

Effects of feeding zooplankton, *Moina macrocopa* (Straus, 1820) on the growth of Nile tilapia *Oreochromis niloticus* L.

M. R. Islam¹, M. R. Hassan², M. Begum², N. J. Punom¹, M. K. Begum¹, N. Sultana² and M. S. Rahman^{1*}

¹Department of Fisheries, Faculty of Biological Sciences, University of Dhaka, Dhaka-1000, Bangladesh

²Zoology Section, Biological Research Division, Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka 1000, Bangladesh

Abstract

Studies were carried out on the growth performance of Tilapia fry, *Oreochromis niloticus* cultured with zooplankton, *Moina macrocopa* in comparison to commercial feed. Three types of feed were used in three treatments where treatment-1 was fed with handmade feed (control), treatment-2 with commercial feed and treatment-3 with live zooplankton *M. macrocopa*. Thirty fry were stocked in each 60 L aquarium for a rearing period of 56 days. The fishes were fed twice a day at 90-400 *Moina*/individual fish for first 20 days, then 500-850 *Moina*/individual fish for 15 days and 900-1250 *Moina*/individual fish for remaining days. Sampling was done at 14 days interval. The growth performance of *M. macrocopa* was higher in the treatment fed with *Spirulina* which was 6350 individuals/ L of water and in the treatment fed with yeast it was 5100 individuals/L of water at 12th days. The study showed that condition factor of tilapia fry found in treatment-3 fed with *M. macrocopa* was comparatively higher (2.18 ± 0.09) than that of treatment-2 fed with commercial feed (1.86 ± 0.13) at a 56-day culture period. Average daily gain was significantly higher in the treatment-3 fed with *M. macrocopa* (0.13 ± 0.01) than those of treatment-1 (0.06 ± 0.01) and treatment-2 (0.08 ± 0.01). The best value of feed conversion ratio and specific growth rate was found in treatment-3 fed with *M. macrocopa* than commercial feed and handmade feed. Protein content was significantly higher (15.91%) in treatment-3 than those of treatment-1 (10.96%) and treatment-2 (11.88%). The findings of this study suggest that growth parameters and body composition of Nile Tilapia was better in treatment-3 fed with *M. macrocopa*.

Keywords: *Moina macrocopa*; Nile tilapia *Oreochromis niloticus*; Live food; Growth performance; Body composition

Introduction

In many tropical and subtropical areas of Africa, America and Asia, Tilapia is as an important food fish item. Throughout the world it serves a new scenario on aquaculture as an extensive source of animal protein and income (Barriga-Sosa *et al.*, 2004). Like some Asian countries, Bangladesh introduces Nile Tilapia, *Oreochromis niloticus* in 1974. Zooplanktons are important food components for young and some adult freshwater fishes (Kenneth, 1990). Throughout the year, among freshwater zooplankton, rotifers, cladocerans and copepods are dominant group (Hutchinson, 1967). For certain qualities such as purity, availability, acceptance, nutritional indicators, digestibility, reproductive and economic viability, some zooplanktons are selected as food sources in fish larvae culture (Watanabe and Kiron, 1994). Sufficient dietary supply of protein is needed for optimum growth of fish thus protein is the main constituents of the fish body.

Freshwater cladoceran or water flea *Moina macrocopa* has an excellent potential as a live food for larvae of finfish and crustaceans (Alam *et al.*, 1993; Kang *et al.*, 2006). *Moina* contains superior nutritional value than commercially available newly hatched *Artemia nauplii* (He *et al.*, 2001). Worldwide distribution of *Moina* has increasing demand for food of larvae and juvenile finfish, because of their rapid growth potential (Pennak, 1989; Benider *et al.*, 1998). The protein content of *Moina* usually averages 50% of the dry weight and the total amount of fat per dry weight is 20-27% for adult females and 4-6% for juveniles (Rottmann *et al.*, 2003). All zooplanktons are not suitable for fry rearing but live rotifers, *Moina* and *Daphnia* species are reported to be good freshwater zooplanktons that can enhance protein and other nutritional values of farmed fish (Olojo *et al.*, 2003). Larger prey such as *Moina*, *Daphnia* become preferable with the increasing age and size of fish larvae, most of early fish larvae consume rotifers in large amount (Khadka and Rao, 1986).

* Corresponding author e-mail: shamsur@du.ac.bd

Cladocerans have been found to be rich in essential nutrients, are 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).

