Sjournals
Scientific Journals
Scientific Journal of Zoology (2013) 2(6) 54-63
ISSN 2322-293X

Contents lists available at Sjournals
SCIENTIFIC JOURNAL OF ZOOLOGY
Journal homepage: www.Sjournals.com

Original article

Survival and growth of C*larias gariepinus* (burchel 1822) fry on cultured freshwater zooplankton and decapsulated *Artemia*

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ARTICLE INFO

Article history:
Received 29 May 2013
Accepted 10 June 2013
Available online 29 June 2013

Keywords:
Spawning
Dried zooplankton
Feed conversion
Condition factor

ABSTRACT

Artemia and dried zooplankton were fed to four day-old *C. gariepinus* fry at 3% and 5% feeding rates each as first feed. Dietary treatments were in triplicate, in a completely randomized design. Composition of mix-cultured zooplankton showed *Rotifera* (53.12%) to be dominant. Spawning with ovaprim at 0.5% ml/kg recorded 76% fertilization and 79% hatchability at temperature range of 28 to 30^{0}C. The best percentage survival (70.00 ±12.77) was obtained for larvae fed zooplankton at 3% feeding rate. Fry fed *Artemia* at 5% feeding rate, recorded specific growth rate of 12.68 ±0.64, which was significantly ($P < 0.05$) higher than other three treatments. The condition factors ranged from 3.32 ± 0.09 to 1.73 ± 0.71 and were not significantly different ($P > 0.05$). Feed conversion ratio was best (0.31 ±0.09) in fry fed zooplankton at 3% feeding rate, and no significant ($P > 0.05$) difference between the treatments. Water temperature ranged from 26.85^{0}C to 29.05^{0}C pH 7.71 to 7.83. Fry fed dried mixed-freshwater zooplankton diet had highest survival rate and the best growth rate obtained for fry fed *Artemia*. It was therefore concluded that *Clarias gariepinus* fry can be fed dried mixed-cultured freshwater zooplankton in event of scarcity and un-affordability of decapsulated *Artemia*.

1. Introduction

A major prerequisite for successful *C. gariepinus* aquaculture enterprise is a reliable and consistent source of fish seeds (fingerlings) of commercially important species (Nwuba and Aguigwo, 2002). According to Abayomi *et al.* (2010), the need for the production of quality fish seed for stocking artificial ponds and natural water bodies has been steadily increasing, and hatchery produced seed through artificial propagation constitute the only practicable means of producing enough quality fish seed.

In the hatchery system, the development of embryos and newly hatched larvae (fry) is the most sensitive and delicate of the development stages in the life history of a fish (Craig and Frank, 2000). Therefore, great care must be taken to provide them with the proper incubation and hatching environment. More so (Ezechi and Nwuba, 2007) state that one of the major challenges in fish hatchery management is the provision of adequate and appropriate food for fish hatchlings and the success of fish hatchery operations all over the world is intricately linked to the ready availability and supply of natural food, notably zooplanktonic organisms (Uhlig, 1980). In Nigeria, most fish hatcheries depend on imported *Artemia* for their operation due to the difficulty in raising sufficient live freshwater zooplankton for hatchery use (Ovie *et al.,* 1993). It could be possible to substitute the use of *Artemia*, which is not only costly to import but also tends to reduce profit margin of fingerlings production in fish hatcheries. This could be achieved by developing a means of mass culturing and processing of freshwater zooplankton for feeding fry. Therefore, the knowledge of comparative advantage of the use of dried mixed cultured freshwater zooplankton over *Artemia* is likely to help in raising the survival rate of *C. gariepinus*. In view of this importance, this study examined the major groups of zooplankton present in mixed cultured zooplankton, its proximate composition and the opportunity costs of feeding the dried mixed cultured zooplankton and *Artemia* at different feeding rates to *C. gariepinus* fry in terms of survival and growth rates.

2. Materials and methods

The spawning and feeding experiments were conducted at the Fish Hatchery of the Department of Forestry and Fisheries on latitude 13^0 07' 78''N and longitude 05^0 12'25''E at 275m above sea level (Google Earth, 2011), at the permanent site of Usmanu Danfodiyo University, Sokoto, Nigeria. The zooplankton production was carried out at the Natural Food Production Section of the fish hatchery complex of National Institute for Freshwater Fisheries Research (NIFFR) New-Bussa, Niger State, Nigeria.

