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Effects of Different Feed Types on Growth and Production of the Early Life Stages of Farmed Fish

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ABSTRACT

Newly hatched larvae of *Carassius auratus* and *Cyprinus carpio* var. *koi* were stocked separately in 50-liters culture tanks with 250 individuals/ tank in triplicate. Specimens were divided into four groups and fed with pelletized feed, *Thermocyclops decipiens*, *Moina micrura*, and mixed diet (50% *T. decipiens* and 50% *M. micrura*) for 40 days. The final results of *C. auratus* (length 21.40 ± 0.15mm and weight 54.79 ± 1.37mg) and *C. carpio* var. *koi* (length 25.73 ± 0.66mm and weight 65.07 ± 1.40mg) growth parameters, specific growth rate, biomass and percentage weight gain were significantly higher in *T. decipiens* feeding regime. However, the survival rates of both fish larvae were high in mixed diet regime. The biochemical profiles of both larvae were significantly different (P<0.05) between the feeding regimes. Based on the results, live-feed organisms are more effective foods than pelletized feed for the early stages of both larvae.

INTRODUCTION

Sustainability in aquaculture depends on various factors, including yield, environmental condition, hatchery and farm management. Live feed is fundamental factors in larval rearing for sustainable culture of fin fishes and shellfishes. Fin fishes larvae have undeveloped digestive system with low level enzymes. The ornamental fish is an economically important trade sector in the global scenario **(Subharanjani *et al.*, 2015)**. The ornamental fishes culture have the prospective to contribute to the national trade **(Abraham *et al.*, 2007; de Araújo *et al.*, 2020)**. The goldfish *Carassius auratus* and carp *Cyprinus carpio* var. *koi* are the most popular aquarium fish known for their ability to grow in a wide range of environmental conditions **(Zambrano *et al.*, 2006; Martinez, 2008)**. The development of larvae to reach the juvenile stage constitutes the most critical period in the life cycle of fish. **Qin and Fast (1997)** stated that, rotifers and *Artemia* nauplii are common live feed organisms to fish larvae. They are common live food organisms for hatchery use. For replacement of those live feeds, in the present study, cladoceran and cyclopoid copepod were used as starter feed. There is a need for a

growing concern with respect to the production of cladoceran **(Adeyemo *et al.*, 1994; Sivakumar 2005; Altaff & War, 2010)** and cyclopoid **(Sivakumar, 2005).**

Many authors have studied the application of different starter feeds for feeding the early stages of fry in various fish species **(Stottrup *et al.*, 1986, 1997; Toledo *et al.*, 1999; Sorgeloos *et al.*, 2001; Sivakumar, 2005; Hojgaard *et al.*, 2018)**. *Artemia* nauplii are widely recognized to be the preferred starter feed for ornamental fish species **(Lim *et al.*, 2003)**. Seed production and larval developments of freshwater and marine water fishes were successfully reared using live feed organisms **(Bodis *et al.*, 2007; Hamackova, 2007; Wang *et al.*, 2008; War *et al.*, 2011; Demir & Sarigoz, 2016)**. Fish larvae have successfully been reared using live zooplanktons **(Watanabe & Fujita, 1983; Sivakumar, 2005; War *et al.*, 2011)**. Among these, the genus *Moina* is a suitable initial feed for *Chanos chanos* **(Villegas, 1990)** and *Clarias macrocephalus* **(Fermin & Bolivar, 1991)**, the genus *Mesocyclops* sp. for *Poecilia reticulata* **(Zehra, 2000)** and the genus *Cryptocyclops* sp. for *Gambusia affinis* **(Sujatha, 2000)**.

The fin and shellfish larvae are reared using wild live food **(Altaff *et al.*, 2002)** and cultured live food organisms **(Alam *et al.*, 1993; Kumar *et al.*, 2005; Sivakumar, 2005; Mollah *et al.*, 2009)**. In the large scale, for fish larvae production, the amount of live food needed is important on account of the cost-effectiveness of its production and its low dependability. The amount of food wastage can be reduced by ascertaining the amount of live food required daily, to support fish larvae growth and survival **(Kamrunnahar *et al.*, 2019).** The Indian ornamental fish has great demand in the International market. Hence, the present study aims to evaluate the effects of cyclopoid copepod, *T. decipiens*, and cladoceran *M. micrura* on the growth, survival, and biochemical profile of *C. auratus* and *C. carpio* var. *koi* larvae.

