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ROTIFER (*BRACHIONUS CALYCIFLORUS)* COULD COMPETE FAVOURABLY WITH *ARTEMIA* NAUPLII AS ALTERNATIVE STARTER FOR AFRICAN CATFISH (*CLARIAS GARIEPINUS)*

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Abstract

Background and Aim: *Artemia* nauplii and decapsulated cysts have remained the first choice for the first feeding of fish larvae, under intensive culture. The controlled production of *Artemia* nauplii which creates a dependence on the international cyst market - which is plagued by fluctuating prices, quality stability and high cost of shipping - have tremendously led to the scarcity of *Artemia* to farmers in the rural communities, and also sky-rocketed the cost of production to the very few who can afford it. Therefore, the need to find an alternative larvae starter feed that can compete side by side with *Artemia* nauplii and a sustainable zooplankton rearing technique that is inexpensive, relatively abundant and that can easily be carried out by fish farmers cannot be over-emphasized.

Methods: Four-day old *C. gariepinus* larvae of initial length of 7.84mm and initial weight of 10mg were stocked into plastic aquaria and fed with five different diets: 100 % *Artemia,* 100 % *B. calyciflorus,* 50% *Artemia* + 50 % *B. calyciflorus*, 70 % *Artemia* + 30% *B. calyciflorus* and 30% *Artemia* + 70 % *B. calyciflorus* under ambient hatchery conditions for 35 days.

Results: All growth parameters - Mean total length, Final mean weight, Percentage weight gain (PWG), Specific growth rate (SGR) and Percentage survival of fry were significantly different ($P < 0.05$) at the end of the feeding trial. Fry fed with combined diets performed better in weight and length than fry fed on a single diet. However, the mixture of *B. calyciflorus* at a higher proportion (70 %) and *Artemia* nauplii (30 %) proved to be very efficient in achieving good growth rate and survival index.

Conclusion: Therefore, the authors posited that *B. calyciflorus* can compete favourably, side by side, with *Artemia* nauplii as an alternative starter for fish larvae and fry. The significance of the findings to aquaculture production of African catfish fingerlings are also discussed.

Keywords: Starter feed, catfish, Zooplankton, proximate, growth

INTRODUCTION

Over the past decades, aquaculture has grown in leaps and bounds in response to an increasing demand for fish as a source of protein globally (Robison *et al.,* 2001; Akinrotimi, *et al.,* 2007; Food and Agricultural Organization (FAO), 2012). The African catfish (*Clarias gariepinus*) is a member of the Claridae family and is the most cultured commercial cultured fish in Nigeria which has become a popular choice for aquaculture because of its air breathing characteristics, attractive market price, fast growth, ability to tolerate a wide range of environmental conditions, disease resistance, excellent taste and ease of breeding in captivity (Arimoro, 2007; Adewolu and Adamson, 2011; FAO, 2015). Hence, as a result of this high demand, there is a proportional increase in demand for quantity and quality fingerlings (FAO, 2015). Despite the popularity and demand for *C. gariepinus* by fish farmers and consumers, one of the problems hindering the successful and large scale production of this fish is the unprecedented high rate of mortalities in the early developmental stages of the fry (Ludwig and Lochmann, 2000). According to FAO (2016) reports on the culture of *C. gariepinus*, most of the high mortalities experienced in fish breeding within the first 4 weeks of development are usually associated with the type of feed and feeding techniques used to culture fry. Under aquaculture conditions, fry not properly fed within these early stages of development become stunted and do not attract good market price (Olurin, *et al.*, 2012).

Culturing of the African catfish fry to fingerlings in tanks would allow monitoring of survival, growth and enable culturists to maintain and other growing conditions (Arimoro, 2005). Also, for commercial fingerling producers, it would eliminate the need and stress of involved in harvesting fingerlings from ponds and transporting them to holding tanks before shipping to growers (Ludwig and Lochmann, 2000; Arimoro, 2007)

Research over the years has shown that the use of zooplankton in larviculture has tremendously increased the survival and growth of fish fry. Zooplankton plays a vital role in the food chain of fish as animal food, which supplies amino acids, fatty acids, vitamins and minerals (Ovie, *et al.*, 2003). Successful culturing of most fish fry requires the presence of the smallest zooplankton, mainly rotifers, as fish food (Arimoro and Ofojekwu, 2003). It has also been shown that it is still better for the first feeding larvae of most fish species, since it leads to healthier larval growth (Wang *et al.,* 2005). In spite of different efforts to replace live food by inert feeds, the rearing of fry and juvenile of fishes (especially zooplankton feeders) in nursery ponds mostly depend on the greater abundance of zooplankton (Sulehria *et al*., 2010; Najeeb *et al.,* 2015). According to Rudabeh (2012), most fish and prawn species depend on zooplankton and some even feed exclusively on zooplankton during their entire life. For example, about 90% of herring (*Clupea harengus*) consists of zooplankton (Michele *et al.,* 2006). Zooplankton have been used to rear fry and larvae especially for species which normally do not accept artificial feeds (Akbary *et al.,* 2010; Kibria *et al.,* 2011).

