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EFFECT OF ZOOPLANKTON FEEDING FREQUENCY ON THE GROWTH AND SURVIVAL OF THE AFRICAN CATFISH, *CLARIAS GARIEPINUS* (BURCHELL, 1822) EARLY LARVAE

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ABSTRACT: Compared to other fish species, *C. gariepinus* fry needs quality live food after hatching and resorption of the yolk sac. An imported and costly *Artemia* cyst has been used as a source of live food for *C. gariepinus* hatcheries in Ethiopia. But imported *Artemia* cyst is very costly and cannot be afforded to sustain small scale hatchery business. An experiment that used local zooplankton species as a source of live food was conducted to determine whether it could be a replacement and its performance for growth and survival of *C. gariepinus* larvae. Local zooplankton groups from Lake Tana were inoculated and multiplied in zooplankton culture ponds fertilized with commercial fertilizer. Larvae with mean weight of 23 mg were stocked in 50 l aquarium at a stocking density of 2 larvae/l. Zooplankton were provided for larvae at a rate of 5 individuals/ml at a stocking density of 20 larvae/l. Four different feeding frequencies (twice a day, 3x, 4x and 5x a day) were compared. Catfish larvae provided with zooplankton at a feeding frequency of four times a day showed 152.8 mg final weight, 18.91±0.38 mg daily weight gain, 27.2±0.1%/day SGR and 95.33±4.6% survival rate. The result was significantly higher ($p<0.05$) compared to the other treatments (feeding frequencies). This experiment clearly indicated that zooplankton multiplied in ponds can effectively be used as source of live food and result in better performed *C. gariepinus* larvae when provided at a feeding frequency of four times a day.

Key words/phrases: Cladocera, Copepoda, Diversity, Fertilizer, Live food, Multiplication pond, Rotifera.

INTRODUCTION

The African catfish, *Clarias gariepinus* larvae require a more precise and conscientious care and all the essential requirements such as adequate rearing device, nearly saturated oxygen level, suitable temperature, removal of waste matter, control of enemies, health management and external food.

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Lack of suitable food and improper hygiene are believed to be the main causes of mortality of the larvae of *C. gariepinus*. Compared to other fish species, after hatching and resorption of the yolk sac, *C. gariepinus* fry cannot rely on formulated feed directly (Verreth *et al*., 1992; Tocher, 2010). The larvae start feeding approximately 3–4 days after hatching (depending on temperature) and therefore is normally transferred into well prepared and protected nursery ponds or aquaria (Hecht, 2013).

During the onset of exogenous feeding, *C. gariepinus* larvae require live food such as *Artemia nauplii*, yeast, unicellular algae, rotifers, copepods, cladocerans as the most appropriate starter feeds because the larvae have difficulty in assimilating dry formulated diets due to the incomplete development of the digestive system (Kolkvoski, 2001). Feeding live zooplankton from nearby fresh water fish ponds seem to be the most reliable technique for Ethiopia since importation of *Artemia* cyst is very costly to purchase and import. Rather, waterbodies in the tropics are rich in diversity of important zooplankton used as live food (Abaho *et al*., 2016) and easy to multiply. Furthermore, microcrustacean zooplankton in Lake Tana constitutes a major component of the food chain on which the copepods and cladocerans contributed the majority of the crustaceans (Eshete Dejen, 2003; Ayalew Wondie, 2006; Imoobe and Akoma, 2008).

Research has shown that live food like small *Daphnia*, *Moina* or other zooplankton of suitable size are good sources of freshwater live food essential for the first 4 to 6 days after the start of exogenous feeding (Awaiss and Kestemont, 1998; Haylor, 1993; Hecht, 1996; Olojo *et al*., 2003). The reason for this is that the stomach of the larvae is not functional at the start of exogenous feeding (three days after hatching), and its development extends beyond the eleuthero-embryo stage into the larval stage. The stomach only becomes functional 5 to 7 days after the start of exogenous feeding (Verreth *et al*., 1992; Segner *et al*., 1993; Hecht, 2013). Once the stomach becomes functional and pepsin activity contributes significantly to protein digestion, the larvae can be weaned from live food to a dry feed (Verreth *et al*., 1993).

Zooplankton are essentially used to feed fry of fish species that do not accept artificial feeds (Bryant and Matty, 1980; Arrhenius and Hanson, 1993) but the importance depends primarily on their composition, density, easy availability, purity, acceptance, easy reproduction (digestibility and composition), nutritional indicators and economic viability (Fernando, 1994; Watanabe and Kiron, 1994). They are important source of protein, lipids,

fatty acids, minerals and enzymes for fry. Enzymes found in live zooplankton and playing an important role in larval digestion are amylase, protease, exonulease and esterase (Munilla-Moran *et al*., 1990; Mims *et al*., 1991).