MATERIALS AND METHODS

2.1 Culture of live feed

Zooplankton samples were collected using plankton net (mesh size 50µm) from Velachery freshwater bodies, Chennai, during the early hours of the day. They were transported to the laboratories within 1 hour and were acclimatized in the laboratory for 24 hours. *T. decipiens* and *M. micrura* were sorted out from the samples using the binocular stereomicroscope. These organisms were cultured with chicken manure (100ppm) and mixed algae (*Pennate* sp., *Eurastrum* sp. and *Stephanodiscus* sp.) at the rate of 4.25 x 10^4 cells/ml in 25 l fiber tanks. The inoculum of *T. decipiens* (50nos./l) and *M. micrura* species (40nos./l) was introduced into the culture tanks **(Sivakumar, 2005)**. The cultured species of *T. decipiens* and *M. micrura* were harvested from 7^{th} days and 4^{th} days onwards from the culture tank and fed to the fish larvae.

2.2 Broodstock and maintenance conditions

Breeding, spawning, and larval rearing of the goldfish, *C. auratus*, and koi carp, *C. carpio* var. *koi* were carried out in the laboratory. Broodstocks of these species were procured from Kandhan hatchery, Chennai, India, and maintained in cement tanks and fed with live-feed (tubifex worms and Chirnomous larvae). The breeding and spawning tanks water was maintained with a pH of 6.5-7, the temperature of 27-32ºC, and ammonia level less than 0.5mg/l for breeding these fishes. The tank water is continuously aerated. The breeding tanks were provided with aquatic weed (*Chara*). The brooders were introduced in the late evening hours into the breeding tanks. The usual male: female ratio of *C. auratus* introduced was 4:1 and in the case of *C. carpio var. koi* it was 2:1.

The brooders were carefully transported to another tank when the spawning process was completed. The aquatic weeds with attached eggs were carefully removed from the breeding tank and distributed uniformly into a hatching hapa (2.5 x 1 x 1.5m) constructed of thin cloth and kept in water of comparable quality to the breeding tank. Depending on the water temperature during embryonic development, the incubation period varies from 36 to 72h after fertilization. The hapas with developing eggs were maintained undisturbed until the eggs hatch out into larvae.

2.3 Experimental design

To evaluate the live feed organisms (*T. decipiens*, and *M. micrura*), a batch of 250 larvae of *C. auratus* (length 3.27 ± 0.18mm and weight 9.09 ± 0.03mg) and *C. carpio* var. *koi* (length 4.17 ± 0.05mm and weight 12.99 ± 0.37mg) were introduced into the separate culture tank [90cm (length) x 70cm (diameter)] in 50 lit of water in triplicate. The initial length and weight of 100 individual larvae were measured. The stocking densities of larvae were 5 animals / lit. They were divided into 4 groups viz., Group I - pelletized feed (control feed); Group II - *T. decipiens*; Group III - *M. micrura*; Group IV- mixed diet (50% *T. decipieins* and 50% *M. micrura*). The larval tanks were aerated and maintained without feed during the non-feeding stage of the larvae. The control (30% of body weight) (Sivakumar, 2005) and experimental feeds (500 individual/fish day^{-1}) (Qin and Fast, 1997) were supplied to the fish at 7:00, 13:00, and 18.00 hours daily, and feed was provided to the larvae for 40 days. Every day morning hour's fecal matter and excess feed were removed by siphoned out from the larval rearing tank and 50% of water was replenished.

At the end of the experimental period, the length and weight of 100 randomly collected larvae from each rearing tanks were measured. The survival rate of both the larvae was recorded on every 8 days interval of the experimental periods.