Various kinds of live food or zooplankton can be used as diets for fish fry and; the culture and utilization of these potential organisms are vital for fish fry production in hatcheries. Information about mass culture and nutritional values of *M. macrocopa* under suitable culture conditions and its applications as live food for freshwater Tilapia culture improves the quality, quantity and cost effectiveness of the production facilities. The present study was aimed at rearing *M. macrocopa* and to investigate the growth and body composition of Tilapia fry fed with *M. macrocopa* as live zooplankton feed.

Materials and methods

Experimental design

The whole experiment was designed for 2 types of culture; a) culture of live zooplankton *M. macrocopa* and b) culture of experimental fish fry of Tilapia, *O. niloticus*.

Experiment 1: Effects of different diets on rearing *M. macrocopa*

The experimental organism, *M. macrocopa* samples were collected from various places of Gulshan Lake (about 23°48' N latitude and 90°25' E longitude), the northernmost lake in a chain of water bodies located in Dhaka city and carried to the laboratory located in Zoology Section, Biological Research Division, Bangladesh council of Scientific and Industrial Research (BCSIR). Samples of *M. macrocopa* were easily collected in winter (November) from the water surface by sieve number 270 (mesh=0.05 mm) and kept in cool and dry place. The collected *M. macrocopa* was identified according to Brooks (1959). To prepare *M. macrocopa* stocks, collected samples were kept in aquarium at a temperature of $25 \pm 2^\circ\text{C}$ and having pH of 7.5 and aerated vigorously. After 7 days, aeration was stopped and they were removed to some new aquaria by siphoning out. Before starting the main experiment, they were fed with Spirulina flake. During stock maintenance, culture was examined daily, all exuviae and any dead individuals were removed and up to 50% of water was also changed twice a week.

M. macrocopa was semi continuously cultured for 30 days. The culture was designed as four treatments and each treatment had two replications. Treatment-1 was fed with handmade feed, treatment-2 was fed with cabbage leaves, treatment-3 was fed with yeast and treatment-4 was fed with Spirulina (*Spirulina platensis*) flake.

Mass cultivation of *M. macrocopa* was carried out in eight aquariums of size 0.9m × 0.46m × 0.6m with 24 hours aeration having 60 liters of tap water under natural light illumination at a temperature of $25 \pm 2^\circ\text{C}$ adjusted by using thermostatically controlled heaters, pH 7 ± 1 and a dissolved oxygen level of 3-6 mg/L. The tap water was left one day for seasoning. On the 2nd day feed was applied in the aquarium according to the experimental design. On the 3rd day, 200 individual of *M. macrocopa* was stocked to each aquarium. To count the population of zooplankton 1000 ml of culture water was sampled randomly and then in 1 ml of that water was taken by a dropper and number of zooplankton was counted. Finally total population density was determined according to the formula outlined by Ovie (1991): $P_d = 100 \times B_x / V$ ml, where P_d = population density of *M. macrocopa* in 1000 ml of water, V = Average volume of water sample, B_x = Average number of *M. macrocopa* counted in various random sampling.

Experiment 2: Effects of *M. macrocopa* on culture of Tilapia fry

The culture of *O. niloticus* was conducted for 56 days. The experiment was designed as three treatments where treatment-1 was fed with handmade feed (control), treatment-2 was fed with commercial feed & treatment-3 was fed with live food *M. macrocopa* (fed Spirulina). The proximate composition of the experimental diets are shown in Table I. The experimental homemade feed was combined with fish grain 13.7%, shrimp grain 13.7%, soybean 13.7%, Wheat 14.5%, vitamin and minerals 0.85%, corn grain 14.5%, rice bran 14.5%, oil cake 13.7% and fat 0.85%. Six culture aquariums of 1.1m × 0.46m × 0.3m were washed, drained and left to dry for a couple of day prior to the beginning of the experiment. The experimental aquariums were disinfected by 70% alcohol prior to the experiment started.

Fry of Tilapia (*O. niloticus*) (2.87 ± 0.04 cm and 0.424 ± 0.03 g) were collected from Mymensingh and carried in oxygenated bags with water in the laboratory located in Zoology Section, BCSIR Lab, Dhaka. Before stocking, Tilapia fry were acclimated in laboratory conditions at a temperature of $25 \pm 2^\circ\text{C}$ adjusted by using thermostatically controlled heaters, pH 7 ± 1 , 24 h continuous aeration and a dissolved oxygen level of 3-6 mg/L for 24 h without supplying any food.