Rotifer a zooplankton, transmits adequate supplies of micro and macronutrients, vitamins and even antibodies to fish larvae (Thomas and Anthony, 2004; Okunsebor,

2014). The level of polysaturated ώ-3 fatty acid in rotifer is believed to affect both survival and growth rate of fish larvae (Koven *et al.*, 2008; Abaho *et al.,* 2016). In freshwater aquaculture, *B. calyciflorus* and *B. rubens* have been used as food for fish larvae and their limited use is probably due to convenient inert food being available to feed freshwater fish larvae (Mostary, *et al.*, 2007). Mass production of *B. calyciflorus, Daphnia pulex* and *Moina micrura* have been used for the improvement of the hatchery production of *Clarias* species and *Heterobranchus* species *(H. longifilis* and *H. bidorsalis),* fry (Okunsebor, 2014). Therefore understanding the unique nutritional needs of larval fish can improve the health, quality and optimal growth of cultured fish particularly in the fry stage. It was against this backdrop this research was designed with the aim of providing feeding alternatives in the production of the cultured *C. gariepinus* using the freshwater rotifer, *Brachionus calyciflorus* – with the ultimate goal of satisfying the ever-increasing demands of *Clarias gariepinus.*

MATERIALS AND METHODS

Experimental Site

This research was conducted at the hatchery unit of Water Resources, Aquaculture and Fisheries Technology (WAFT) department, and the postgraduate laboratory of the Biological Sciences Department - both of Bosso Campus of Federal University of Technology (FUT) Minna, Nigeria.

Larva were fed daily with each of the experimental diets to satiation points usually shown by cessation in feeding, withdrawal and/or resting stage of larva, and non-wagging of caudal fin (Arimoro, 2007; Wang *et al.,* 2005).

Determination of Physico-chemical Parameters

The tanks were monitored daily for temperature, pH, dissolved oxygen, total dissolved solids, conductivity, and ammonia using APHA/AWWA/WPCF (1995) methods.

Determination of the Proximate Analysis of Fry Fed at Different Levels

The Proximate analysis of fry fed at different levels was monitored for moisture, crude proteins, crude lipids, and ash contents using the Kjeldahl digestion methods as described by Ayuba and Iorkohol (2013).

Collection and Preparation of Experimental Foods

Mixed population of zooplankton community comprising rotifers, copepods and cladocerans were collected from a stream at Dutsen Kura bridge, Western By-pass, Chanchanga Local Government, Niger State with a plankton net (50 µm mesh size) and then transferred to the Water Resources, Aquaculture and Fisheries Technology hatchery unit. Larger animals and other unwanted materials and sediments were removed by physical observation and manual selection. Mono-specific culture of the rotifer, *B. calyciflorus,* was achieved by repeated subculture according to the methods described by Okunsebor (2014), adopted with slight modifications. A drop of zooplankton medium was put into several places in a glass slide mounted on a microscope, with a graduated pipette. The various organisms were viewed and identified with a Sony digital camera,

cybershot model 7.2 mounted on Olumpus binocular microscope, while desired organism, *B. calyciflorus* was collected and transferred into a conical flask 'a' containing a borehole water (Okunsebor, 2014; Ovie and Egborge, 2002). After 3 days intensive feeding with a mixture of algae and manure, a dominant population of *B. calyciflorus* appeared in the conical flask then the process was repeated in conical flasks 'b', 'c', 'd' and then'e'. *B. calyciflorus* was cultured using the batch culture method of Arimoro (2006) in plastic tanks of 5 x 10 x 1.5 meters. Mono-specific culture of *B. calyciflorus* was started at 10 rotifers/tank (Arimoro, 2006; Frank, 2002), and algae and manure combinations at different concentrations were fed to the rotifers daily. The culture media was gently aerated using portable battery aerators, (AP – 800 AIR PUMP). The *B. calyciflorus* was mass-cultured by using Algae and filtrate of manure combinations (Arimoro, 2006).