Zooplankton are good source of carotene and they improve flavour, colour and texture of fish fed on them (Spenelli, 1979). Yurkowski and Tabachek (1979) reported that zooplankton satisfy all food requirements of fish and supported fry growth. Zooplankton has high ratio of unsaturated fatty acids to saturated fatty acid (Lokman, 1994) and appreciable quantity of Lysine and Methionine (Dabrowski and Rusiecki, 1983) which indicates that zooplankton is good quality food for rearing fish larva. The polyunsaturated fatty acid (PUFA) contents showed high concentrations of eicosapentanoic acid (20:5ω3) and docosahexanoic acid (22:6ω3) with moderate amounts of linoleic acid (18:2ω6) in zooplankton. As ratios of ω3 to ω6 PUFA are high, the zooplankton is regarded as desirable food (Lokman, 1994).

Cladocerans have been found to be rich in essential nutrients, easily ingested and digested by fish larvae, fulfill the larval dietary requirements and improve water quality by minimizing the need for artificial feeding (He *et al*., 2001). Sipauba-Tavares and Bachion (2002) reported that the culture of cladocerans offers the possibility of obtaining a large number of live food organisms within short periods of time under optimum conditions of temperature, food, and water quality.

Copepods also have a superior feed quality and resulted in high growth and survival rates combined with low incidence of malformations when fed to fish larvae due to the presence of essential nutrients (van der Meeren *et al*., 2008; Hamre *et al*., 2008). Copepods can also be multiplied in large numbers (up to 13,000 individuals/l) in fertilized ponds (Piasecki *et al*., 2004). A moderate hatchery (production of about 500,000 fingerlings a year) needs at least 10,000m^2 ponds to produce the required quantity of zooplankton (Hecht, 2013). Large quantities of zooplankton can easily be collected daily using a 100–150 micron mesh plankton net (Mack *et al*., 2012).

Rotifers have been viewed as potential substitutes for *Artemia* as a live starter feed in rearing *C. gariepinus* larvae because of their good morphological, behavioural and nutritional characteristics (Watanabe *et al*., 1983; Koven *et al*., 1990; Lubzens *et al*., 2001; Stelzer, 2012). Rotifers are excellent feed sources for larval fish because they are small in size, move slowly, can be grown in high densities, and have a fantastic reproductive

rate (Polo *et al*., 1992). Rotifers have also the habit of staying suspended in the water column and can tolerate temperatures of between 15 and 31°C (Ludwig, 2000).

Zooplankton mainly rotifers can be fed for 7–30 days depending on fin fish species at a rate of 3–5 rotifers/ml at a stocking density of 10 to 20 larvae/l for a day (Treece, 1995). A partially bigger mouth in *C. gariepinus* larvae than most cyprinid larvae (Yilmaz *et al*., 2006) permits newly born larval to consume rotifers with sizes greater than 200 µm. Time of feeding and feeding frequency have been reported to affect feed intake and growth performance in different catfish species (Noeske-Hallin *et al*., 1985). Optimal feeding frequency also varies with species, age, size, environmental factors, husbandry and feed quality (Goddard, 1995). Feeding frequency has also a direct impact on the survival rate of fry and larvae of *Clarias* (Verreth *et al*., 1987).

The potential use of locally available zooplankton (rotifers, cladocerans and copepods) as an alternative starter live food to *Artemia* in the feeding of *C. gariepinus* fry can have economical benefits. Production costs can be significantly reduced by replacing smaller sized local zooplankton instead of *Artemia* (Hecht, 2013). Cultured zooplankton from different groups mainly from Rotifers, Cladocerans and Copepods can be given in mixture. Higher percentages of survival were reported for *C. gariepinus* larvae raised on the freshwater rotifer; however, fry fed with mixed zooplankton diet had higher growth rates than those raised with rotifers alone (Mischke *et al.*, 2011; Agadjihouede *et al.*, 2012). The African catfish larvae have a partially bigger mouth than most cyprinid larvae and ingest the bigger Cladocerans even at the first feeding and newly born larval *C. gariepinus* consume rotifers with size >200 µm easily (Yilmaz *et al*., 2006). But larvae preferred the copepods and cladocerans to the rotifers due to their high swimming activity which makes them easier for larval predation (Woynarovich and Horvath, 1980).

Larval fish nutrition in aquaculture has been predominantly dependent on the use of brine shrimp (*Artemia* spp.) particularly for first feedings. An imported *Artemia* cyst has been used and nauplii were hatched in the laboratory to feed to early larvae in most research centres in Ethiopia (personal experience and observation). However, the cost of *Artemia* is prohibitive for resource-poor farmers in the developing world, which has necessitated investigations into alternative feed sources. The practical use of zooplankton harvested from fertilized ponds as live food source and the

frequency of feeding for *C. gariepinus* larvae have not been reported in Ethiopia.

The main objective of this research was to evaluate whether mixed zooplankton groups could be used as live food source and determine the appropriate zooplankton feeding frequency for *Clarias gariepinus* larval rearing.