The fry were randomly distributed at a rate of 30 fry per aquarium. The three diets were fed to the experimental fish in six replicate aquariums per dietary treatment. Feeding was done twice daily at 90-400 Moina/individual fish for first 20 days, then 500-850 Moina/individual fish for 15 days and 900-1250 Moina/individual fish for remaining days. Each

ration was divided into two equal parts, one portion was offered at 10.00 am while the other at 5.00 pm. Partial exchange of water from each aquarium was done daily during the removal of uneaten feed and faeces. Physico-chemical parameters of water such as temperature, dissolved oxygen, pH, conductivity, total dissolved substance and light intensity were recorded twice in a week.

Sampling was performed in the 14th, 28th, 42th and 56th day of the experimental period and, length and weight of individual fish were recorded for further analyses.

Growth indices

Fish growth performance was calculated using the following formulae:

a) Condition factor, $K = W / L^3 \times 100$ Where, K= Condition factor, W= Body weight in grams and L= Body length in centimeters

b) Average Daily Gain (ADG, g/day) = (Mean final weight - mean initial weight) / time interval (days)

c) Specific Growth Rate (% day) = (Log_e final weight - Log_e initial weight) / time interval (days) × 100

d) Feed Conversion Ratio (FCR) = Feed consumed by the fish / weight gain by the fish

e) Survival Rate (%) = Number of fry that survived / Total no. of fry stocked × 100

Body composition analysis

At the end of the 56-day rearing period of Tilapia fry total protein (micro-Kjeldahl method), total lipid, ash and moisture content were determined (AOAC, 1995). Moisture content was estimated by drying the samples to constant weight at 105°C in a drying oven and nitrogen content using a micro-Kjeldahl apparatus (Automatic Kjeldahl Digester, DKL 8 Series, VELP Scientifica, Italy and Kjeltac 2100, Distillation Unit, FOSS Analytical, Denmark). Crude protein was estimated by multiplying nitrogen content by 6.25. Lipid content was determined by ether extraction in a multi-unit Soxhlet extraction apparatus for 16 h. Ash was determined by combusting dry samples in a Muffle Furnace at 550°C for 6h.

Statistical analysis

Data were analyzed by using one-way ANOVA followed by Tukey's HSD post hoc for multiple comparisons. The data were presented as mean ± SEM and evaluated by using the statistical package of SPSS (version 20.0) with the level of significance at $p < 0.05$.

Results and discussion

The present study described the effect of different diets on the population of zooplankton, *M. macrocopa* at different rearing periods and the effect of *M. macrocopa* on the growth parameters and body composition (moisture, protein, fat and ash) of Nile Tilapia fry.

Water quality parameters

Water temperature, dissolved oxygen and pH for the culture of *M. macrocopa* are given in Table I. In the present study the temperature for culturing *M. macrocopa* was $27.99 \pm 1.03^\circ\text{C}$. In the culture period of *M. macrocopa* the pH of water was 8.09 ± 0.18 having dissolved oxygen of 5.74 ± 0.22 mg/L.

In the present study for rearing Tilapia fry dissolved oxygen, temperature, pH, conductivity, total dissolved substance and light intensity were found 5.61 ± 0.13 mg/L, $25.82 \pm 0.91^\circ\text{C}$, 8.01 ± 0.09 , 7.03 ± 0.04 $\mu\text{s/cm}$, 4.41 ± 0.03 mg/L, 0.3 ± 0.1 lx, in different feeding trial of Nile Tilapia, respectively (Table II).

Water quality parameter for culturing of *M. macrocopa* and *O. niloticus* in this experiment varied with the type of diet supplied without affecting the growth of the fish. No significant difference was found in temperature, pH and dissolved oxygen. Rottmann *et al.* (2003) showed that the optimum temperature for culturing *Moina* ranges from 24-31°C and low temperatures reduced its production. They also suggested that excessively high pH (>9.5) may inhibit the production of *Moina* adjusting the culture water pH to 7-8.