A tin of Vacuum-packed *Artemia cysts* (PRO 80) was purchased from a local supplier and hatched in the hatchery unit of WAFT department of Federal University of Technology, Minna as directed by the manufacturer (Ocean Star International, INC. Snowville, UT. 84336 U.S.A.).

Hatching and breeding of *C. gariepinus* Larvae

The method of larva breeding was carried out with slight modification to Kamthorn (2006) manual for catfish hatchery and production. Gravid female of 2.3kg and a matured male of 2.4kg *C. gariepinus* fishes were obtained from God's Time Farms Nigeria Limited, Gwarimpa, Abuja, Nigeria - a commercial fish farm. The brood stocks were transferred to the WAFT hatchery unit, Bosso Campus, Federal University of Minna and allowed to acclimatize for 2 days before artificial breeding was carried out. The female was injected at 6.00 am with ovaprim (Gonadotropic hormone) at 0.5 ml per kilogram with a 2.00 ml syringe and $1^{1/4}$needle size. The needle was inserted 2.00 cm intramuscularly between angles 30 and 45^{o} of the anterior part of the dorsal fin towards the direction of the tail. After 10 hours of latency period, the female was stripped by applying slight pressure on the abdomen and the eggs were collected in a plastic container. The male was anaesthetized for 3 minutes in quinaldine solution (7 drops quinaldine in 4 liters of water) before the testes was removed and squeezed to let out the milt for fertilizing the eggs. Wet fertilization was carried out by mixing the milt and the eggs in a plastic bowl using a feather and then 300 cc of normal saline water was added to the eggs and mixed for another two minutes. The fertilized eggs contained in bowl were incubated by spreading them on submerged happa netting in a prepared nursery tank and left to hatch for 22 hours. Each hatchery tank was supplied with a network of air tubes and air stones connected to electrical aerators (SBQ 9820) and portable battery aerators (AP – 800 AIR PUMP). After 36 hours of fertilization, the fish larvae were carefully transferred into another nursery tank to avoid fungus and disease that would be easily attracted to egg shells, unfertilized and dead larva.

Stocking of *C. gariepinus* larvae and Feeding with *B. calyciflorus*

On the fourth day after hatching and yolk-absorption, the fry were randomly distributed into 15 plastic tanks with 5 treatments (100% *Artemia,* 100% *B.*

calyciflorus, 50% *Artemia* + 50% *B. calyciflorus*, 70% *Artemia* + 30% *B. calyciflorus* and 30% *Artemia* + 70% *B. calyciflorus*) each and 3 replicates (55cm x 35cm x 25cm) containing 15 liters of dechlorinated tap water to commence exogenous feeding (Okunsebor and Sotolu, 2011). The water in each tank was not exceeded above 12cm to enable surface respiration of fry. Fry were stocked 100 per tank under natural photoperiod regime (Ovie *et al.,* 2007). Each tank was fully equipped with electrical aerators (SBQ 9820) and substituted with portable battery aerators (AP – 800 AIR PUMP) in the cases of power failure. Fry were reared for 5 weeks and fed 4 times daily, between the hours of 8 a.m and 9 p.m with *Artemia* at 5% body weight and *B. calyciflorus* using 50µm size plankton net at a density of 50 individual per ml till satiation (Okunsebor, 2014; Madu and Ufodike, 2001). The water in the nursery tanks was changed with a suction tube daily to maintain a good water quality suitable for fry (Nwadukwe and Ayinla, 2004). Weight and length measurements were taken at 7, 14, 21 and 35 days with a sensitive electronic weigh balance and a translucent calibrated ruler respectively (Ayanwale *et al*, 2014).

Table 1. Different groupings and treatment methods adopted in feeding the fry for 35 days.

Treatments	Groupings
100 % Artemia	Treatment 1
100 % Zooplankton	Treatment II
50 % Artemia + 50 % Zooplankton	Treatment III
70 % Artemia + 30 % Zooplankton	Treatment IV
30 % Artemia + 70 % Zooplankton	Treatment V

Fecundity Analysis

Fecundity of the brood stock was estimated according to Elgamal (2009), and Abdulraheem *et al.,* (2012), where:

Total No of Eggs = 650[*Body weight before stripping* - *Body weight after stripping* (*g*)]

$$\%\ Fertilization\ rate = \frac{\text{Number of Fertilized Eggs}}{Total\ Number\ of\ Eggs\ spread\ on\ kankaban} \times 100$$

$$\%\ Hatchability = \frac{\text{Number of Hatchlings}}{Fertilized\ eggs} \times 100$$

$$\%\ Survival = \frac{\text{Survived hatchlings after 3days}}{Total\ \text{number of hatchlings}} \text{ x } 100$$