MATERIALS AND METHODS

Experimental area and setup

The experiment was conducted at the laboratory of Fishery and Aquatic Life Research Centre at Bahir Dar (BFALRC) using 12 glass aquaria of 50 l capacity arranged in a rack in the larval rearing room. Experimental *C. gariepinus* larvae were stocked at a lower rate (2 fish/l) compared to other studies (Treece, 1995) as the biomass of zooplankton multiplied in ponds might not accommodate more population. The temperature of the room was regulated between 24–27°C using room heater. The culture water of each aquarium was refreshed daily using the recirculating water in the hatchery. The recirculation facility has biological filtration system (with sand and bids) and UV light to treat the culture water before it entered to the rearing aquaria.

All the experimental aquariums were cleaned thoroughly using non-toxic detergents and antibacterial and anti-fungal chemicals. There were four treatment groups (four different feeding regimes or frequencies). Each treatment was replicated three times. All the treatment groups were fed with local zooplankton species harvested daily from plankton multiplication ponds. Feeding was started at late 8:00 am in the morning and stopped at late 5:00 pm. The larvae in the first treatment were fed with zooplankton mass every 6 h (twice a day). Treatment two received every 4 h (3 times a day), the third and fourth treatments were provided with harvested zooplankton mass every 3 h (4 times a day) and 2 h (5 times a day), respectively. A protocol used during feeding and other routine activities in a hatchery was prepared as indicated on Fig. 1.

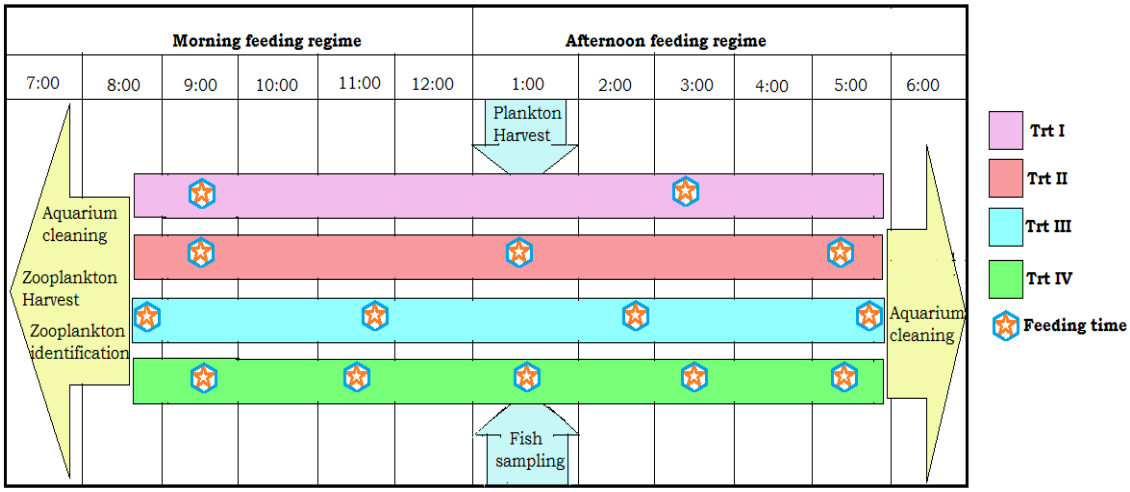

Fig. 1. Schematic representation of daily feeding routines during the experimental period.

Zooplankton multiplication and harvesting

Zooplankton groups used as live food were locally available ones from Lake Tana inoculated in three multiplication ponds. Each multiplication concrete pond has an area of 100 m^2. To multiply the zooplanktons in a big mass, the pond water was fertilized using commercial fertilizer (Di-Ammonium Phosphate - DAP) at a recommended rate of 5 g/m^2 (Hepher, 1963).

Zooplankton were collected from hyper eutrophic ponds using 150 µm mesh sized plankton net having 200 ml collection cup. The net had a mouth opening of 50 cm and 100 cm length and zooplankton were collected by pulling the net horizontally. Every day, zooplankton were harvested from three ponds and each pond was seined 20 times, 10 times early in the morning and 10 times in early afternoon. The harvested zooplankton mass from each pond was filtered through 125 µm sieve in order to remove bigger sized zooplankton from the collection. The filtered and concentrated zooplankton mass was washed repeatedly using 64 micron zooplankton sieve to clean the pond water (as suggested by Mack *et al*., 2012).

The concentrated zooplankton mass was immediately poured in a 2 l bucket with treated hatchery water. The cleaned zooplankton mass (2 l in volume) harvested from each pond was pooled together, mixed and stocked in a 10 l total capacity aquarium with gentle aeration. The zooplankton mass harvested at a time (6 l) served only for half day and was provided to larvae portion by portion according to the feeding regime indicated on Fig. 1 for

the whole experimental period of 7 days.

