ISSN: 2347-5129
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2016; 4(6): 11-15

www.fisheriesjournal.com
Received: 03-09-2016
Accepted: 04-10-2016

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Performance of African Catfish *Clarias gariepinus* (Clarridae) fry fed on live rotifers (*Brachionus calyciflorus*), formulated diet and a mixture of rotifers and formulated diet

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Abstract
Long larval and fry rearing period due to unreliable live food sources are problematic in fry rearing process affecting aquaculture production in most hatcheries. As a result, this study investigated the performance of African catfish (*Clarias gariepinus*) fry fed on live rotifers, a mixture of rotifers and formulated diet (Ugachick feed 45%). Seven days post hatch fry of *Clarias gariepinus* were reared under three different treatments; A, B and C with triplicates in a complete randomized design in 40L concrete tanks. Fry in treatments A and C were exclusively fed on live rotifers and formulated feed respectively. In B, the fry were fed on mixture of live rotifers and formulated feed for 15days. At the end of the experiment, final mean total length (TL), specific growth rates (SGR) and survival rates (SR) were determined. Significantly highest (P<0.05) mean length (1.40±0.0214cm) and SGR (0.083%) were observed in treatment B followed by treatment A (1.10±0.0204cm, 0.069%). The least SGR (0.064%) was observed in fry solely fed on the compound diet (0.994±0.0205cm). The results of the study demonstrate a comparatively higher growth and fry survival (82.2%) when fed on the mixture of live rotifers and formulated feed, seven days after hatching.
Since no artificial feed formulation is yet available to completely substitute feeding live prey to young fish, it is concluded that a mixture of live and formulated diets are more suitable for feeding the African catfish fry seven days post hatch.

Keywords: African catfish fry, live rotifers, formulated diet and mixed diet

1. Introduction
Aquaculture continues to expand worldwide to meet increasing human demand for fish following a decline in capture fisheries [1]. With the high annual human population growth in Africa (2.5–2.8%) and Uganda in particular (3.1-3.4%), there has been increased market demand of fish which has resulted in high costs of food especially dietary fish protein. This has led to over exploitation of the capture fisheries through over fishing which has consequently resulted in rapid decline of fish stocks from the wild. Hence insufficient fish cannot sustain the ever growing population.
This factor is attributed to have caused malnutrition and poverty, the key challenges facing African society today [2]. Therefore, this calls for increased aquaculture production of the available local fish species to supplement the capture fisheries so as to meet the high market demand of fish and fish products thus minimizing the pressure by the fisher communities on the wild fish stocks.
The species which have demonstrated yield potential in Africa include; Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*) and the common carp (*Cyprinus carpio*). *C. gariepinus* has become a popular species for aquaculture in sub-Saharan Africa. In Uganda, it emerges the second most cultured fish species after *O. niloticus* of which 60% of aquaculture production is owed to its culture [3]. It is mainly being cultivated for food, used in ponds stocked with mixed *O. niloticus* to control over population and also grown as bait fish for the lake Victoria Nile perch fishery. *C. gariepinus* is one of the fish species that spreads across all the waters of Uganda especially those linked to the swamps and has traditionally been a primary target for a good segment of fishing community.
It has distinguished behaviors such as omnivorous feeding habits, ability to feed on both natural and supplemental feeds, resistance to diseases, tolerance to low oxygen levels, crowding as well as fluctuating pH levels [4]. These factors make it a highly desired fish candidate for aquaculture by most farmers on the African continent.

Seed production of *C. gariepinus* particularly rearing of larvae and fry are the most critical steps in aquaculture [6]. Among other factors, lack of the most reliable diet that provides essential nutrition for growth and survival of fish especially at fry level strongly affects aquaculture production both in hatcheries and grow-out facilities. Therefore larval nutrition mostly of the sensitive first-feeding larvae has become one of the major bottlenecks preventing the full commercialization of many farmed fish species. Moreover, formulated feeds do not generally meet all these requirements and usually result in poor growth and survival in small fish larvae as well as fry. The natural diet of most cultured fish consists of a wide diversity of phytoplankton species (diatoms, flagellates) and zooplankton organ isms (copepods, cladocerans, rotifers) found in great abundance in the natural water. Rotifers especially *Brachionus calyciflorus* have been viewed as potential substitutes for Artemia (Brine Shrimp) as a live starter feed in African catfish larvae rearing because of their good morphological, behavioral and nutritional characteristics [7-10]. A partially bigger mouth in African catfish larvae [11] than most cyprinid larvae permits *C. gariepinus* larvae to consume rotifers with sizes greater than 200 µm.