2.4 Biochemical analysis

At end of the experiments, 10 larvae were collected from each tank for biochemical parameters such as protein **(Lowry *et al.*, 1951)**, carbohydrate **(Roe 1955)**, and lipid **(Folch *et al.*, 1957)** were analyzed of both the fish larvae.

2.5 Data collection and statistical analysis

Both fish larvae were sampled at various points during the study period to measure growth and survival. The larvae's specific growth rate (SGR), percentage weight gain (PWG), survival percentage **(Dash *et al.*, 2014)**, and condition factor **(Htun-Han, 1978)** were calculated.

$$SGR = \frac{\ln(\text{final weight of the larvae}) - \log(\text{initial weight of the larvae})}{\text{Experimental periods in days (t)}}$$

where:

SGR % = percentage increase in body weight per fish per day

$$Percentage\ weight\ gain\ (PWG) = \frac{\text{Final weight of the larvae} - \text{Initial weight of the larvae}}{\text{Inital weight of the larvae}} \text{ x } 100$$

$$Survival\ (\%) = \frac{\text{Number of live fish counted}}{\text{Number of fish stocked}} \text{x} 100$$

$$\text{Biomass (mg)} = \text{No. of animal x average weight of the animal(mg)}$$

Condition factor

$$Conditionfactor\ (CF) = \frac{\text{Weight of the larvae}}{\text{Length of the larvae}^3} \text{x} 100$$

The experimental data were normalized by normality and homoscedasticity using the Shapiro–Wilk and Bartlett tests, respectively. They are presented as mean and standard deviation. Repeated-measures analysis of variance (rANOVA) was performed on survivorship with $p<0.05$ significance level. The growth parameters of larvae comparison with one-way ANOVA was performed at $p<0.05$ significance level using SPSS 21.0 ver.

RESULTS

The growth parameters of *C. auratus* and *C. carpio* var. *koi* larvae fed with different feeding regimes are shown in tables 1 & 2. The final length and weight of the *C. auratus* larvae (21.40 ± 0.15mm and 54.79 ± 1.37mg) and the *C. carpio* var. *koi* larvae (25.73 ± 0.66mm and 65.07 ± 1.40mg) showed a significant increase in *T. decipiens* (Group II) feeding regimes. This was followed by an increase in the order of mixed diet (Group IV), > *M. micrura* (Group II), > pelletized feed (Group I). The lowest growth parameters of both the fish larvae were recorded in control feeding regimes. Tukey's test showed that larvae growth parameters were significantly ($p < 0.05$) varied between the feeding regimes (Tables 1 and 2). Regression analysis between length and weight of both the larvae are depicted in figures 1 and 2. The result shows that length and weight were linearly increased in all the feeding regimes of both the fish larvae. However, *C. auratus*

larvae fed with *T. decipiens* feeding regime were high in their weight gain when compared to the length (Fig 1b).

Table 1: Growth and survival of *C. auratus* larvae with pelletized and live feed for 40 days

	Group I	Group II	Group III	Group IV	F	p
Initial length (mm)	3.23 ± 0.23[a]	3.23 ± 0.23[a]	3.27 ± 0.15[a]	3.33 ± 0.21[a]	0.15	0.92[NS]
Final length (mm)	15.43 ± 0.25[a]	21.40 ± 0.15[b]	16.75 ± 0.10[c]	18.57 ± 0.60[d]	174.66	0.00[*]
Initial weight (mg)	9.09 ± 0.03[a]	9.09 ± 0.02[a]	9.10 ± 0.04[a]	9.09 ± 0.03[a]	0.06	0.98[NS]
Final weight (mg)	21.77 ± 0.25[a]	54.79 ± 1.37[b]	37.40 ± 0.85[c]	43.80 ± 1.54[d]	452.83	0.00[*]
SGR (%)	2.18 ± 0.03[a]	4.49 ± 0.06[b]	3.53 ± 0.05[c]	3.93 ± 0.08[d]	913.27	0.00[*]
PWG (%)	139.46 ± 2.56[a]	502.96 ± 14.05[b]	311.12 ± 7.81[c]	381.64 ± 15.45[d]	549.29	0.00[*]
Biomass (mg)	2525.10±50.85[a]	9205.40±272.76[b]	7181.00±183.01[c]	9373.90±361.64[b]	506.294	0.00[*]
CF	47.02 ± 0.69[a]	85.34 ± 2.43[b]	74.44 ± 1.28[c]	78.63 ± 0.40[d]	416.34	0.00[*]
Survivorship	χ^2 (9) = 101.87, p = 0.000; F (4,44) – 37.560, p = 0.000					

