry fed with dried-ground shrimp in this study (Figure 5) is in agreement with that of Person^[31] who reported that live feeds promotes survival when compared to formulated diets. But the survival rate of fry fed with artificial feed Durante® in this study (Figure 5) is similar to Ukwe *et al.*,^[37] who reported that Aqualis a commercial diet has survival percentage survival when compared to Artemia as fry feed. The result of the economic analysis is satisfactory. These results show a significant increase in the cost of experimental live diets versus artificial diet Durante®. As shown in Table 4, a reduction in the cost of production of one kilogram of fish is about 20% by using the artificial diet Durante® compared to the live feed Artemia.

Conclusion

The feeding of live and artificial feeds to *Clarias gariepinus* fry within the first twenty-one days produced a similar growth response and survival rate but an artificial diet required

reduced cost while dried-ground Shrimp should not be recommended for feeding *Clarias gariepinus* fry. A Flow-through system is recommended for fry rearing, to avoid the presence of ammonia and Nitrite that can lead to mortality.

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