Sampling the harvested zooplankton

Immediately after cleaning the concentrated mass (aliquot) and before mixing zooplankton from all ponds, a subsample of 1 m1 was taken from each pond using pipette and fixed with 4% formalin for identification. Zooplankton identification was based on standard methods (Fernando, 2002). Another concentrated aliquot of volume 0.5 ml was taken with micro pipette from a well-mixed sample of 5 ml and poured into the gridded glass counting chamber to determine the number of individuals (according to Lind, 1979). Identification and enumeration was assisted using binocular compound microscope (Olympus CH-2) at different magnifications. The total number of zooplankton counted from the subsample were then extrapolated to the total mass of the aliquot harvested in a day.

Feeding the larvae

Each aquarium was cleaned twice a day (early in the morning and late evening) using siphoning tube. Thermostat and aerator were fixed to each aquarium to keep the temperature and oxygen level of the culture water at its desired range for larval rearing. The culture water spilled during cleaning was replaced, in the meantime refreshed, using cleaned water. Before taking the live food for feeding, the concentrated zooplankton in the aquarium was mixed thoroughly through applying higher aeration for 2 minutes. Each aquarium received one litre of aliquot or zooplankton mass in a day and the live food was equally divided into portions according to their respective feeding frequency. Zooplankton were fed to *C. gariepinus* larvae at a rate of 5 individuals/ml for fishes stocked at a density of 20 larvae/l as indicated in other studies (Treece, 1995; Ut *et al*., 2013).

Experimental fishes

The source of gravid broodstocks (both male and female) used to hatch the larvae were F1 (first filial generation) catfishes from BFALRC grown in a concrete pond. Larvae were hatched from these gravid parents induced with acetone dried catfish pituitary extract. On the third day after hatching, 12,000 early larvae were selected for the experiment. On the fourth day, 1200 healthy looking larvae were selected from the total population. The recruited experimental larvae were distributed over 12 aquaria and each aquarium received 100 *C. gariepinus* larvae. Feeding started at their 4th day and the experiment was conducted for a period of 7 days.

Every day, at 1:00 pm, a subsample of 10 larvae was taken randomly from each aquarium and weighed. Regular inspection to record the deaths was done every morning and afternoon. The total counts of live experimental *C. gariepinus* larvae in an aquarium was taken during the start and at the end of the experiment and checked with the daily mortality record to confirm the number of larvae lost during the experimental time.

At the 7th day, all the experimental larvae in each aquarium were collected, counted and their weight measured using electronic sensitive balance. Mean weight gain, percentage weight gain (%/day), specific growth rate (mg/day) and survival rate (%) of fishes were estimated using the formula below:

- $\text{Mean Weight gain (MWG)} = Wf - Wi$
- $\text{Mean Daily gain (MWG)} = \frac{(Wf - Wi)}{T}$
- $\text{Specific growth rate (SGR)} = \frac{(\text{Ln}\,Wf - \text{Ln}Wi)}{T}$
- $\text{Survival rate} = \frac{\text{No.of hatchlings that survived}}{\text{Total no.of hatchlings stocked}} x100$;

where W_i is the initial weight in mg, W_f is the final weight in mg, and T is time in days.

Data analysis

Basic statistical methods were used to describe the mean and standard error. Zooplankton in an aliquot was identified and enumerated to analyze the variations among the different feeding dates. The difference among the means on growth performances and survival of *C. gariepinus* larvae grown in three different live food feeding regimes were compared. Data were analyzed using one way analysis of variance (Steel and Torrie, 1960). Where there existed difference between treatment means, Duncan *post hoc* multiple comparison test was made. The statistical data analysis was carried out using SPSS version 20 software.

RESULTS AND DISCUSSION

Zooplankton groups and species identified

The multiplication ponds showed diverse zooplankton community composition with good species richness from 10 different families that comprised a total of 17 species (Table 1). This did not include the unidentified nauplii and other invertebrates which escaped the sieve. The diversity of harvested zooplankton from these fertilized concrete ponds was better compared to Lake Tana (Tesfaye Wudneh, 1998; Ayalew Wondie, 2006; Ayalew Wondie and Seyoum Mengistou, 2014), and similar with other studies in terms of the number of copepods (Eshete Dejen, 2003). But the diversity was lower compared to the zooplankton community of Lake Tana studied by Imoobe and Akoma (2008).

Cladocerans and Rotifers composed of 7 species each and copepod group comprised of only three species (17.6%). The contribution of Cladocerans, which are rich in essential nutrients, from the total production (harvest) was a bit higher (35%) compared to rotifers and copepods (Fig. 2). The higher contribution of Cladocerans in these multiplication ponds might be due to their ample morphological and ecological plasticity (Mártinez-Jeronimo *et al*., 2007), adapting to eutrophic water condition (Wang *et al*., 2007) and quick resistance to changes in oxygen concentrations due to their ability to synthesis haemoglobin (Rottmann *et al*., 2003). Studies indicated that large and medium sized zooplankton, mainly Cladocerans dominated zooplankton multiplication ponds when there is no fish predation (Havens and Beaver, 2011).