Values are represented as mean ± SD of triplicate.
Data at the same sampling time with the different alphabet in row wise indicate significant difference ($p < 0.05$)

Table 2: Growth and survival of *C. carpio var. koi* larvae with pelletized and live feed for 40 days

	Group I	Group II	Group III	Group IV	F	p
Initial length (mm)	4.15 ± 0.05[a]	4.17 ± 0.07[a]	4.17 ± 0.06[a]	4.17 ± 0.06[a]	0.06	0.98[NS]
Final length (mm)	18.67 ± 0.35[a]	25.73 ± 0.66[b]	21.40 ± 0.78[c]	23.20 ± 0.26[d]	85.34	0.00[*]
Initial weight (mg)	12.88 ± 0.3[a]	13.01 ± 0.41[a]	13.03 ± 0.43[a]	13.04 ± 0.44[a]	0.10	0.96[NS]
Final weight (mg)	33.97 ± 0.70[a]	65.07 ± 1.40[b]	46.61 ± 1.13[c]	54.07 ± 0.81[d]	464.82	0.00[*]
SGR (%)	2.43 ± 0.03[a]	4.02 ± 0.03[b]	3.19 ± 0.04[c]	3.56 ± 0.04[d]	852.20	0.00[*]
PWG (%)	349.42 ± 2.68[a]	516.55 ± 5.89[b]	413.50 ± 11.76[c]	456.83 ± 4.12[d]	301.77	0.00[*]
Biomass	3328.90±87.84[a]	9825.30±236.95[b]	8017.90±225.71[c]	10705±187.38[d]	866.253	0.00[*]
CF	60.65 ± 0.16[a]	84.29 ± 0.38[b]	72.63 ± 1.48[c]	77.68 ± 0.56[d]	449.32	0.00[*]
Survivorship	χ^2 (9) = 110.38, p = 0.000; F (4,44) = 33.680, p = 0.000					

Values are represented as mean ± SD of triplicate.
Data at the same sampling time with the different alphabet in row wise indicate significant difference ($p < 0.05$)