Experiment 1: Effects of different diets and rearing period on population density of *M. macrocopa*

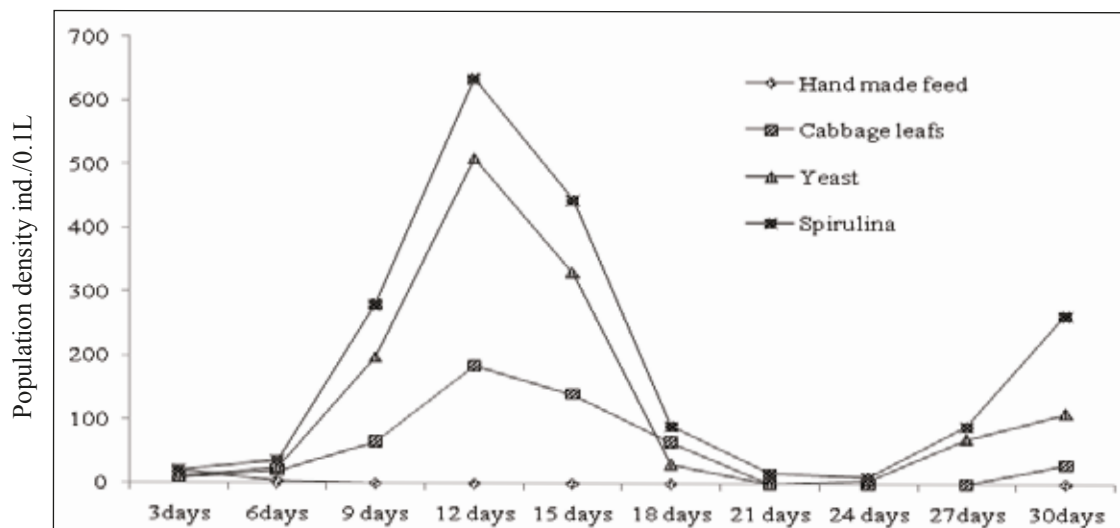
The results of the rearing period of growth of *M. macrocopa* indicated that population density was increased from day 3 to the day 13 in all treatments except handmade feed (Fig. 1). Among four treatments, population of *M. macrocopa* was increased from 20 individual/L of water to 6350 individuals/L of water in the 13th day in treatment-4 fed with Spirulina. The declining growth rate of *M. macrocopa* was observed from the 14th to 24th day in treatment-4 fed with Spirulina. After that, the growth rate was increased. In the treatment fed with yeast, population of *M. macrocopa* was enhanced from 10 individuals/L of water to 5100 individuals/L of water in the 13th day during growth period. Then declining growth rate was observed from the 14th to 21th day. After that the increasing growth rate was recorded. In handmade feed treatment, after 9 days no individual was found in the random sample water. In cabbage leaves, maximum growth was found in the 13th day which was 1900 individuals/L of water. Then population was gradually declined up to 27 days. On the other hand, rearing period of

Table I. Water quality parameters in live zooplankton feed, *M. macrocopa* culture aquarium under different treatments during the study period

Parameter	Diet type			
	Cabbage leaf	Handmade feed	Yeast	Spirulina
Temperature (°C)	28.2±1.02	28.2±1.15	28.08±1.21	27.48±0.73
Dissolved oxygen (mg/L)	5.57±0.31	5.39±0.30	6.06±0.14	5.94±0.12
pH	7.9±0.06	8.28±0.30	8.26±0.29	7.94±0.07
Conductivity (µs/cm)	6.99±0.06	6.91±0.08	6.87±0.06	6.95±0.06
TDS (mg/L)	4.95±0.30	6.02±0.08	6.14±0.21	6.09±0.09
Light intensity (lx)	3.06±2.40	2.40±1.89	2.42±1.89	2.64±0.96

Table II. Water quality parameters in Nile Tilapia, *O. niloticus* aquarium under different treatments during the study period

Parameter	Diet type		
	Handmade feed (Control)	Commercial feed	Live feed (<i>M. macrocopa</i>)
Temperature (°C)	25.92±0.94	25.82±0.91	25.76±0.81
Dissolved oxygen (mg/L)	5.53±0.28	5.57±0.27	5.61±0.13
pH	8.16±0.28	8.05±0.17	8.01±0.09
Conductivity (µs/cm)	7.04±0.08	7.00±0.10	7.03±0.04
TDS (mg/L)	4.35±0.07	4.42±0.08	4.41±0.03
Light intensity (lx)	0.39±0.10	0.39±0.10	0.4±0.05

**Fig. 1. Effects of rearing period on the number of individuals of *M. macrocopa* in four types of feed media**

M. macrocopa with 4 different feed media, Spirulina showed the highest population density.

In the culture of live zooplankton feed, *M. macrocopa*

highest population density was detected in the treatment fed with Spirulina at the 13th day. According to Rottmann (2003) *Moina* reproduces at only 4-7 days of age, with a brood size of 4-22 per female. Broods are produced every 1.5-2.0 days,

with most females producing 2-6 broods during their lifetime. The growth, reproductive potentials and longevity of *Moina* sp. are affected by the nutrient conditions of the culture media (Jana and Chakrabarti, 1993). Loh *et al.* (2009) reported that *M. macrocopa* fed with *Spirulina* elapsed 7 days for rising population to its peak.