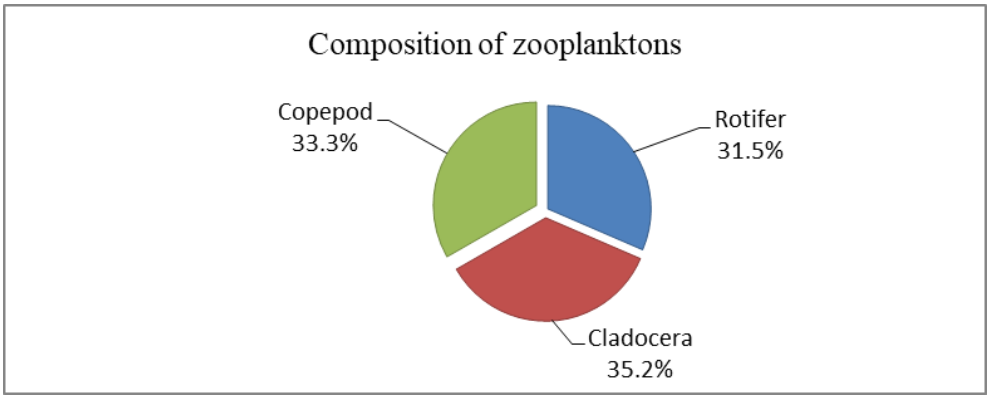

Fig. 2. Population density of each zooplankton group.

Table 1. Zooplankton species checklist and their distribution during the sampling dates.

Zoo taxa	**Species**	**Harvesting dates and ponds**																				**Occurrence**
		6/08/2017			**07/08/2017**			**08/08/2017**			**09/08/2017**			**10/08/2017**			**11/08/2017**			**12/08/2017**		
		1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	
Rotifers	*Trichocerca longiseta*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	21
	Lecane bulla	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	21
	Keratella crassa	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	21
	Keratella tropica	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	21
	Trichocerca similis	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	21
	Filinia longiseta	0	+	0	0	+	0	0	0	0	+	+	+	+	+	+	+	+	+	+	+	+	14
	Keratella cochlearis	0	0	0	0	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	16
Cladocerans	*Alona quadrangularis*	0	0	0	0	0	0	0	0	+	0	0	+	+	+	+	+	+	+	+	+	+	11
	Diaphanosoma sarsi	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	21
	Moina micrura	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	21
	Bosminia longrostris	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	21
	Diaphanosoma exisum	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	21
	Daphnia lumoholtzi	0	0	0	0	0	+	0	+	+	0	+	+	+	+	+	+	+	+	+	+	+	14
	Ceriodaphnia cornuta	0	0	0	+	0	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	16
Copepods	*Thermodiaptomus galebi*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	21
	Thermocyclops ethiopiensis	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	21
	Mesocyclops aequatorialis	0	+	0	0	0	+	+	0	+	+	+	+	+	+	+	+	+	+	+	+	+	16

Water quality parameters of larval rearing aquarium

The mean temperature of larvae culture water was 24.97, 25.02, 25.15 and 25.29°C for treatments I, II, III and the IV, respectively, indicating warmer temperature in Trt IV. Water salinity was maintained at 0.09 ppm for all the treatments throughout the experimental period. The dissolved oxygen (DO) level varied between 5.67 to 5.83 mg/l. The pH was 8.65±0.03, 8.56±0.12, 8.68±0.02 and 8.76±0.04 for treatments I, II, III and IV, respectively. But the difference in water quality between the treatments was not statistically significant at $p<0.05$ level (Table 2).

Table 2. Mean (±SE) of water quality parameters for different treatments.

Water quality parameters	Trt I	Trt II	Trt III	Trt IV
Temperature, °C	24.97±0.32 a	25.02±0.37 a	25.15±0.27 a	25.29 ±0.56 a
DO, mg/l	5.83±0.11a	5.75±0.06 a	5.72±0.16 a	5.7±0.19 a
pH	8.66±0.06 a	8.76±0.07 a	8.68±0.04 a	8.14±0.73 a
Salinity, ppm	0.09±0.0 a	0.09±0.0 a	0.09±0.0 a	0.09±0.0 a
TDS, ppm	0.122±0.002 a	0.123±0.001 a	0.121±0.0 a	0.123±0.001 a
EC, µs/cm	0.188±0.004 a	0.190±0.004 a	0.187±0.001 a	0.191±0.002 a

Note: Values are means from triplicate group of aquarium where the means in each row with the same letters are not significantly different ($p<0.05$).