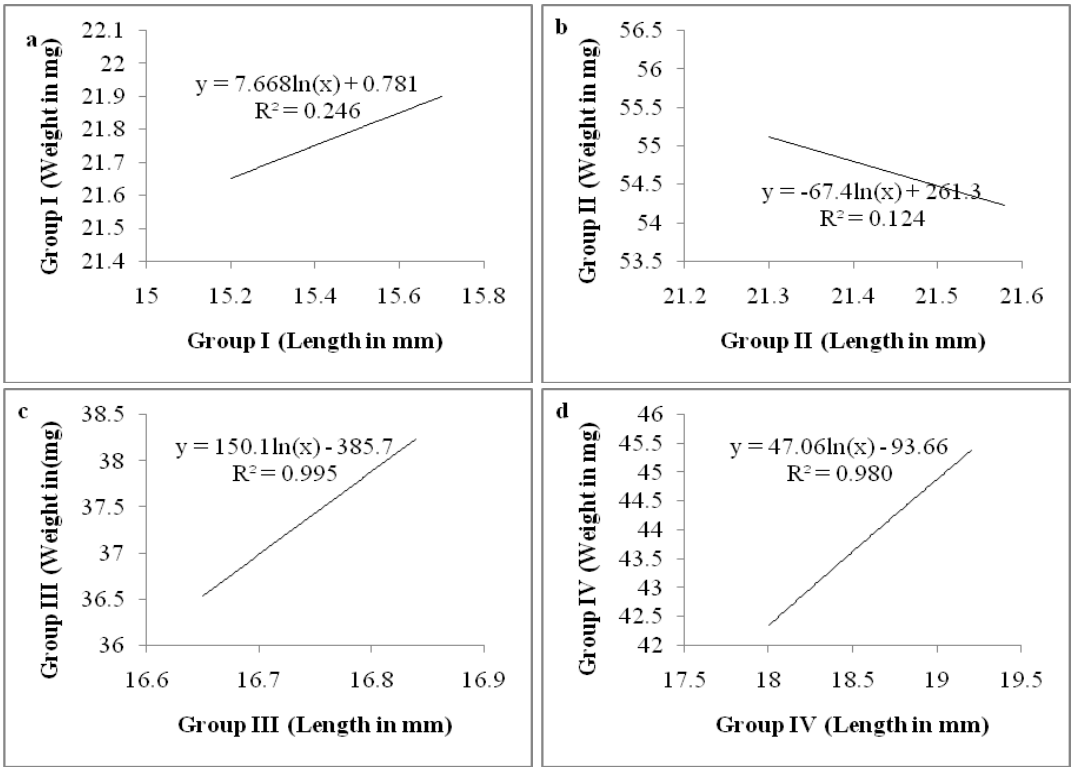

Fig. 1: Regression analysis between length and weight of *C. auratus* larvae fed in different feeding regimes

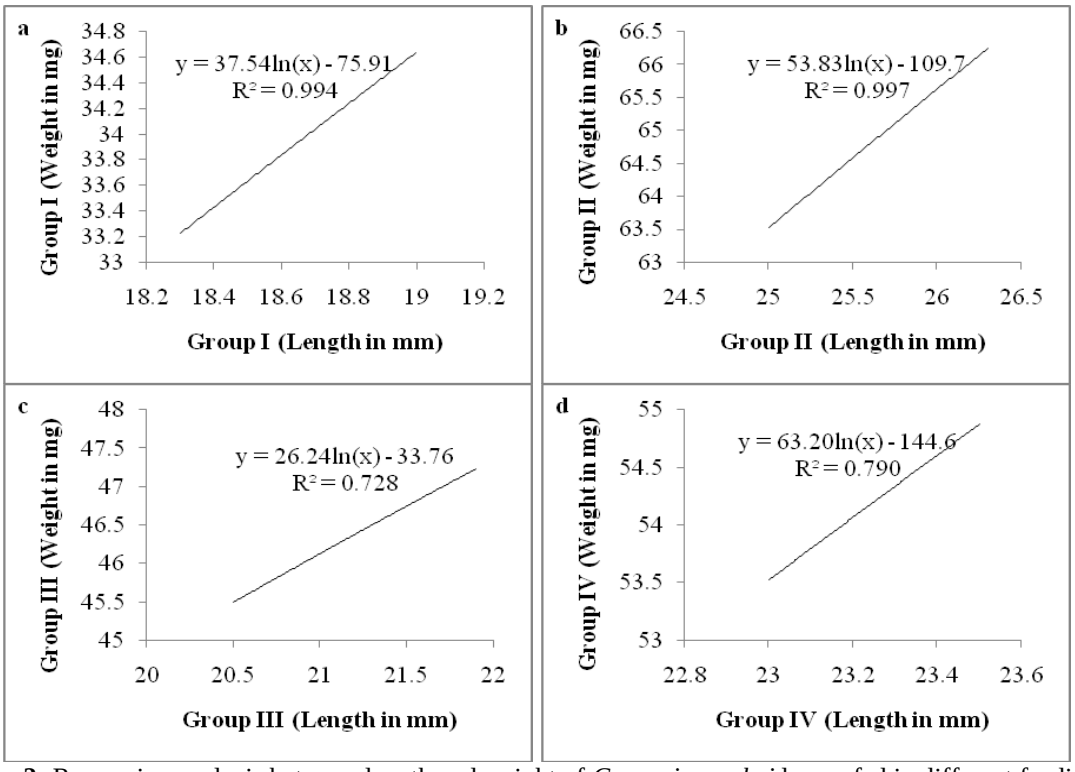

Fig. 2: Regression analysis between length and weight of *C. carpio var koi* larvae fed in different feeding regimes