This abundance and maximal diversity of food organisms of different sizes and nutritional composition provide maximal chances for meeting all the requirements of the predator larva e and fry.

Seed production and fry rearing in particular are the most critical steps in aquaculture production. Success of this stage is mainly determined by larval as well as fry feeding and nutrition. However, inconsistent supply and relatively higher cost of the most popular live feeds such as artemia have led to long larval rearing period. These are highly problematic in larval and fry rearing process. More so, inadequate hatchery operations and lack of the most appropriate and reliable diet with adequate nutrients essential for fast fish growth especially at the fry level have raised great concern in the Ugandan current aquaculture production. This is evident both in the hatcheries and grow out facilities. As a result, this has led to increased costs of production due to compromised fish performance which strongly impact on profitability as well as sustainability of aquaculture practices. Unlike temperature and photoperiod management studies at larval stage of *C. gariepins* immensely researched [12, 13] there still exists paucity of information on diets that can enhance faster fish growth and survival to meet the growing demand of fingerlings by grow-out farmers and subsequently food fish in the market. This creates need to establish more appropriate and reliable diet that can enhance faster fish growth so as to meet the high demand of fingerlings by grow-out farmers and table fish in the market. Therefore, the present study was to compare growth performance and survival of African catfish fry fed on live rotifers, compound diet and a mixture of the two diets to be able to establish the best diet which can enhance faster fish growth so as to meet the high demand of fish on the market. Establishing the appropriate diet combination facilitates shorter growth span and eventually leading to low costs of production and high profit margins. Consequently the performance of African catfish fry fed on different diet combinations was established.

1.1 General objective

To evaluate the performance of African catfish fry fed with live rotifers, a mixture of live rotifers and formulated diet,

1.2 Specific objectives

i) To determine growth and survival of African catfish fry fed on live rotifers, a mixture of rotifers and formulated diet.

ii) To assess variations in specific growth rates of African catfish fry fed on live rotifers, a mixture of rotifers and formulated diet.

2. Materials and Methods

2.1 Study area

The experiment was carried out at Kireka fish farm in Wakiso District Central Uganda (N00.35212 E032.64111, ELV. 1172) due to its well established African catfish hatchery infrastructure.

The experimental fish fry were obtained by artificial reproduction as described by Ngugi *et al*., (2007). Ripe, sexually mature female and male catfish were obtained from one of the brood stock ponds at Kireka fish farm. The females were injected with the pituitary gland extract and then kept in separate tanks with well aerated water at 24 °C. The fish were stripped after 18 hrs and the obtained eggs fertilized using the milt from the male catfish. The fertilized eggs were incubated in the incubation tanks for a period of 24 hrs. With aeration and temperature maintained at 28 °C. After hatching, the larvae were transferred to the hatchling tanks until they completely absorbed the yolk sac. Then, the fry were fed on zooplanktons (rotifers) as the starter feed for seven days prior to the start of the experiment so as to obtain uniform growth.

The rotifers that formed the starter feed were cultured in one of the earth en ponds at Kireka fish farm. This was done by fertilizing the pond water with the chicken manure at the rate of 0.5 kg per m^2**.** These zooplanktons were harvested by using plankton nets of mesh sizes 80µm and 100µm to obtain the desired size for feeding the fry at a given stage. For the first week after the absorption of the yolk sac harvesting was done using 80µm to obtain small species of rotifers for feeding the young fry that need small food in the early stages. As the fry grew, the size of the mouth increased thus need for relatively large food particles and as a result, harvesting at this stage was done by a 100µm to capture relatively large rotifers. Unlike the rotifers, the commercial feed used was obtained from the farm and according to manufacturer was 45% Crude protein.