2.1. Zooplankton culture and flakes production

The zooplankton was cultured by using loamy soil to form bottom sediment; cow dung was used by fermentation method to fertilize the medium and to promote algal bloom on which the zooplankton feed (Okoye, 1996). Zooplankton was then trawled and concentrated with scoop net of 153µm mesh size from fish holding ponds, and 1ml of the sample was taken and treated with 4% formalin to preserve the samples. The species in scooped population was identified under an inverted Kyowa electronic microscope (Model XSZ-21) using the taxonomic guide of Jeje and Fernando (1988). The zooplankton composition identified in the untreated sample was inoculated into the culture tanks. At about 7-8 days, the inoculated zooplankton reached the peak of their population density and was due for harvest (Ovie *et al.,* 1993). Zooplankton estimation was carried out following the procedure in Moody (2001). The sample harvested was spread along the perimeter of a white cloth and dried in the sun. The sun-dried sample was scraped from the cloth in flakes form and was packed in plastic satchets before use for feeding trial. The proximate composition of the dry flakes was determined by the AOAC (1990) method. The processed *Artemia* used for feeding trial was a marine copepod zooplankton produced into decapsulated form by INVE Aquaculture Inc., USA.

2.2. Spawning experiment

Mature gravid *C. gariepinus* brooders (male and female) were collected from concrete fish ponds at the study site. Selection was made based on the protocol of Viveen *et al.* (1985). The brooders were weighed prior to hormonal injection with ovaprim at 0.5 ml/kg of gravid female. The latency period was observed by taking note of the time of injection and of stripping, and then milt collection, fertilization and incubation were done according to the procedure of Viveen *et al.* (1985).

2.3. Feeding experiment

Decapsulated *Artemia* and dried mix-cultured zooplankton, each fed at 3% and 5% of fry body weight, constituted the four treatments of the experiment, and each treatment was replicated three times in a completely randomized design (CRD). Twelve 30litre capacity plastic bowls (experimental unit) were used for the feeding experiment, with 100 larvae stocked in each. The initial weight and standard length of the fish for each experimental unit were measured using JT 210N series electronic top loading balance of two digits and a plastic ruler (cm). The proximate composition of the diets is illustrated in Table 1. The flaked mix-cultured zooplankton was mixed in a petri-dish with water before feeding, while the *Artemia* was fed directly. Feeding each group was thrice daily, in the morning (7:00-8:00am), afternoon (1:00-2:00pm), and evening (6:00-7:00pm). Remains of feed were siphoned out of the culture medium before feeding and same quantity of water removed during siphoning was replaced immediately. Total renewal of whole water was done every three days, and the bowls bottoms were scrubbed to remove dirt from the medium. The survival and mortality rates were monitored on daily basis. The weight and the total length of the fry were taken at intervals of 7 days. Two water quality parameters (pH and temperature ^{0}C) were monitored in the morning, afternoon and evening daily

2.4. Data analytical tools

Data collected on number of eggs spawned, percent fertilization, percent hatchability, survival rate, body weight and length, feed fed, water temperature and pH were analyzed as follows;

The total number of eggs spawned (Spawning fecundity) was estimated using the equation for estimation of the fecundity of *Clarias lazera* by Hogendoorn (1979);

Total number of eggs= 66.6 × difference in female body weight before and after spawning.

Relative fecundity (RF) was determined according to the method of De Kimpe and Micha, (1974):

$$RF = \frac{Total\ number\ of\ eggs}{Body\ weight\ (g)}$$

The percent fertilization was estimated from the number of unfertilized eggs by the equation: % Fertilization $= \frac{N-n}{N} \times 100$ (Hogendoorn, 1979).