Experiment 2: Effects of *M. macrocopa* on culture of *Tilapia* fry

Growth performances of *O. niloticus* fed with *M. macrocopa* Higher growth and feed utilization of *Tilapia* fry were observed in the present study having *M. macrocopa* as live feed. This study revealed that growth indices such as condition factor, ADG, FCR, survival rate and SGR of Nile *Tilapia* were better for live feed, *M. macrocopa* than those of other feed.

Condition factor: The highest condition factor was found in the treatment-3 (2.18 ± 0.09) fed with live feed and the lowest was in the treatment-1 (1.87 ± 0.09) fed with handmade feed given in Fig. 2. On the 56th day, comparatively higher value (2.18 ± 0.09) was found in live feed treatment than those of handmade and commercial feed.

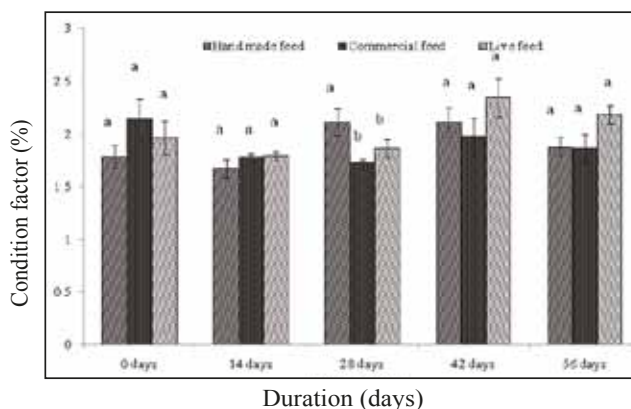


Fig. 2. Condition factor (%) of *Tilapia* fry at 56 days rearing period. Bars (Mean \pm SEM) with different letters are significantly different within group (ANOVA, HSD; $p < 0.05$)

Average daily gain (ADG g/day): Fig. 3 represented the highest average daily gain of *Tilapia* fry was found in treatment-3 and the lowest was in treatment-1. The ADG value of treatment-3 (0.13 ± 0.01) was significantly higher than that of treatment-1 (0.06 ± 0.01) at 5% level. On the 14th and 28th days average daily gain of fish fed with live feed was found highly significant compared to handmade and commercial feed. On the 56th day, significantly (ANOVA, $F_{2,29} = 5.995$, $p < 0.05$) higher average daily gain was observed in live feed treatment (0.13 g/day) compared to commercial feed (0.08 g/day).

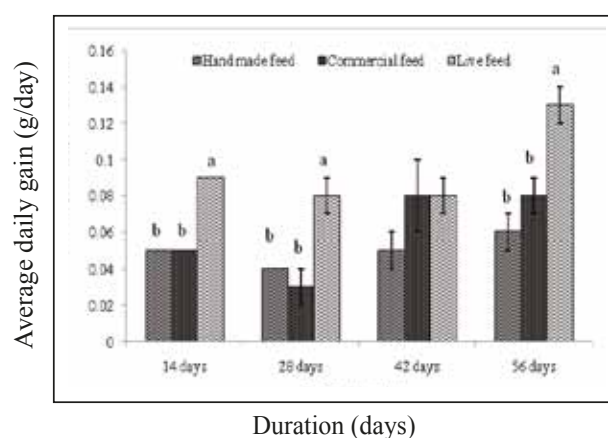


Fig. 3. Average daily gain (g/day) of *Tilapia* fry at 56 days rearing period. Bars (Mean \pm SEM) with different letters are significantly different within group (ANOVA, HSD; $p < 0.05$)

Feed conversion ratio (FCR): Fish, that were fed on live feed (1.74 ± 0.17) exhibited lowest feed conversion ratio (FCR) than those fed on handmade (3.14 ± 0.72) and commercial feed (2.23 ± 0.54). On the 56th day, feed conversion ratio did not differ significantly (ANOVA, $F_{2,29} = 0.833$, $p > 0.05$) (Fig. 4).