Growth Analysis: Length

At the end of every week, 10 fry from each tank were randomly sampled. Each fry was sampled one by one using a piece of fine mesh net and gently placed on blotting paper to absorb the adhering water. The total length was determined by measuring the interval between the mouth to the end of the tail fin. They were individually measured with a graduated transparent meter ruler in millimeters. This method of manipulation and measurement was safe for the fish and they were returned to their respective tanks without any loss (Ayanwale *et al.,* 2014).

Growth Analysis: Weight

The weight of the fry was determined weekly by taking the individual weight of the randomly sampled fry. This was determined by using a sensitive digital compact scale (Model CS 2000 HAUS) - thus:

Weight gain = final weight – Initial weight (mg).

Length gain = final length – Initial length (mm).

$$Percentage\ Weight\ gain = \frac{(W_2 - W_1)}{W_1} \text{ x } 100$$

(Cheikyula and Ofojekwu, 2003; Adewolu, *et al*, 2008).

$$Specific\ Growth\ Rate\ (SGR) = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{T}$$ (Adewolu *et al.*,2008)

$$\%\ Survival = \frac{-S_1}{S_2} \text{ x } 100\ldots$$ (Adewolu *et al*., 2008)

S_1 = No. of fish at the end of experiment

S_2 = No. of fish at the beginning of experiment

where,

W_1 = Initial weight of fish

W_2 = Final weight of the fish

T is the period of experiment in days

Log_e is the base of natural logarithm.

Data Analysis

Data from environmental variables of test tanks, growth and survival of fry under different culture media were subjected to analysis of variance (ANOVA) test. The least significant differences (LSD) at ($p<0.05$) were used to separate the difference of various means using Tukey's multiple range test.

RESULTS

The mean values of the water quality variables of *B. calyciflorus* cultured media is summarized in Table 2. The result showed that the water quality only differed slightly among the various treatments administered. The highest values of dissolved oxygen and biological oxygen demand (BOD) were recorded from the fry that were fed with Treatment V (30 % Arthemia + 70 % zooplankton). Conversely, the highest value of conductivity recorded was from the fry that were fed with 100 % Arthemia (Treatment I). The pH did not vary ($P > 0.05$) among the treatments. However, repeated Analysis of Variance (ANOVA) conducted revealed that temperature, BOD, ammonia, TDS, and conductivity varied significantly ($P< 0.05$) in all the treatments.

The results of fecundity evaluations of the artificial breeding between male and female *C. gariepinus* is presented in Table 3. A total number of 292, 500 eggs were stripped from the female; out of which 85% was fertilized, 96% of the larvae was hatched, and 91% of the fry survived after 3 days of hatching.

Table 2: Some aspects of the water quality variables of the tanks stocked with African catfish fry and fed with the different treatments

Parameters	Treatments				
	I	II	III	IV	V
Temperature (ºC)	27.96±0.74^{d}	27.78±0.15^{b}	27.73±0.08^{a}	27.99±0.10^{e}	27.82±0.14^{c}
pH	7.87±0.08	7.86±0.07	7.86±0.08	7.87±0.04	7.88±0.06
Dissolved Oxygen (mg L^{-1})	5.28±0.19^{a}	5.58±0.10^{b}	6.00±0.03^{c}	6.08±0.04^{c}	6.14±0.07^{d}
BOD (mg L^{-1})	2.19±0.03^{a}	2.30±0.03^{b}	2.40±0.01^{c}	2.49±0.01^{d}	2.72±0.02^{e}
Ammonia (mg L^{-1})	2.84±0.005^{c}	2.14±0.001^{a}	4.92±0.006^{d}	2.14±0.002^{a}	2.74±0.004^{b}
TDS (mg L^{-1})	647.61±0.4^{e}	635.2±0.4^{a}	637.61±0.4^{c}	638.23±0.2^{d}	636.8±0.4^{b}
Conductivity (µS cm^{-1})	258.14±0.3^{c}	252.15±0.2^{a}	262.23±0.2^{e}	256.30±2.4^{b}	260.52±4.4^{d}