Where N = total number of eggs spawned

n = number of unfertilized eggs

Hatchability was determined from the direct data count of numbers of hatchlings at one day old (NACA, 1989), as follows:

$$\text{Percent hatchability} = \frac{Numberof\ \ hatchelings\ \ (one\ \ day\ \ old)}{Total\ \ numbers\ \ of\ \ fertilized\ \ \text{eggs}.} \times 100$$

Percent Survival Rate (S) was calculated (NACA, 1989) as:

$$S\ \% = \frac{number\ \ of\ \ fry\ \ stocked\ \ at\ \ the\ \ beginning\ \ of\ \ the\ \text{exp}eriment}{number\ \ of\ \ fry\ \ alive\ at\ the\ end\ \ of\ \ the\ \ \text{exp}eriment} \times 100$$

Weight Gain (WG) and Percent Weight Gain (PWG), were computed following the procedures as in Sveier *et al.*, (2000):

(WG) = Final weight (g) – Initial weight (g)

$$PWG = \frac{Final\ \ weight\ \ (g)\ \ -\ \ Initial\ \ weihgt\ \ (g)}{Initial\ \ weight} \times 100$$

Specific Growth Rate (SGR), was calculated as described by Castell and Tiewes (1980):

$$SGR\ \% = \frac{\log_e w - \log_e i}{time\ (\text{days})} \times 100\text{, where}$$

Log_e = Natural logarithm
W_i = initial weight (g) of fish at the beginning of experiment.
W_f = final weight (g) of fish at the end of the experiment.
Feed Conversion Ratio (FCR) and Food Efficiency (FE), were computed as in NACA (1989):

$$\text{FCR} = \frac{Diet\ fed\ (g)}{Weight\ gained\ (g)}$$

$$\text{FE} = \frac{Weight\ gain\ (g)}{Feed\ consumed (g)}$$

Condition Factor (K)
Condition Factor (K) of the fry was calculated following the procedure of Bagenal and Tesch (1987)

$$\text{K} = \frac{100W}{L^3}$$

Where
W = weight of fish (g)
L = standard length of fish (cm).

2.5. Statistical analysis

Data collected on growth, survival and feed utilization were subjected to analysis of variance (ANOVA) and means were separated using New Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984). Computer analysis was carried out using the SPSS Version: 16.0 (2007) package for windows.

3. Results and discussion

The groups of zooplankton identified in the mixed culture are shown in Table 2. A total of ten zooplankton types were identified, of which three, two, and five types were *Cladocerans, Copepods* and *Rotifera,* respectively. *Rotifera* was the most abundant and diverse (53.12%) followed by *Cladocerans* (40.33%) while the *Copepods* (6.55%) were the least. Abundance and diversity of *Rotifera* could be as a result of the short reproductive cycle (3.5 days) they exhibit as in (Allan, 1976).

The proximate composition of the dried mix-cultured zooplankton, as presented in Table 1, revealed crude protein (crude protein) content of 41.65% which was less than 54% crude protein of the decapsulated *Artemia* (Table 1). The ash concentration was higher in mixed-cultured zooplankton (24%) than in the decapsulated *Artemia* (4%). The zooplankton flakes were brownish in colour and exuded fishy odour. The crude protein (41.65%) of the dried mixed-cultured zooplankton was above the recommended baseline protein level (20% crude protein) in fish feed (FAO, 1980), but less than the crude protein of the decapsulated *Artemia* (54%) used for comparison. The crude protein level recorded in the dried mixed-cultured zooplankton could be as a result of the mixed species composition of the zooplankton, the culture medium, and the dry nature of the sample analyzed. Ovie and Ovie (2006) reported higher crude protein content of 52.4%, 54.3% and 50.3% in *Moina micrura, Diaphanosoma excisum* and *Brachionus calyciflorus,* respectively, and Watanabe *et al.* (1983) reported 49.7 to 79% depending on culture medium for *Moina australis*. Mitra *et al*. (2007) reported that the protein of fresh mixed-zooplankton varied from 73 to 80% crude protein when cultured in earthen ponds, which are higher than 41.65% crude protein of dried mixed zooplankton obtained in this study. The mixed–cultured zooplankton in this study was dominated by members of the *Rotifers* and *Cladocerans* with little *Copepods.* The variation in the crude protein contents of these zooplankton species might have accounted for the lower crude protein recorded compared with the crude protein reported in single species. Ako *et al.* (1991) reported that larval fish require higher protein content above 45%, this is higher than the protein content of the zooplankton used in the present study.