The mean values of temperature, dissolved oxygen, pH, salinity, Total Dissolved Solids (TDS) and Electrical conductivity (EC) for each treatment was within the desired range in *C. gariepinus* larviculture as indicated by other studies (Bruton, 1979; Britz and Hecht, 1998). This was due to the regulation of temperature using room heater and thermostats fitted in each culture aquarium.

Larval weight gain and growth rates

The *C. gariepinus* larvae fed with local zooplankton groups harvested from multiplication ponds showed >100% growth (weight increment) in one week time. The final weight of the experimental fish in a week time was 134.7, 138.5, 152.8 and 136.1 mg for treatments I, II, III and IV, respectively. *Clarias gariepinus* early larvae fed with zooplankton mass four times a day (Trt III) showed significantly higher final weight compared to the others (Fig. 3). Mean daily weight gain was 15.95±1.63 for Trt I, 16.51 ±0.32, 18.91±0.38 and 15.88±1.24 mg/l for Trt II, III and IV, respectively. This indicated that treatment groups fed zooplankton mass every 3 h showed higher daily weight gain and the difference was significant ($p<0.05$) compared to the other treatments (Table 3).

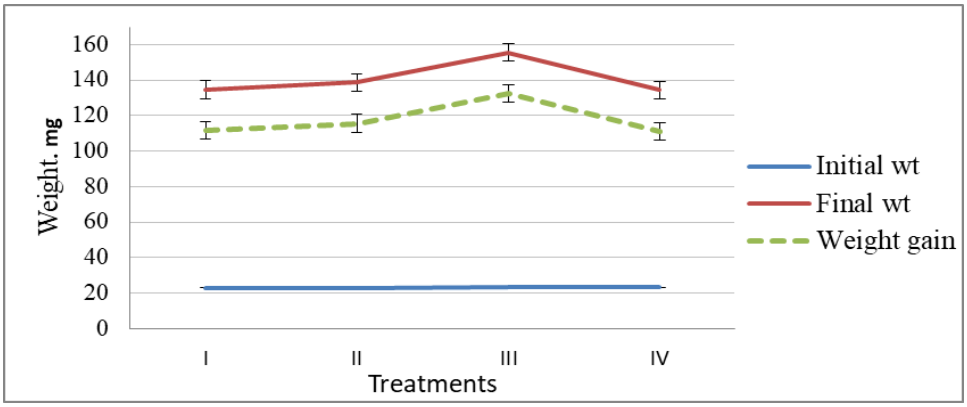

Fig. 3. Mean initial and final weights and observed weight gain. Bars are standard errors of means.

Table 3. Mean growth indices and survival rate of *Clarias gariepinus* early larvae fed with indigenous live food at different frequency.

Treatments	Initial weight, mg	Final weight, mg	Weight gain, mg	Daily weight gain, mg/day	SGR, %/day
I	23±0.00 a	134.67±4.54 a	111.67±4.54°	15.95±1.63 a	25.2±0.5 a
II	23±0.00 a	138.6±2.23 a	115.6±2.23 a	16.51 ±0.32 a	25.7±0.2 a
III	23.27 ±0.25 a	155.67±2.91 b	132.4±2.67b	18.91±0.38b	27.2±0.1b
IV	23.27±0. 15 a	134.4±8.85a	111.13±8.7 a	15.88±1.24 a	25±0.8 a

Note: Numbers in brackets are SE of means. Numbers with the same superscripts do not have significant differences at $p<0.05$.

There was a difference in specific growth rate (SGR) between the treatments. The SGR of Trt III was higher compared to the other treatments and the difference was significant ($p<0.05$). Treatment groups fed zooplankton mass very frequently (every 2 h) showed lowest weight gain and growth rate compared to the other treatment groups (Table 3, Fig. 4).

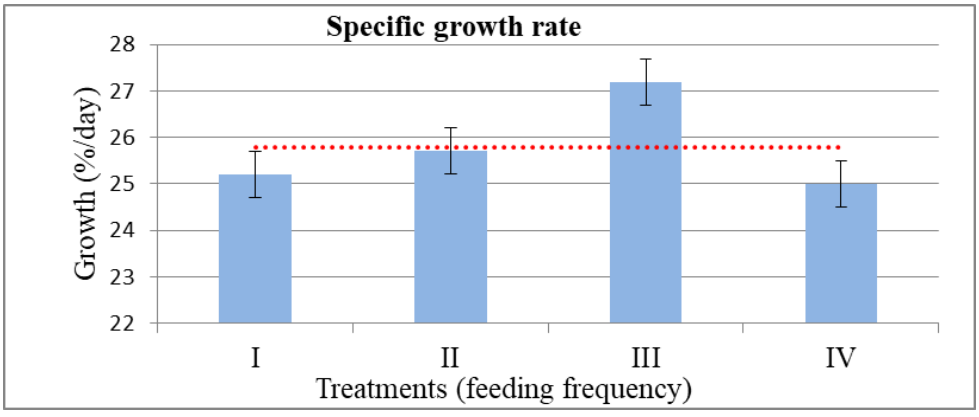

Fig. 4. Mean specific growth rate of early larvae fed with local zooplankton groups.
Note: Bars are standard errors and the dotted line is mean value. Dotted lines indicate the overall geometric mean per treatment.