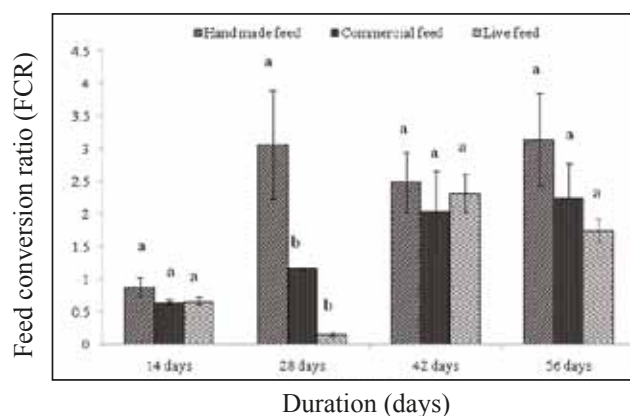


Fig. 4. Feed conversion ratio of *Tilapia* fry at 56 days rearing period. Bars (Mean \pm SEM) with different letters are significantly different within group (ANOVA, HSD; $p < 0.05$)

Specific growth rate (%): The highest specific growth rate of *Tilapia* fry was found in treatment-3 ($2.58 \pm 0.20\%$) and the lowest was in treatment-1 ($2.18 \pm 0.44\%$). SGR value of treatment-2 was higher than treatment-1 and lower than treatment-3 (Fig. 5). On the 56th day specific growth rate did not vary significantly (ANOVA, $F_{2,29} = 0.981$, $p > 0.05$).

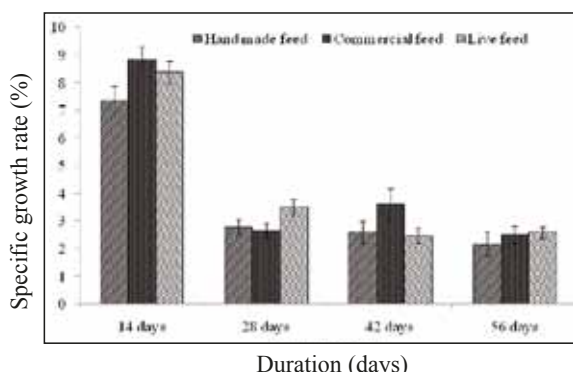


Fig. 5. Specific growth rate (%) of Tilapia fry at 56 days rearing period. Bars (Mean ± SEM) with no letters denote no significant difference within group (ANOVA, HSD; p>0.05)

Survival rate (%): Fig. 6 shows, after culture period of 56 days, the survival rates of Tilapia fry in the handmade, commercial and live feed were (88.5±1.5%), (91.5±1.5%) and (91.5±1.5%), respectively.

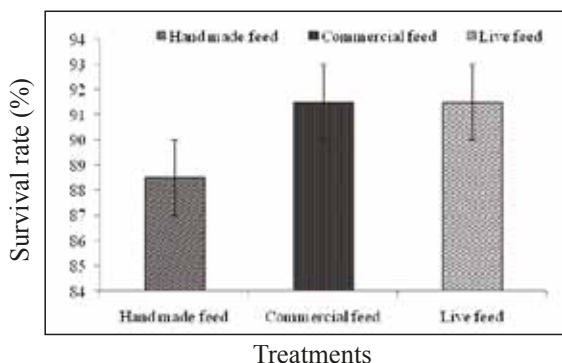


Fig. 6. Survival Rate (%; Mean ±SEM) of Tilapia fry at 56 days rearing period. Bars (Mean ± SEM) with no letters denote no significant difference among treatments (ANOVA, HSD; p>0.05)

In fish, the condition factor (K) reflects the variations on the physiological state in relation to its different factors. Rahman *et al.* (1997) in a study on the survival and growth of cat fish provided with selected supplemental feeds got the values of condition factor between 0.81-0.87. On the 56th day of culture of Tilapia fry comparatively higher value (2.18 ± 0.09) was found in live feed treatment than handmade and commercial feed. From a nutritional point of view, the condition factor indicates the accumulation of fat and gonadal development (Le Cren, 1951).