Values are means and standard deviation of various treatments of nursery tanks and ranges in brackets
Mean within the same row with different superscript differs significantly (p<0.05).
Treatment I = *Artemia* 100%
Treatment II = Zooplankton 100%
Treatment III =*Artemia* 50%+ Zooplankton 50%
Treatment IV=*Artemia* 70%+ Zooplankton 30%
Treatment V=*Artemia* 30%+ Zooplankton 70%

Table 3: Fecundity Evaluations of *C. gariepinus* male and female Artificial Breeding

Parameters	Number
Total number of eggs	292, 500
% Fertilization	85%
% Hatchability	96 %
% Survival	91%

The mean of total body length (mm) and mean weight (mg) increases in of *C. gariepinus* larva through 35 days rearing period with the different diets is given in Tables 4 and 5, respectively. The order of increase in the length and weight of the larva was similar: Treatment V > Treatment III > Treatment IV > Treatment I > Treatment II. Mean length increases did not show much differences as it ranged from 10.84 mm to 37.42 mm, while wide variation was observed in the range of the mean weight (19.89 mg – 386.73 mg). However, the lowest increase in length in the first 21 days (10.84 mm, 15.89 mm and 21.84 mm, respectively) was observed from Treatment I, which was the treatment that had 100% Artemia. Analysis of Variance (ANOVA) revealed significant differences ($P < 0.05$) in length and weight of the larva raised with the different treatments. However, fry fed with 30% Arthemia + 70% Zooplankton (Treatment V) showed the highest growth rates in terms of length and weight than any other feed combinations, as there was also an uninterrupted, steady length and weight increases in fry fed with 30% Arthemia + 70% Zooplankton (Treatment V) throughout the period of the experiment (35 days). Length and weight increment in the growth of the cultured larva was also linear in all the treatments.

The percentage survival, specific growth rates, and growth performances of the African Catfish larvae fed the different diets is given Table 6. Percentage survival rate was slightly high in all treatments (41. 0 % - 88.0 %). However, higher values (70.00 %, 79.00 %, 71.00 %, and 88.0 %) were reported for fry that were fed any of the diets that contained zooplankton – with the highest value of survival (88.0 %) recorded from larva that were fed with Treatment V (30 % Arthemia + 70 % Zooplankton). Similarly, the highest values of specific growth rates and other growth performance indicators were recorded from the fry that were fed with Treatment V (30 % Arthemia + 70 % Zooplankton). ANOVA showed significant differences in the parameters of growth performance, survival, and specific growth rates for all the treatments.

The proximate analysis of *C. gariepinus* fry fed the different diets for 35 days is presented in Table 7. The range of values of percentage moisture, percentage ash content, percentage crude protein, and percentage crude lipids were 22.17 % to 27.57 %, 1.00 % to 1.01 %, 32.16 % to 39.3 %, and 6.5 % to 9.50 %, respectively. However, the proximate analysis index were generally highest in the fry fed with 100 % Arthemia (Treatmen

Table 4: Mean of total length (mm) increase of *C. gariepinus* larvae through 35 days rearing period with different diets

Days	Treatment I	Treatment II	Treatment III	Treatment IV	Treatment V
0	7.84±0.02	7.84±0.04	7.84±0.02	7.84±0.03	7.84±0.02
7	10.84±0.06^{a}	10.87±0.08^{a}	11.02±0.03^{c}	10.90±0.07^{b}	11.31±0.02^{d}
14	15.89±0.4^{a}	16.05±0.02^{b}	17.10±0.02^{e}	16. 37±0.07^{c}	16.83±0.03^{d}
21	21.84±0.5^{a}	22.65±0.06^{c}	22.46±0.08^{b}	23.03±0.02^{d}	23.29±0.06^{e}
28	29.54±0.02^{b}	28. 89±0.72^{a}	30.37±0.14^{d}	30.01±0.63^{c}	31.64±0.23^{e}
35	32.08±0.14^{b}	31.73±0.11^{a}	35.29±0.06^{d}	34.97±0.03^{c}	37.42±0.24^{e}

Values are means and standard deviation of various treatments
Mean within the same row with different superscript differs significantly (p<0.05).

Table 5: Mean of weight (mg) increase of *C. gariepinus* larvae through 35 days rearing period different diets.