The highest percentage of specific growth rate (SGR) and percentage weight gain (PWG) of *C. auratus* (4.49 ± 0.06% and 502.96 ± 14.05%) and that of *C. carpio* var. *koi* (4.02 ± 0.03% and 516.55 ± 5.89%) were recorded in the *T. decipiens* feeding regime. However, biomasses of these larvae were found significantly highest in mixed feeding regimes (Tables 1 and 2). The initial period SGR and PWG (up to 16 days) of both the larvae were high in control and *M. micrura* feeding regimes. Subsequently, the SGR and PWG values significantly increased ($P < 0.05$) in *T. decipiens* and mixed feeding regimes. The SGR and PWG of 2.18 ± 0.03% and 139.46 ± 2.56% in *C. auratus* and 2.43 ± 0.03% and 349.42 ± 2.68% were recorded as low percentages in control feeding regimes. Anova followed by Tukey's test performed that the biomass of *C. auratus* fed with *T. decipiens* and mixed diet regime was no significant different ($p > 0.05$), while in the case of C. carpio var koi biomass was significant different ($p < 0.05$) between the feeding regimes (Tables 1 and 2). The condition factors (CF) of both the larvae in control feeding regimes were gradually decreased during the entire experimental period. In the live feed organisms (Group II, III, and IV) feeding regimes showed an isometric increase in the length and weight of both the larvae. ANOVA followed by Tukey's test performed on those parameters showed significant difference ($p < 0.05$) between the different feeding regimes. (Tables 1 and 2)

However, the highest percentage survival of 85.6% and 79.2% for *C. auratus* and *C. carpio* var. *koi* larvae were recorded in mixed feeding regimes (Group IV) on the 40^{th} day, respectively. The lowest survival of *C. auratus* (46.40%) and *C. carpio* var. *koi* (39.20%) larvae was recorded in control feeding regimes (Figs. 3 and 4). Repeated ANOVA for the survival of both the larvae showed significant difference ($p < 0.05$) when compared to the 8^{th}, 16^{th}, 24^{th}, 32^{nd}, and 40^{th} days of the experiment. Among the larvae of these two fishes, all the growth parameters and survival were high in *C. auratus*. However, PWG was high in the larvae of *C. carpio* var. *koi.*

The biochemical profile of C. *auratus* and *C. carpio* var. *koi* larvae fed in different feeding regimes are shown in table 3. The high protein and carbohydrate of *C. auratus* were 3.73 ± 0.15gm/mg and 1.18 ± 0.03mg/gm, respectively, recorded in *T. decipiens* feeding regime, but no significant difference ($p > 0.05$), and in larvae fed with a mixed diet. The lipid content of *C. auratus* larvae showed no significant changes ($p > 0.05$) among live feed organisms (Table 3). In *C. carpio* var. *koi* larvae protein content was high in mixed feeding regimes. The lipid content of *C. carpio* var. *koi* showed no significant change between different feeding regimes. (Table 3)

Table 3: Biochemical composition of *C. auratus* and *C. carpio* var. *koi*

	C. auratus			*C. carpio var koi*		
	Protein (mg/g)	**Carbohydrate (mg/g)**	**Lipid (mg/g)**	**Protein (mg/g)**	**Carbohydrate (mg/g)**	**Lipid (mg/g)**
Group 1	3.06 ± 0.05^{a}	0.75 ± 0.05^{a}	0.13 ± 0.02^{a}	3.05 ± 0.05^{a}	1.08 ± 0.03^{a}	0.15 ± 0.01^{a}
Group II	3.73 ± 0.15^{b}	1.18 ± 0.03^{c}	0.15 ± 0.01^{ab}	3.80 ± 0.10^{b}	1.28 ± 0.02^{c}	0.17 ± 0.01^{a}
Group III	3.30 ± 0.10^{a}	1.01 ± 0.04^{b}	0.14 ± 0.01^{ab}	3.50 ± 0.10^{c}	1.13 ± 0.02^{ab}	0.15 ± 0.01^{a}
Group IV	3.60 ± 0.10^{b}	1.15 ± 0.05^{c}	0.16 ± 0.01^{b}	3.90 ± 0.10^{b}	1.22 ± 0.08^{bc}	0.16 ± 0.02^{a}
F	23.80	66.02	0.91	53.79	13.81	1.98
p	0.00^{*}	0.00^{*}	0.48^{NS}	0.00^{*}	0.002^{*}	0.20^{NS}