The results of induced spawning of *C. gariepinus* using Ovaprim hormone are presented in Table 3. The average weight of the female broodstock was 695g, the quantity of Ovaprim yield was 0.35ml, the total weight of ovulated eggs was 32.64g, and the estimated number of eggs was 9,663, while the fertilization and hatchability were 76% and 79%, respectively. The fertilized eggs were spherical, adhesive and stick to the spawning mat, and the latency period was 9 hours at an average temperature of 28±0.71^{0}C. The incubation period was 23 hours at average temperature of 30±1.73^{0}C. This supports the finding of Viveen *et al.* (1985) that female *C. gariepinus* of 500g is gravid for spawning, and the percent hatchability is similar to the findings of Madu (1986) who recorded good hatchability of *C. gariepinus* within 24 hours at a temperature between 30 and 32^{0}C.

The results (Table 4) showed higher percent survival (70.00±12.77) in fry fed zooplankton diet at 3% feeding rate, followed by (59.67±0.70) those fed diet zooplankton at 5% feeding rate, but both were not significantly different (P>0.05) from the survival of fry fed *Artemia* at 5% feeding rate. The survival rate of fry fed diet containing 3% *Artemia* was significantly (P<0.05) lower than those fed zooplankton at 3% and 5% feeding rates. The low survival rate of fry recorded in this experiment may be attributed to the type of feed used and effect of temperature. It has been reported that the growth and survival of fish fry are enhanced when fed live forms of plankton (Ovie, 2003; Ojutiku, 2008; Adeyemo *et al.* 1994). This could be because of their easy availability, high reproductive potential, short generation time, preference for moving live feeds that attracts fry sight to natural foods (Dabrowski, 1984); and high nutritional quality in providing adequate essential amino and fatty acids to the young growing fish. Other qualities of natural foods such as suitable size that is smaller than the mouth diameter of the fry enable easy handling and ingestion (Oyero *et al.,* 2009). The tenderness and fragile nature of the fry observed during the course of weight and length measurements could have also resulted to stress and high mortality rate. The better survival rate recorded for the fry fed dried-mixed cultured freshwater zooplankton may be as a result of the feeding with freshwater zooplankton in accordance with (Ovie and Adeniji, 1990).

The results of the growth indices (Table 4) showed that fry fed *Artemia* at 5% feeding rate recorded significantly (P<0.05) higher weight gain (0.05±0.01) and % weight gain (1341.10±186.3) than other dietary treatments. The lowest final weight values were recorded in fry fed zooplankton at 5% feeding rate, but these were not significantly (P>0.05) different from those fed the *Artemia* and zooplankton at 3% feeding rate. The SGR (12.86±0.64) of fry fed dietary treatment containing *Artemia* at 5% feeding rate was higher, but not significantly different (P>0.05), from that of dietary treatment (10.50**±**14.29) containing *Artemia* at 3% feeding rate. The SGR of fry fed various rates of the zooplankton diet at the two feeding rates and the group fed diet containing *Artemia* at 5% feeding rate were not significantly different (P>0.05). The trend of fry weight increase over time (Fig.1) revealed that fry fed *Artemia* had the best growth increase than those fed mixed zooplankton. Earlier study by Oyero *et al*. (2009) found that fry fed decapsulated *Artemia* had better growth rate than those fed liqui-fry. The low growth rate recorded by the fry fed zooplankton could be attributed to lower crude protein content and low digestibility of the dried mixed-zooplankton (Table 1). Hogendoorn and Vismans (1980) attributed poor growth performance of *Clarias lazera* larvae on artificial diet to poor digestion of the dry feed concentrate. The crude protein and lipid contents of the zooplankton were below the minimum of 45% crude protein and 18.5%, respectively required by *Clarias gariepinus* larvae (Uys, 1989). Also, the crude protein of the mixed-cultured zooplankton was lower than that of the *Artemia.*

In this experiment, fry fed *Artemia* at 5% significantly (P<0.05) performed better in terms of growth than those fed *Artemia* at 3% feeding rates; this suggests preference for the former in feeding fry. The findings also indicate that it is better to feed fry with dried freshwater zooplankton at 3% body weight than 5% body weight (Table 4). It was observed during the course of the experiment that, in the four dietary treatments with zooplankton, the remains of uneaten particles settled at the bottom of the water, most probably due to low feed consumption. This could have contributed to the relatively poor growth recorded.