2.2 Experimental design

The experiment comprised three treatments under which African catfish fry were raised for a period of 15 days after stocking. These included tanks in which the fry were exclusively fed on live rotifers and formulated diet respectively and a mixture of rotifers and the formulated diet. The treatments were assigned simple labels; A, B and C for easy identification and to avoid mistakes during their monitoring.

2.3 Sample collection of the micro-algae and experimental set-up

Micro-algae samples were collected from the pond that has been well fertilized (with dark green color). The samples were collected using the 5L bucket.

2.4 Isolation, purification and culture of the *Chlorella vulgaris*

The collected water samples contain a mixture of both phytoplanktons and zooplanktons thus need to be isolated and purified to get a pure strain of *chlorella vulgaris*. Planktonic nets of 100, 80 and 40µ mesh were applied to eliminate

zooplanktons, Basudine and Flubendazole were also applied at 1.5mg/L and 0.5mg/L respectively to knock out copepods and other zooplanktons respectively. The precipitate was then diluted and cultured using batch culture / continuous method for subsequent multiplications, under sufficient illumination and temperature (25 °C).

DAP/UREA was used as nutrient source supplied at 1 kg per four liters of the culture solution at the lag phase of growth and 0.65kg during the exponential phase of growth.

2.5 Mass culture of freshwater rotifer (*Brachionus calyciflorus*)

2.5.1 Sample collection, isolation and purification

Zooplankton samples were collected from Kireka fish pond that had been well fertilized. Collected samples were concentrated by fin e filtration using 50µm plankton net and transferred to the culture tanks. The collected water samples were filtered using 100 µ mesh and the adult rotifers retained since they have bigger size compared to 100µ mesh. The retained rotifers were used as starter culture for subsequent multiplication. Micro-algae (*Chlorella vulgaris*) were used as the culture feed for the rotifers.

2.5.2 Culture of the freshwater rotifers

During the culture, total counts of all individuals present in the zooplankton sample were made using a sedge-wick rafter cell counting chamber and microscope. Zooplankton identifications were guided by relevant identification keys [14]. Zooplanktons were identified as cladocerans, rotifers and copepods, but due to the key interest in the rotifers, these were further identified as *Brachionus calyciflorus.* Live rotifers were collected using 50-µm mesh size plankton nets from the Kireka fish farm ponds. The samples were thoroughly rinsed to reduce contamination by unwanted organisms and immediately transported live to the tanks for culture. Plastic containers of 1000 L capacity were used as culture units and dechlorinated water was used as a culture medium. Temperature and pH ranges (25-27 ^{0}C and 6.5-9.0) were maintained and 40 watt electric light tubes used.

Chlorella algae, grown on inorganic fertilizers (Diammonium phosphate (DAP) and urea) were used as a food source at an established feeding rate. Constraints due to culture density was monitored to avoid decreased fecundity due to overcrowding; by up scaling when the density reaches 10ind/L. Pure rotifer culture was obtained through application of Basudine, an Organophosphoric acid ester at a rate of 1.2mgl^{-1} following Agbon *et al*., (2002)

This chemical at the best concentration, knocks off copepods, cladocerans, and mosquito larvae but does not harm rotifers, thus maintaining only rotifer population [15].

Mild aeration was placed in the culture units in order to help maintain microalgae in suspension promote better algae distribution and avoid anoxic areas in the tank.

2.6 Growth performance (Total length) of African catfish larvae

Commercial fish hatchery unit located at Kireka fish farm was utilized for this feed in g experiment. This fish farm's hatchery was utilized for testing performance of African catfish larvae fed on, Rotifer B. *calyciflorus,* Formulated feed and mixture of Rotifers and the formulated feed as starter feeds. The water supplied to the hatchery was sieved through a 50 µm mesh to eliminate zooplankton contamination from the water supply ponds. Experimental plastic basins (50 L) were used as culture tanks in triplicate of the three feed experiments and modified to fit in the flow – through system of the hatchery unit.