Values are represented as mean ± SD of triplicate.
Data at the same parameters with the different alphabet in column wise indicate significant difference ($p < 0.05$)

DISCUSSION

In the present study, *C. auratus* and *C. carpio* var. *koi* larvae were accepted the pelletized feed and live feed. These diets supported to growth and survival of the fish larvae in forty-day larval rearing experiment. The larval rearing of finfishes invariably needs live feed organisms. In ornamental fish rearing, *Moina* is used for the rearing of fishes **(Rottmann *et al.*, 2003; Lim *et al*., 2003)**. *P. conchonius* was reared using *T. decipiens* **(Divya and Ramasubramaniyam, 2019).** In the present study, *T. decipiens* and *M. micrura* were used for the rearing of *C. auratus* and *C. carpio* var. *koi*. The length and weight of these fish larvae recorded faster growth in the *T. decipiens* feeding regime compared to other feeds, because it offers a different size spectrum of prey which includes nauplii, copepods, and adults. Faster growth parameters of fish larvae were recorded with live feed fed larvae. Many authors reported that finfishes and shellfishes preferred live feed organisms compared to pelletized feed during early stages **(Murugesan *et al.*, 2010; Bakhtiyar *et al.*, 2011; Priyadarshini *et al.*, 2011)**. **Wang *et al.* (2008)** reported that *Misgurnus anguillicaudatus* showed a slower growth rate and least survival fed with microparticle diets compared with *M. micrura*. Similar results were also reported for other finfish species **(Degani, 1991; Hung *et al.*,1999; Hebb *et al.*, 2003).**

The selection of feed is important during the early stages of fish; it is the transmission from endogenous to exogenous feeding (Sivakumar 2005). During this stage, the live feed plays a vital role in the growth and survival of fishes **(Santamaria *et al.*, 2004).** The rearing of fishes larvae fed with artificial feed showed relatively poor results **(Akbary *et al.*, 2010)** compared with natural food indicated by faster growth and a high survival rate **(Caristein, 1993)**. *C. auratus* fed with rotifer showed significantly faster growth than dried diet **(Demir and Sarigoz, 2016)**. In the present study, *C. auratus* and *C. carpio var. koi* larvae attained faster growth in the order of *T. decipiens, M. micrura,* and mixed diet (50% *T. decipiens* and 50% *M. micrura*) feeding regimes; while in pelletized feed slower growth was recorded in both of the fish's larvae. **War *et al.* (2011)** have demonstrated

that in *C. striatus* larvae fed with *M. micrura* and *D. carinata* showed increased length during 1st week of their experiments. In the present study, results of *C. auratus* and *C. carpio var. koi* larvae length and weight were no significant changes in pelletized feed (125 - 200µm particle size) and live feed up to 8 days. Thereafter, faster growth and a high survival rate of these fish larvae in live feeding regimes. In the early stages, mouth size is small; due to this reason amount of prey predation is low. After the development of proper visualization, fish larvae contact with food items, larvae prey predation increases **(Qin and Fast, 1997)**. **Adeyemo *et al.*, (1994)** reported that *Heterobranchus bidorsalis* and *Clarias gariepinus* fry fed with *Moina dubia* is faster growth rates and higher survival rates than fed with *Artemia nauplii*. In freshwater ornamental fish rearing, *Moina* was commonly used to feeding young fish **(Lim *et al.*, 2003).**