The results of the condition factor, as presented in (Table 4) showed that fry fed dietary treatment with *Artemia* at 5% feeding rate had higher (3.32±0.09) value than those on dietary treatments. However, there was no significant (P>0.05) difference among the four treatments. The feed conversion ratio (FCR), (Table 5) was better (0.31±0.09) in fry fed *Artemia* at 3% feeding rate, followed by (0.34±0.16) that of diet containing zooplankton at 3% feeding rate. The worst FCR was recorded in dietary treatment containing zooplankton at 5% feeding rate with no statistical significance (P>0.05). This shows that the fry fed dried mixed culture freshwater zooplankton competed favourably with those fed *Artemia.*

The water temperatures and pH during the period of the experiment (Table 6) revealed that the morning, afternoon and evening temperature varied from 28.4 to 25.3^{0}C, 30.3 to 27.8^{0}C and 29.8 to 27.4^{0}C with mean

values of 26.85±1.55^{0}C, 29.05±1.25^{0}C and 28.60±1.20^{0}C in that order. The overall mean temperature value during the experiment was 28.2±0.30^{0}C. The pH values in the morning, afternoon and evening ranged from 7.41 to 8.00, 7.56 to 8.10 and 7.56 to 7.92 with mean values of 7.71±0.30, 7.83±0.27, and 7.74±0.81, in that order. The overall mean pH value was 7.76±0.25. The results of the water quality parameters monitored were within desirable ranges for survival and growth of fishes when compared with temperature range of 25^0-30^{0}C (Adeniji, 1987; Viveen *et al*., 1985) and pH of between 6.7 and 8.6, considered adequate for freshwater fish culture.

Table 1
Proximate composition of the dried mix-cultured zooplankton and decapsulated *artemia.*

Parameter	% Composition	
	Dried mixed cultured zooplankton	***Artemia****
Ash	24.0	4
Lipid	10.0	9
Fibre	4.0	6
Crude protein	41.65	54
N.F.E	20.35	5%max.

*(*Artemia*) INVE Aquaculture Inc. USA.

Table 2
Zooplankton diversity and estimated abundance in the culture media.

Taxonomic Group	(Tank 1)	(Tank 2)	Overall	% composition
Cladocerans				
Moina sp.	12.81x10^7	74.2x10^6	20.23x10^7	29.58
Diaphanosoma sp.	25.2x10^6	37.8x10^6	63.0x10^6	9.21
Bosmina sp.	42.0x10^7	6.3x10^6	10.5x10^6	1.54
Sub total	15.75x10^7	11.83x10^7	27.58x10^7	40.33
Copepodites				
Cyclopoida sp.	18.9x10^6	70.0x10^4	19.6x10^6	2.87
Calanoida sp.	21.0x10^5	23.1x10^6	25.2x10^6	3.68
Sub total	21.0x10^6	23.8x10^6	44.8x10^6	6.55
Rotifera				
Brachionus sp.	73.5x10^6	94.5x10^6	16.8x10^7	24.56
Asplanchna sp.	11.13x10^7	35.7x10^6	14.7x10^7	21.49
Keratella sp.	63.0x10^5	-	63.0x10^5	0.92
Filinia sp.	21.0x10^5	-	21.0x10^5	0.32
Lecane sp.	84.0x10^5	31.5x10^6	39.9x10^6	5.83
Sub total	20.16x10^6	16.17x10^7	36.33x10^7	53.12
Total	38.01x10^7	30.38x10^7	68.39x10^7	

4. Conclusion

It has been shown from the results obtained in the survival and growth of *C. gariepinus* on *Artemia* and mixed-cultured zooplankton experiment that there was higher growth rate (P<0.05) in terms of weight gain, specific growth rate and percent weight gain of fry fed 5% *Artemia* diet compared to those fed 3% *Artemia* and mixed-cultured zooplankton at 3% and 5% feeding rates. However, in terms of feed intake, feed conversion and survival rate, fry fed dried mixed-cultured zooplankton competed favourably with those fed *Artemia* (P>0.05). It is

therefore concluded that *C. gariepinus* fry can be fed dried mixed-cultured freshwater zooplankton in event of scarcity and un-affordability of decapsulated *Artemia*.