Watanabe *et al.* (1990) studied the growth, survival and feed conversion ratio of Florida red Tilapia and found the average daily gain 1.94 g on 84 days. In this study higher average

daily gain was found in live feed treatment (0.13g/day) than commercial feed (0.08g/day).

For fish fed with well-prepared diets, FCR values below 1 have been reported, although generally it ranges between 1.2 and 1.5 (De Silva and Anderson, 1995). On the 56th day of this study, the estimated optimum FCR was 1.74 ± 0.17 when Tilapia fry was fed with live feed. Ogunji and Wirth (2000) proclaimed that FCR was 1.19 when they used fish meal diets and that indicated the most efficient utilization of feed by *O. niloticus* fingerlings.

Fermin (1991) showed that the specific growth rate of sea bass was 18.82% fed by *M. macrocopa*. SGR 3.39 at the dietary protein content of 33.32% DM, indicated the most efficient utilization of feed by *O. niloticus* fingerlings (average initial weight 4 – 5 g) (Ogunji and Wirth, 2000). Average SGR was 3.54 on 84 days was recorded when Watanabe *et al.* (1990) studied the growth, survival and feed conversion ratio of Florida red Tilapia. In the present study highest specific growth rate of Tilapia fry was found in treatment-3 (2.58 ± 0.20%) fed with *M. macrocopa*. de la Pena (2001) showed that the survival rate of sea bass larvae was 92.4-99.0% fed by *Diaphanosoma celebensis*. In the present study the survival rate was (91.5±1.5%) fed by *M. macrocopa* which is very similar.

Chemical analyses of Tilapia fry O. niloticus

Significantly (ANOVA, $F_{2,3} = 32.636, p < 0.05$) higher value of moisture was found (82.76%) in handmade feed treatment than live feed (78.62%) (Fig. 7).

Significantly (ANOVA, $F_{2,3} = 50.008, p < 0.05$) higher value of protein was observed in live feed treatment (15.91%) and lowest value in handmade feed (10.96%) at 5% level of significance.

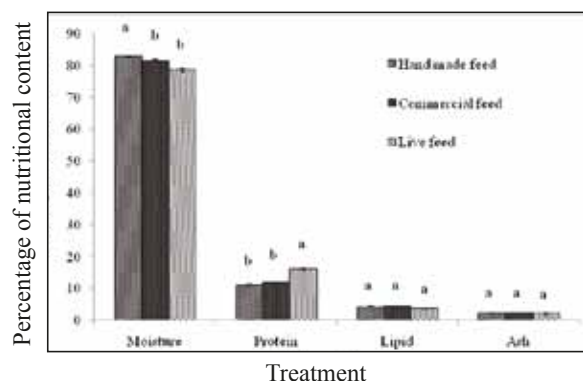


Fig. 7. Chemical composition of Tilapia fry at 56 days rearing period. Bars (Mean ± SEM) with different letters are significantly different within groups (ANOVA, HSD; p<0.05)

For lipid and ash content no significant difference was found among three treatments at 5% ($p < 0.05$) significance level.

Concerning chemical composition, crude protein, lipid, fat, moisture and ash contents of Nile Tilapia fed with *M. macrocopa* were better compared to other feeds. However, the highest protein content was observed in live feed. The highest lipid and ash contents were recorded for commercial feed. In a study Desrosier and Derossier (1977) reported that generally fish contain 70-80% moisture and the amount of protein in fish was reported to be in a range of 13-20%. In another experiment (INFS, 1983) protein content of fresh water fish was reported to be in a range of 15-18%. Govindan (1985) also showed a range of 9-25% protein in freshwater and marine fish. In the present study, the protein content in treatment-3 is similar to the value reported in these previous studies. Hence, body composition is mainly influenced by the dietary lipid supply and availability as it has been demonstrated in other fish species such as Eurasian perch (Xu *et al.*, 2001; Mathis *et al.*, 2003). According to Pouomogne *et al.*, (1997) dietary mineral composition influenced crude ash incorporation in body tissues of Tilapia.

Conclusion

In the present study, significantly positive effect was found by using *M. macrocopa* as live zooplankton feed on the growth and body composition of Tilapia fry. On the other hand, Nile Tilapia fed with handmade feed showed the poorest growth and body compositions. The average daily gain, specific growth rate, survival rate and protein contents were better in live feed treatment of Tilapia culture than those of other treatments. Therefore, *M. macrocopa* can be used as alternative of commercial feed for Tilapia fry rearing in hatchery and nursery.

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