The higher growth performance in Trt III might be due to higher feeding frequency which enable the fry to prey on enough live food and satiate themselves for longer time of a day and get proper feed utilization. The slower weight gains and growth rates recorded on larvae fed at an interval of 2 h might be due to the energy expended to compete for the limited zooplankton. In such a case, larvae might use the live food for maintenance instead of growth and development of their tissue. The lower growth of larvae fed twice a day might be due to higher concentration of zooplankton beyond the threshold level. Larvae were observed resting for long time on the bottom of the aquarium with a very big belly after feeding. Studies confirmed that *C. gariepinus* stomach at an early stage gets stuffed and attempted to digest all the ingested food (Verreth *et al*., 1993).

Larval survival rate

Mortality was higher during the first two days of the experiment and was observed in all the treatment groups. The number of deaths decreased through time in all the treatments and stopped at the fourth day except Trt I (Fig. 5). The larval death in Trt I might be because larvae were unable to digest the ingested zooplankton. This was confirmed by clearly visible big belly observed while they were alive and the larvae were moving very slowly. Very high mortality observed on Trt I might also be due to the higher mass of zooplankton added at a time which could affect quality of culture water. As a result, the total number of early larva that died during the experimental period were higher on treatment I (74) and IV (39) compared to Trt II and III which was 19 and 14, respectively (Table 4).

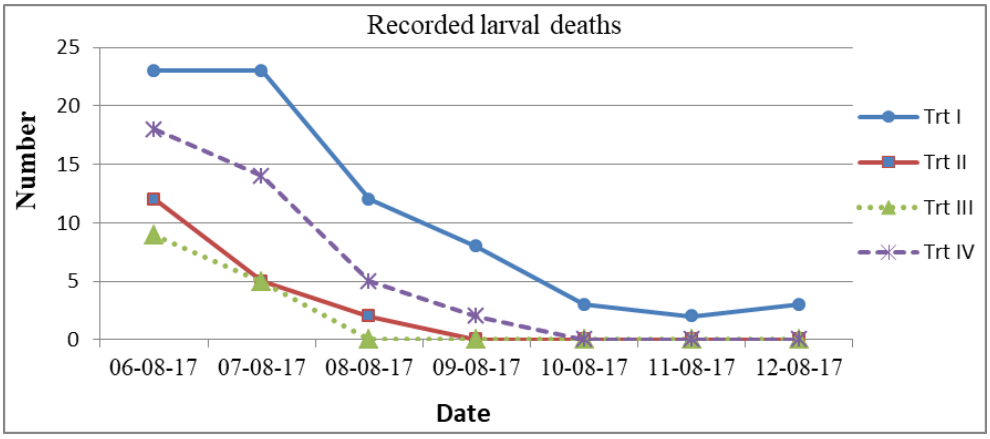

Fig. 5. Observed number of larvae that died during the experiment.

Table 4. *C. gariepinus* early larvae growth and survival.

Counts and rates	Trt I	Trt II	Trt III	Ctrl
Total no. of larvae stocked	300	300	300	300
Total no. of larvae died	74	19	14	39
Survived larvae (Mean ± SD)	75.33±5.51b	93.67±4.93 a	95.33±4.62 a	87±4.58 a
Survival rate (Mean ± SD)	75.33±5.51b	93.67±4.93 a	95.33±4.62 a	87±4.58 a

Note: values (Mean±SD) with the same superscript letters in a row were not significantly different at 0.05 level.

At the end of the 7th day, the mean number of larva that survived were 75.33, 93.67, 95.33 and 87 for treatments I, II, III and IV, respectively. The proportion of larvae that died during the experimental period was higher (nearly 25%) in Trt I and the difference was significant at $p<0.05$. Higher survival rates were observed in treatments II and III as indicated in Table 4 and shown on Fig. 6 and 7. The larvae of *C. gariepinus* fed with zooplankton mass every 3 h (Trt III) showed better growth performance and survival rate compared to those that received over and under this feeding frequency (Fig. 7).