Days	Treatment I	Treatment II	Treatment III	Treatment IV	Treatment V
0	10±0.04	10±0.16	10±0.03	10±0.06	10±0.02
7	19.89±0.18^{b}	19.68±0.02^{a}	20.17±0.16^{c}	22.36±0.21^{d}	24.65±0.24^{e}
14	41.63±0.17^{a}	47.59±0.42^{b}	58.72±0.02^{c}	69.93±0.06^{d}	78.54±0.03^{e}
21	79.48±0.63^{a}	81.19±0.35^{b}	112.28±0.23^{d}	104.31±0.34^{c}	126.37±0.13^{e}
28	117.83±0.04^{a}	102.51±0.42^{b}	189.95±0.77^{d}	156.34±0.34^{c}	206.49±0.24^{e}
35	214.62±0.52^{b}	197.29±0.73^{a}	328.46±0.38^{d}	303.94±0.41^{c}	386.73±0.77^{e}

Values are means and standard deviation of various treatments
Mean within the same row with different superscript differs significantly (p<0.05).

Table 6: Percentage survival, specific growth rates, and growth performances of the African Catfish larvae fed the different diets

	Treatment I	Treatment II	Treatment III	Treatment IV	Treatment V
Final length (mm)	32.08±0.14^{b}	31.73±0.11^{a}	35.29±0.06^{d}	34.97±0.03^{c}	37.42±0.24^{e}
Mean gain in length (mm)	24.24±0.74^{b}	23.89±0.16^{a}	27.45±0.06^{d}	27.13±0.43^{c}	29.58±0.31^{e}
Final weight (mg)	214.62±0.52^{b}	197.29±0.73^{a}	328.46±0.38^{d}	303.94±0.41^{c}	386.73±0.77^{e}
Mean gain in weight (mg)	204.62±0.35^{b}	187.29±0.02^{a}	318.46±0.46^{d}	293.94±0.31^{c}	376.73±0.23^{e}
Specific growth rate (%)	8.76±0.33^{b}	8.52±0.76^{a}	9.98±0.33^{d}	9.75±0.27^{c}	10.44±0.42^{e}
Survival Rate (%)	41±0.02^{a}	70±0.06^{b}	79±0.33^{d}	71±0.34^{c}	88±0.06^{e}

Values are means and standard deviation of various treatments. Initial body length = 7.84 mm, Initial body weight = 10.00 mg. Mean within the same row with different superscript differs significantly ($P < 0.05$).

Table 7: Proximate Analysis of *C. gariepinus* Fry Fed at Different Levels

Parameters	**Treatments**				
%	**I**	**II**	**III**	**IV**	**V**
Moisture	27.57±0.343^{d}	23.27±0.008^{b}	27.70±0.003^{e}	26.29±0.003^{c}	22.17±0.003^{a}
Ash Content	1.01±0.003	1.00±0.003	1.01±0.005	1.00±0.003	1.01±0.005
Crude Protein	39.3±0.02^{e}	35.05±0.04^{b}	37.59±0.30^{d}	32.16±0.04^{a}	36.45±0.02^{c}
Crude Lipid	9.50±0.003^{d}	7.00±0.006^{b}	7.00±0.05^{b}	8.00±0.006^{c}	6.5±0.028^{a}

Values are means and standard deviation of various treatments
Mean within the same row with different superscript differs significantly ($p<0.05$).
Treatment I = *Artemia* 100%
Treatment II = Zooplankton 100%
Treatment III =*Artemia* 50%+ Zooplankton 50%
Treatment IV =*Artemia* 70%+ Zooplankton 30%
Treatment V =*Artemia* 30%+ Zooplankton 70%

DISCUSSION

There were slight fluctuations in the water quality variables of the various tanks. However, these values were well within tolerable ranges for the rearing of larvae of fish (Lubzens *et al.,* 2001; Arimoro, 2007; Ajepe *et al.*, 2014). The results of each treatment were not altered by water quality variables in this experiment since the differences observed within them were without wide variation. The drop in dissolved oxygen in Treatments I and IV compared to the reversed combination (Treatments II and V) might have been due to the disintegration of micro-pellets of *Artemia* nauplii in the freshwater tanks, since *Arthemia* nauplii can hardly last for one hour in freshwater, being a marine organism. The results presented by Ovie *et al.* (2007) on the effect of the quantity of zooplankton on the growth of *H. longifilis* corroborated with this claim. This is also supported by Boeing (1999). The wider variation observed in the significant difference from ammonia concentration of treatment III, especially within the first 2 weeks of feeding in comparison to other treatments, suggested that the digestive system of the fry at the early weeks of development was not strong enough to handle different variety of feed at equal proportions – since it seemed to have coped (digested) very well when one concentration was higher than the other or in a single type of diet. Furthermore, this must have led to the improper digestion and excretion of *Artemia* nauplii and *B. calyciflorus* at the highest combined concentrations (50% *Artemia* + 50% *B. calyciflorus*) in a single treatment. The high increase in ammonia in treatment III also suggested gross selectivity of starter feed by the fry as there seemed to be confusion of which particular feed to feed on, thus, the decomposition of both starter feeds. This could pose unfavorable health conditions and high mortality threats to the fry under intensive/ mass breeding. Even though this effect could be countered by continuous changing of the water or initiating a flow-through system, it is more cost intensive as the starter feeds would be prone to waste and more labourious to the fish breeder as the cost of labour would be increased. The findings in this experiment was in line with Ludwig and Lochmann (2000), who offered only rotifers to fry earlier, and then later trained them to eat other artificial diets in the culturing of sunshine Bass *Morone chrysops* x *M. saxatilis*. This, according to him, was in order to obtain good survival and growth of fry.