Similarly, the results have shown that it is preferable to feed *C. gariepinus* fry with *Artemia* at 5% feeding rate than at 3% and when feeding fry with dried mixed-cultured freshwater zooplankton, it is preferable to feed at 3% feeding rate. The use of dried mixed-cultured zooplankton provides option for fry rearing as it could easily be made locally available compared to *Artemia* that is imported, costly and scarce and could also reduce importation and conserve foreign exchange earnings.

Table 3
Summary of induced ovulation and spawning of *clarias gariepinus* using ovaprim hormone.

Parameter	Quantity/Quality
Average male brood body weight (g)	1400
Average female brood bodyweight (g)	695
Female broodstock weight after stripping (g)	558.9
Difference in female body weight before and after stripping (g)	145.1
Quantity of hormone induced (ml)	0.35
Latency period (Hour)	9
Total weight of ovulated egg (g)	32.64
Nature of egg ovulated	Mature (greenish colour)
Spawning Fecundity	9664
Relative fecundity	13
Fertilization (%)	76.6
Incubation period (Hour) Estimated number of hatchlings	23 7404
Hatchability (%)	79
Fry average survival (%)	67
Water temp. during latency period (^{0}C)	28±0.71
Mean water temp. during incubation (^{0}C) Mt=29±2.0^{0}C	30±1.73
At=32±0.6^{0}C Et= 28±0.61^{0}C	

Mt=morning temperature, At= afternoon temperature, Et=evening temperature

Table 4
Growth performance of *clarias gariepinus* fry fed mixed-cultured zooplankton and *artemia.*

Parameter	Diet/Treatment			
	Artemia		Zooplankton	
	3%*Art*	5%*Art*	3%Zoo	5%Zoo
Experiment period (days)	21	21	21	21
Total initial fish number	300	300	300	300
Total final fish Number	51	105	210	179
Percent survival rate	17.00±16.37^b	35.00±31.58^{ab}	70.00±12.77^a	59.67±19.86^a
Average initial weight (g) Average	0.0047±000	0.0043±0.00	0.0040±0.00	0.0047±0.00
Final weight (g)	0.043±0.01^b	0.063±0.01^a	0.029±0.00^b	0.028±0.01^b
Mean weight gain (g)	0.04±0.01^b	0.05±0.01^a	0.03±0.00^b	0.02±0.01^b
Mean percent weight gain	833.65±274.1^b	1341.10±186.3^a	636.18±103.27^b	514.20±241.3^b
Mean specific growth rate (%/day)	10.50±14.29^{ab}	12.68±0.64^a	9.47±0.70^b	8.40±1.85^b
Mean initial length (cm)	0.51±0.03	0.53±0.02	0.54±0.04	0.51±0.03
Mean final length (cm)	1.37±0.14	1.38±0.30	1.00±0.05	1.03±0.23
Mean length increase (cm) Mean	0.86±0.16^a	0.85±0.29^a	0.46±0.06^b	0.52±0.20^{ab}
percent length increase	169.6±37.2^a	158.9±51.4^a	85.5±13.9^b	99.8±32.5^{ab}
Condition factor	1.73±0.71	3.32±0.09	2.99±0.74	2.71±1.12

*Means with same letters in row are not significantly different (P>0.05).