In the present study, the highest percentages of SGR and PWG were recorded with cyclopoid *T. decipiens* in both *C. auratus* and *C. carpio* var. *koi* larvae, followed by mixed diet, and *M. micrura* and pelletized feeding regimes. For fish larvae, feed composition plays a major role in their growth **(Pillay, 1990).** *Catla catla* and *Cyprinus carpio* fed with cyclopoid and combination of cyclopoid and cladoceran diet showed high SGR **(Murugesan *et al.*, 2010; Priyadarshini *et al.*, 2011).** In our study also a similar type of result was recorded. SGR of *C. auratus* fed in *T. decipiens* and mixed feeding regime is 4.49 ± 0.06% and 3.93 ± 0.08%, and in *C. carpio* var. *koi* it is 4.02 ± 0.03% and 3.56 ± 0.04%, respectively. Similar to SGR, PWG of *C. auratus* is 502.96 ± 14.05% and 381.64 ± 15.45% and *C. carpio var. koi* of 516.55 ± 5.89% and 456.83 ± 4.12% recorded in the order of those feeding regimes. **Kadhar *et al.* (2014)** also reported that *Catla catla* SGR and PWG are high in cyclopoid feeding regimes, followed by mixed (cyclopoid and cladoceran) feeding regimes.

Length and weight relationships are important parameters in fishery studies. CF calculates the length and weight relationship, which in turn indicates the suitability of the environmental parameters and feed quality of the fish rearing medium. In the present study, CF values are gradually increased in the live feed medium of both the fish larvae. However, the control feeding regime showed linearly decreased values up to the end of experiments. The CF values of *C. auratus* and *C. carpio* var. *koi* were 47.02 ± 0.69 and 60.65 ± 0.16, respectively in the control feeding regime. The length and weight relationships get influenced by some factors include food, water quality, seasons, and physiology of the fishes **(Ambily, 2016).** The results of the present study point out that, live feed organisms are a suitable diet for both the fishes in hatchery larval rearing.

According to **Sales (2011)**, fish larvae fed with live feed have a better chance to live in a higher density than a compound diet. In the present study, the highest survival percentage of *C. auratus* and *C. carpio* var. *koi* recorded 85.6% and 79.2%, respectively in mixed

feeding regimes. The survival rate of *Heterobranchus longifilis* larvae was high in fed with *Moina* and *Artemia*, but the growth rate was lower during the experimental period **(Kerdchuen and Legendre, 1994).** In our study, the highest survival of both fishes was recorded in mixed feeding regimes but the highest growth was recorded in *T. decipiens* feeding regimes.

Evaluation of biochemical composition is significant to fulfill the larval requirements of fish. **Kanazawa *et al.* (1979)** stated that essential amino acids and fatty acids are important in the early stages of fish, which are available in plankton at a comparatively higher concentration than formulated feed. The zooplankton serves as living capsules of nutrition to the cultivable species **(Alam *et al.*, 1993).** About the protein, carbohydrate, and lipid contents of the larvae of goldfish and koi carp after 40 days of feeding experiments, there is no statistical difference between the experimental diets. However, further studies on the amino acid and fatty acid content of the fish larvae are necessary to evaluate the nutritional adequacy of the different diets to the fish larvae.

In the present study, a comparison between both the larvae showed better growth recorded in *C. carpio* but high survival in *C. auratus*. Overall, *T. decipiens* feeding regime showed better performance for the rearing of fish larvae, followed by a mixed diet, *M. micrura*, and pelletized feed.

Thus the experimental results demonstrate that the cladoceran and copepod live-feeds used for the production of goldfish and koi carp juveniles could also be applied successfully in the seed production of other freshwater ornamental fish. Currently, the ornamental fish seed production in the breeding centers of local farmers mostly uses wild zooplankton **(Altaff et al., 2002)** and in the freshwater bodies, desire plankton not available throughout the year leads to production of fish larvae are affected, which ultimately affects the trade. As the cladocerans and copepods could be mass cultured, the cost of live-feed production will be comparatively less than that of *Artemia* cysts and hence might ensure cost-effective production of ornamental fishes.

CONCLUSION

The present study conclude that larval rearing up to the juvenile stage is better with live feed than artificial pellet as evidenced by the higher growth and survival of the larvae of goldfish and koi carp. For juvenile fish in addition to the live feed provision of supplementary formulated diets might support faster growth.

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