Culturing African catfish fry to fingerlings in tanks would allow monitoring of the survival, growth and condition and enable the culturist to maintain optimal temperature and other growing conditions; and for commercial fingerling producers, it would eliminate the need and stress involved in harvesting fingerlings from ponds and transporting them to holding tanks before they are packed for supply (Arimoro, 2007). All the food diets showed great growth capabilities. However, between Treatments I and II (100% *Artemia* & 100% *B. calyciflorus,* respectively), it was observed that from the beginning of the experiment, Treatment II performed better than treatment I in terms of length and weight, until the fourth week (day 28) where it was observed that Treatment I performed better than Treatment II till the end of the research. The observed differences in growth performance of *B. calyciflorus*- fed to the catfish larvae within the first three weeks compared to *Artemia* could be attributed to

the fact that *B. calyciflorus* rotifers offer a much smaller live feed than the size of *Artemia*, and this must have favoured the initial stages of African catfish larvae since the larvae of African catfish themselves are small at hatching. The larvae of African catfish are small at hatching less or equal to 4mg and 7mm in weight and length, respectively (Abaho *et al*., 2016). The small size of this larvae possibly thrives better on small zooplankton, especially rotifers whose ideal size ranges from 50-200 microns (Pronob *et al.,* 2012) compared to decysted *Artemia* cysts whose size range from 200 to 300 microns, depending upon the strain (Granvil, 2000). This size suitability coupled with their relative mobility makes it easier for them to be found and captured as food with lower energetic cost (Ludwig and Lochman, 2000; Gamal and Abd El, 2001; Abaho *et al.,* 2016). In this case, the availability of different prey sizes as the mouth gape of fish larvae undergoes ontogenic development and provides all the possibilities of preferred prey size for the growing larvae (Abaho *et al.,* 2016). This finding suggested that between two alternatives of artificial feed and zooplankton, hatchlings perform better in terms of length and weight when fed with zooplankton as starter feed within the first three weeks of development, after which they can be weaned with the substitute artificial diets. Rotifers are the most important live food organisms for use as starter food for rearing small fish larvae (Awaiss and Kcstemont, 2008); Lubzens *et al.,* 2001). The freshwater rotifer, *B. calyciflorus* is widely used in aquaculture as a live food to raise larvae of many species during the first two weeks of exogenous feeding (Arimoro, 2006). Although these findings were not in agreement with the findings of Madu and Ufodike (2001) who recommended the feeding of hatchling with only *Artemia* nauplii during the first 10 days of life and a mixture of *Artemia*, zooplankton and fish meal thereafter; it was in consonance with the reports of Ovie and Ovie (2006) and Abaho *et al.* (2016) as their research period did not elapse 21 days just before fry matured into fingerlings.

At various levels of combinations of both diets, the best growth performance experienced in treatment V (30% *Artemia* + 70% *B. calyciflorus*) was probably due to the fact that the diet combination met the nutritional demands within the 35 days of the experiment. As suggested earlier that fry performed better with live feeds during their first 3 weeks of development, the composition must have been efficient enough to sustain a steady and consistent growth and thus, created less difficulty for the fry to consume the artificial diets when they were mature enough with increased appetite. The same trend was also evidenced in Treatment III (50% *Artemia* + 50% *B. calyciflorus*), following its record of a high growth performance next to treatment V because of its content of equal proportions of diets. This was followed by Treatment IV with the least growth performance in the combined diets, 70% *Artemia* + 30% *B. calyciflorus*. These results were in agreement with the findings of Arimoro (2005), Ovie *et al.* (2007), and Abaho *et al.* (2016). They individually stated that fry had a better growth performance and survival when fed with a combination of live feed and artificial diets. The findings from this research succinctly pointed out that the quality of starter feed administered to hatchlings within the first 3 weeks of development, determines the growth rate of the hatchling

from fry to fingerling state and also affects the overall survival of the fry.