Table 5
Feed utilization ratio of *clarias gariepinus* fry fed mixed-culture zooplankton and *artemia.*

Parameter	Diet/Treatment			
	Artemia		Zooplankton	
	3%*Artemia*	5%*Artemia*	3%Zooplankton	5%Zooplankton
Experiment period/day	21	21	21	21
Mean quantity of feed fed (g/day)	0.01±0.00[b]	0.02±0.00[a]	0.01±0.00[b]	0.01±0.00[b]
Feed conversion ratio	0.31±0.09	0.35±0.06	0.34±0.16	0.51±0.10
Gross feed conversion efficiency (%)	323.43±78.5	293.8±47.0	340.20±130.7	199.08±35.1
Feed efficiency (g)	3.32±0.79	2.94±0.48	3.4±1.31	1.99±0.35

Means in rows having same letters are not significantly different (p>0.005).

Table 6
Water temperature and ph during experiment on growth and survival of fry on zooplankton and *artemia.*

Parameter		Morning	Afternoon	Evening	Overall mean
Temperature (^{0}C)	Minimum	25.3	27.8	27.4	26.83±1.34
	Maximum	28.4	30.3	29.8	29.50±0.98
	Mean (±SE)	26.9±1.55	29.1±1.25	28.6±1.20	28.2±1.89
pH	Minimum	7.41	7.56	7.56	7.51±0.09
	Maximum	8.00	8.10	7.92	8.01±0.09
	Mean (±SE)	7.71±0.30	7.83±0.27	7.74±0.18	7.76±0.35

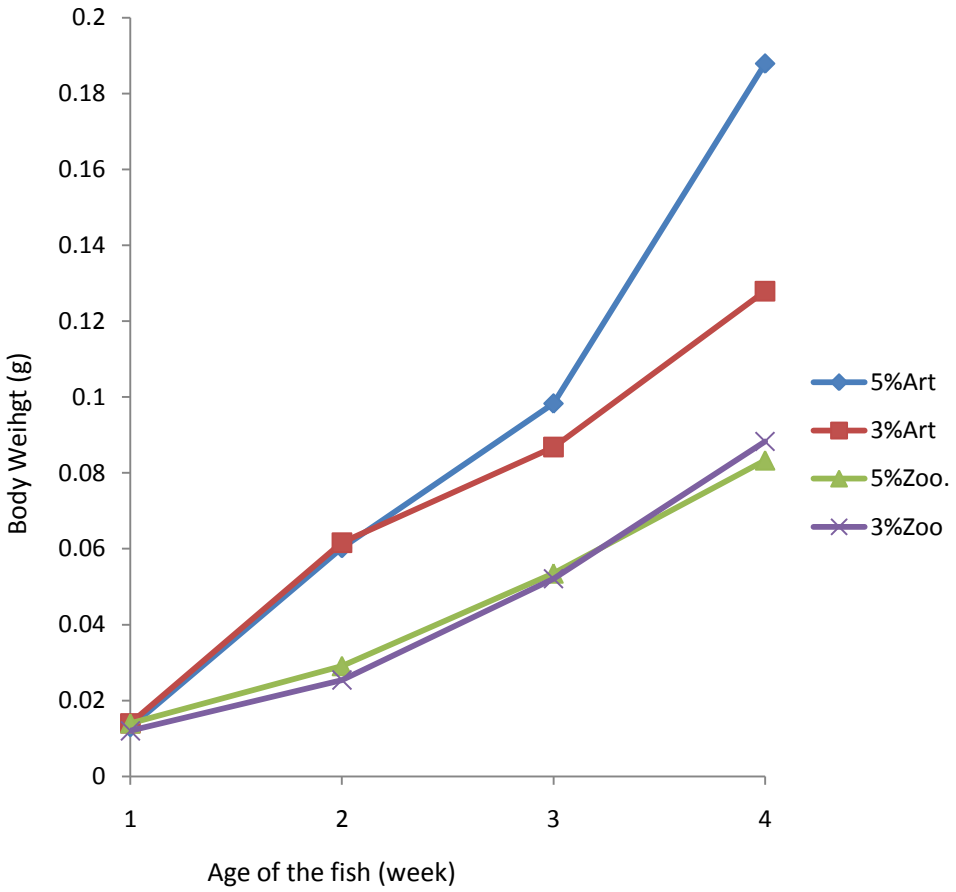

Fig. 1. Growth of *C. gariepinus* fry fed *artemia* and zooplankton.

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