The African catfish larvae were obtained following induced breeding of adult African catfish and subsequent hatching of eggs following routine procedures used at the farm. To each of the experimental tanks (50 liters capacity), three hundred (300) larvae o f a uniform initial mean Total Length (TL) of 7.54 mg were randomly distributed and maintained under ambient hatchery conditions. These larvae appeared healthy and active and had no signs of disease. Water temperature, dissolved oxygen levels, pH and ammonia levels were monitored and maintained regularly after every one hour to appropriate catfish hatchery conditions (Temperature: 24-28 ^{0}C Dissolved Oxygen: 5-8 mg/l, pH: 6-8, and Ammonia: less than 0.1mgl-1during the experiment. African catfish larvae were fed for three days on the starter feeds (B. *calyciflorus* and mixture of the two diets) following commencement of exogenous feeding (day three) as is the practice of fish farmers.

2.7 Data collection

Each treatment had three replicates which were monitored for a period of 15 days. The fry were fed at an interval of two hours between 10:00 am and 6:00 pm at least five times a day till the end of experiment. The experimental culture units consisted of 40 liter concrete tanks which were filled up to a volume of 20 liters. A continuous water flow through system was maintained to allow water exchange and refreshment of quality.

For monitoring of water quality, bottom debris was siphoned from each tank twice a day, once before the first feeding and again 40 minutes after the last feeding. Temperature and pH were measured daily while ammonia values were recorded at every day of sampling. Temperature were maintained between 25-28 °C with a mean of 25.35 °C using warm water from the electric boiler (Table 2). Water temperature was regularly checked using a thermometer. The pH was measured and monitored using a pH meter, dissolved oxygen by a DO – meter while an ammonia kit was used to monitor and determine the ammonia levels in the experimental tanks.

After seven days of feeding with the zooplanktons (rotifers), a sample of 3 0 fry was measured for total length (cm) using a ruler alongside checking the survival rates. Subsequently, a sample of 30 fish fry from each tank was measured for total length (cm) after every five days. At the termination of the experiment, the fish that remained in each study tank were counted and recorded. Throughout the experimental period, total length of fish were measured and recorded in the growth data sheet.

The specific growth rates (SGR) of fish fry under different treatments were calculated with the following formula;

SGR = (lnlt-lnlo)/ (t (days) × 100, where;

lt*:* Final total length (cm)

lo*:* Initial total length (cm)

t: time (days), Feeding period

Ln: Natural logarithm

The survival rate (SR) was calculated as the total number of fry that survived up to the end of the experiment expressed as the percentage of the total initial stock.

SR = (number of fish fry at experiment termination)/ (number of fry stocked) × 100

2.8 Statistical analysis

The data obtained were tested for normality and homogeneity of variances and later compared in the feeding trials

(treatments) using one-way Analysis of Variance (ANOVA) after the collected data conformed to all the ANOVA assumptions to test significant differences ($p<0.05$) in growth.

3. Results

Figure 1 shows the mean length, and specific growth rate and how they were significantly affected by diet ($P<0.05$), the highest mean length and specific growth rate were obtained in fry fed with a mixture of live rotifers and formulated diet. Survival rate was also significantly affected by diet and it was highest in fish fed with a mixed diet followed by those fed live rotifers and the formulated diet only respectively (Table.1).