The percentage survival rates of all the treatments were within acceptable ranges of Alatise *et al.* (2004). However, the percentage survival rate of fry raised on each of the diets that contained the freshwater rotifer, *B. calyciflorus* (70 % - 88 %) was considerably higher those of the fry that were raised on *Arthemia* only (41 %). This is a further proof that freshwater rotifer, *B. calyciflorus,* can be successfully used as a starter feed for the African catfish. The low survival of fry fed with 100% *Artemia* further confirms the claim that fry fed with 100% *Artemia* would experience a high mortality rate because *Artemia* nauplii, which is naturally a salt water organism can survive for only one hour in freshwater due to the differences in salinity, and the subsequent occurrence of haemolysis. This results corroborated the previous studies conducted on burbot larva, *Lota lota* with 69.2 % survival rate (Shirin *et al.,* 2003) and that of African catfish, *Clarias anguillaris* with 62.5 % survival rate (Arimoro, 2007). The high survival rate of fry fed with 100% *B. calyciflorus* clearly demonstrates that there is little or no deleterious effect of using *B. calyciflorus* to feed fry because it is a live food, it does not decompose, it lives longer than artificial feed in the freshwater environment, and has very high level of acceptance and availability.

Generally, fry fed with Treatment I (100 % Arthemia) exhibited the overall highest values of indicators of proximate analyses examined. However, despite the fact that all indicators of proximate analyses were slightly highest in Treatment I compared to other treatments, the latter still performed better in this study. The growth of fish is generally believed to a function of the crude protein level in a diet, yet treatments with lower crude protein performed better than Treatment I with the highest. This may not be unconnected to the fact that *Artemia* has a higher percentage crude protein content of 45 % compared to *B. calyciflorus* which has percentage crude protein content of 38.6 % (Arimoro, 2005). This may also be attributed to the fact that catfish larvae may not necessarily require about more than 30 crude protein for optimal growth, since all the treatments supported relatively high growth rates. National Research Council (NRC, 2000) recommended that crude protein requirement of fish larvae for optimal growth should not be more than 52 %. Similarly, Ajepe *et al.* (2014) stated that crude protein requirement for optimal growth was not more than 58.8 % as observed from his research. It has also been reported that the dietary needs of fish for efficient growth is a function of feeding the possible best diets at levels not exceeding the dietary needs (Aderolu *et al.,* 2010; Ajepe *et al.,* 2014). Lipid requirements for catfish rarely exceeds 6 % (Lubzens *et al.,* 2001; Ajepe *et al.,* 2014). Therefore, the higher value of lipid contained in fry fed Treatment I is not necessarily of any significant advantage. The higher value of the percentage moisture recorded at Treatments with higher proportions of *Arthemia* suggested that fry fed with artificial diets tend to have a high moisture content than fry fed with zooplankton. This could account for the difference in taste between fishes fed under intensive aquaculture conditions and fishes that bred in the wild.

Even though fry fed with 100% *artemia* had the best proximate analysis, it cannot be recommended to fish farmers and

breeders because of the risks and high mortality associated with the diet as it recorded the lowest survival rate during this experiment. A fish that is of high nutritional value but has a low chance of survival is a potential loss and a waste of resource to the fish farmer.

Conclusion and Recommendations

It can be inferred that *Brachionus calyciflorus* possesses great potential as natural starter food for the first three weeks, as it enhances growth and survival more than the use of *Arthemia* -since survival is of utmost importance for any successful freshwater larviculturist. However, *Arthemia* can be introduced after three weeks to sustain better growth rates in the fry as it transcends to fingerlings. Furthermore, the survival rates of fry fed with *Arthemia* basically are very low due to the disintegration of micro-pellets of *Artemia* that reduces the water quality of the nursery tanks.

The benefits of the findings of this research to freshwater larviculturists cannot be over-emphasized, especially in the areas of improving larval performances and increased yields – since *Brachionus calyciflorus* has small size; slow mobility that encourages faster catch; is a freshwater in nature with high levels of acceptance and availability; is cost effective, among others.

Authors' Contributions:

UNK, FOA, and AVA designed the study**. IAO** did the sample collection and analysis while **UNK and AVA** managed the literature searches. **UNK and FOA** performed the statistical analysis and wrote the draft of the manuscript. All authors read and approved the final manuscript.

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