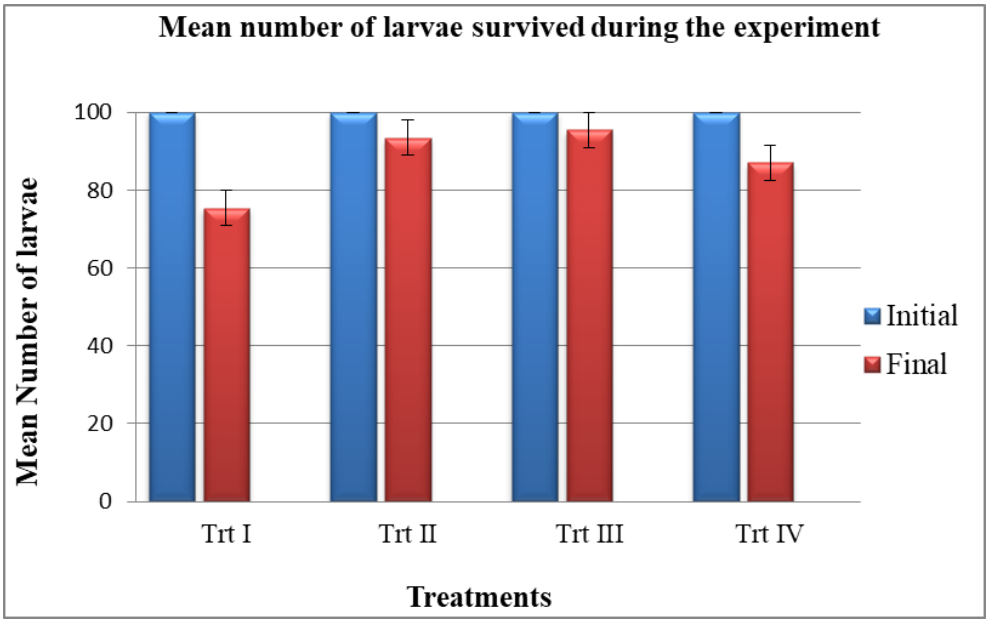

Fig. 6. Mean number of survived larvae during the experimental period (bars are SE of means).

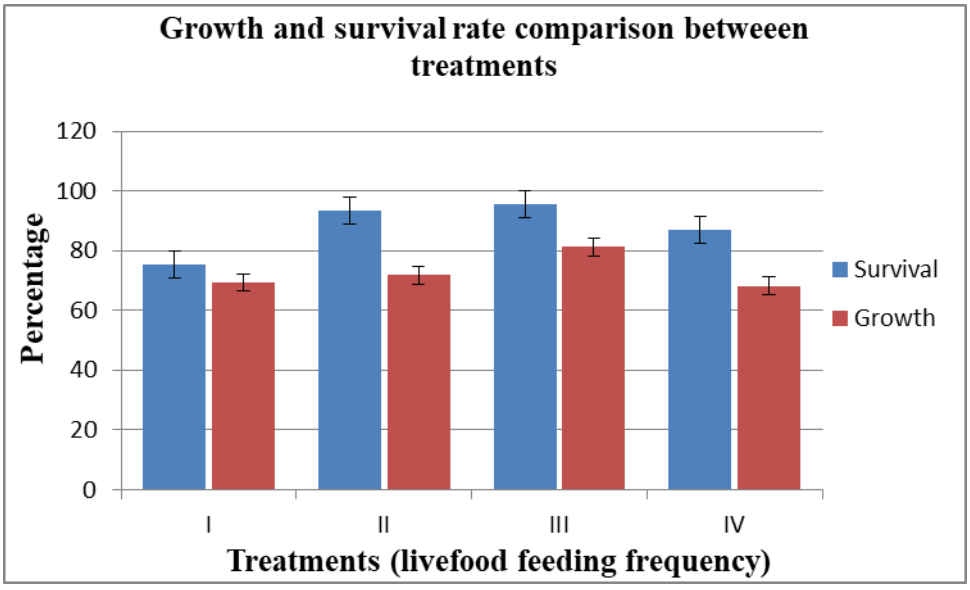

Fig. 7. Comparison of the mean survival rate and growth of *C. gariepinus* larvae.
Note: Bars are standard error of means.

Survival rate increased with feeding frequency. The lower survival of early larvae in the treatment group that received live food very frequently might be due to scarcity of live food as the number of zooplankton provided at each feeding interval was very low.

The higher mortality of *C. gariepinus* larvae in Trt I might be due to the higher load of zooplankton added during feeding which could attack fish larvae. Studies confirmed that some cyclopoids are micropredators of fish larvae, especially at early stages (Piasecki *et al*., 2004). Fish larvae are attacked by adult copepods and more advanced copepodid stages resulting in serious lesions of blood vessels and different body parts particularly the gills (Hartig *et al*., 1982). Piasecki (2000) also reported that mortality rates of larvae depends on the cyclopoid density and the availability of alternative food for copepods.

CONCLUSION

The experiment indicated that multiplying local zooplankton through fertilizing zooplankton multiplication ponds can be used as an alternative live food source for rearing *C. gariepinus* larva. Feeding *C. gariepinus* early larvae with local live food sources resulted in >25% daily growth rate, 100%/day SGR, and 75% survival. Hence, local zooplankton species could be used as replacement of imported and expensive *Artemia* cyst. The *C.*

gariepinus larvae can be provided with zooplankton mass at a rate of 2 individuals/ml and daily feeding frequency of four times a day.

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