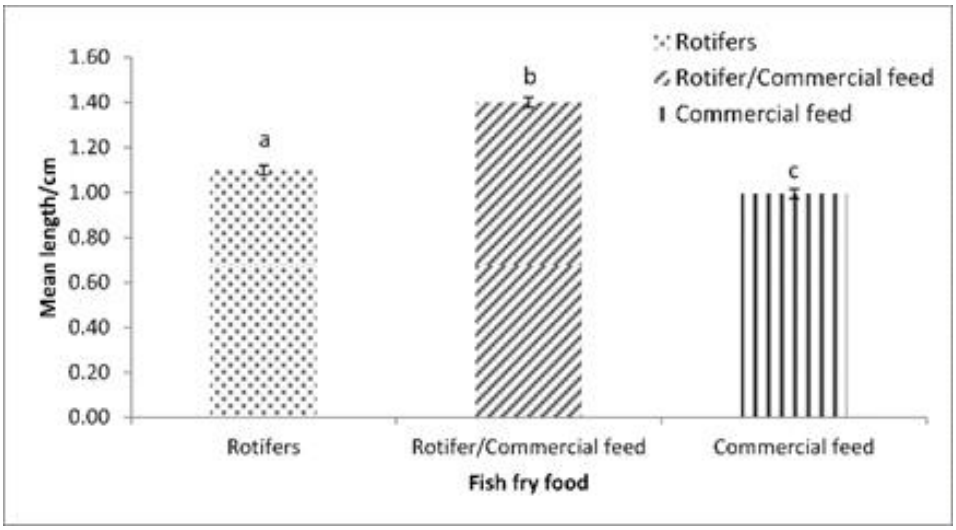

Fig 1: Growth (mean length±SE) of *Clarias gariepinus fry* fed live rotifers, a mixture of live rotifers and formulated d iet and a formulated feed alone for 15 days.

Table 1: Growth (mean length±SE), survival rate (%) and specific growth rate of Clarias gariepinus fry fed live rotifers, a mixture of live rotifers and formulated diet and formulated diet after 15 days.

Fish Fry food	Mean length/cm	Specific growth rate /%	Survival rate / %
Rotifers	1.100±0.0204	0.069	77.2
Rotifer/Ugachick feed	1.400±0.0214	0.083	82.2
Formulated (Ugachick) Diet	0.994±0.0205	0.064	48.3

Table 2: Water quality parameters from tanks stocked with African catfish fry and fed with the live rotifer, a mixture of rotifers and formulated diet for 15 days.

Water parameter	Treatments		
	A	B	C
DO (mg/l)	4.41±0.56	4.36±0.54	4.37±0.57
Temp. (°C)	25.30±3.27	25.32±3.25	25.29±3.28
PH	7.4±0.02	7.28±0.05	7.41±0.08
NH3 (mg/l)	0.039±0.003	0.04 ±0.004	0.04 ±0.003

4. Discussion

Growth and survival rate was highest in fish fed with a mixture of live rotifers and compound diet. Like other live feeds such as artemia, rotifers that comprised the first feeding of fish larvae reported high measure of success. Considerable growth was also observed with the continued use of live rotifers while compound diet was the least. The feeding of seven days post hatch fry with a mixture of live rotifers and formulated diet for 15 days exposed them to a variety of diets. Consequently, fish obtained nutrients from varied sources; live feed and formulated diet. This implies that the fry would obtain their nutrition from both diets and also those which were unable to access live feed would probably opt for formulated diet for their nutrition. This could have greatly contributed to the better growth and survival rate that were obtained since there were minimal cases of starvation due to food availability. The least growth and survival observed in fry which were suddenly weaned from live feed culture to the formulated feed was attributed to some fish still having not fully developed guts as well as poor perception organs such as the olfactory. Even when the formulated diet was ingested at this early stage, some fry could die with guts full of food, suggesting their inability to digest formulated diets.

Further still, obtaining feeds that satisfy the nutritional needs of the fry was difficult since mechanisms of digestion and absorption, as well as nutritional requirements change during their development. The findings in this study that formulated diets resulted in the least growth and survival when used for feeding fish fry is in line with findings in the investigations conducted by other scholars [16].

Under treatment A (rotifers only), a substantial growth on survival rates observed could probably have been due to high nutritional content and the ability of the fry to digest and utilize the live feed. However the performance of African catfish fry was lower compared to treatment B (Rotifers and formulated feed). Since the fry continue to feed on live rotifers even after the seventh day post hatching for 15 more days, the fry gape size had increased and the fry would spend more energy hunting for small zooplanktons accounting for the slow growth. More so, rotifers lack some essential nutrients required for optimum growth.

5. Conclusions

In conclusion, *C. gariepinus* fry grow best on a mixed diet of live rotifers and formulated feeds provided seven days post hatching**.** While considerable growth and survival can be obtained when fish fry are continuously fed live rotifers, formulated feeds do not meet all the nutritional requirements and are not readily digested at an early age of fish hence usually result in poor growth and survival in small fish fry.

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