www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 11: 523-528 (2011) DOI: 10.4194/1303-2712-v11_4_05

Growth and Survival of Larval Snakehead *Channa striatus* (Bloch, 1793) Fed Different Live Feed Organisms

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Received 18 August 2010
Accepted 28 March 2011

Abstract

One of the important cultivable indigenous finfish which deserves immediate attention for commercial scale seed production and farming is the snakehead, *Channa striatus*. Provision of suitable live feed is the bottleneck in rearing larvae of this fish. Culture performance of larval snakehead was examined in the present study by feeding them with cladocerans (*Ceriodaphnia cornuta, Moina micrura* and *Daphnia carinata)* and *Artemia* nauplii as individual and mixed cladoceran diet (*C. cornuta, M. micrura* and *D. carinata*) for four weeks. Fish fed *Artemia* nauplii, *C. cornuta* and mixed cladocerans showed higher weight gain (15.88±0.11 mg), (9.72±0.04 mg) and (10.0±0.06 mg) respectively during the I[st] week. Fish fed *C. cornuta* and *M. micrura* showed better weight gain (12.88±0.21 mg) and (11.90±0.09 mg) respectively during the 2[nd] week. Fish fed on mixed cladocerans showed better survival and growth with less cannibalism in the last three weeks. Fish fed *Artemia* nauplii showed less growth and more cannibalism during the last two weeks. It is concluded that *C. striatus* larvae could be fed cladocerans both individually as well as in mixed preparation during their early life stages. The nauplii of the brine shrimp *Artemia* which are extensively used in hatcheries are exotic and highly priced resulting in higher cost of seed production. Use of cladocerans for early larval rearing of *C. striatus* will reduce the expenditure for seed production. It is also observed that with the increase in age and growth, the fish prefers large sized prey than the smaller ones. Cannibalism can be reduced at different stages by providing prey of suitable size to the growing fish.

Keywords: Larval rearing, *Channa striatus*, live feed, cannibalism.

Farklı Canlı Yemle Beslenen Larva Dönemindeki Yılankafa balığının *Channa striatus* (Bloch, 1793) Gelişimi

Özet

Yılankafa balığı, *Channa striatus,* işlenebilir ve ticari ölçüde yavru üretimi ile yetiştiriciliği öncelikli olarak yapılması gereken önemli yerli balıklardan birisidir. Bu balığın larvalarının yetiştiriciliğinde uygun canlı yem sağlanması darboğaza girmiştir. Bu çalışmada larva dönemindeki yılankafa balıklarının kültür performansı dört hafta boyunca kopepodlar (*Ceriodaphnia cornuta, Moina micrura* ve *Daphnia carinata*) ve *Artemia* nauplii 'nin tek başına ya da kopepodlar ile birlikte hazırlanan yem verilerek test edilmiştir. *Artemia* nauplii, *C. Cornuta* ve kopepod karışımı ilk hafta boyunca daha yüksek ağırlık artışı [sırasıyla (15,88±0,11 mg), (9,72±0,04 mg) ve (10,0±0,06 mg)] sağlamıştır. *C. cornuta* ve *M. micrura* 2. hafta süresince daha iyi ağırlık artışı [sırasıyla (12,88±0,21 mg) ve (11,90±0,09 mg)] göstermiştir. Son üç hafta balık yemi olarak kopepod karışımı verilen balıklar daha az kanibalizm ile birlikte daha iyi gelişme ve yaşamını sürdürebilme yetkinliği göstermişlerdir. Son iki hafta balık yemi olarak *Artemia* nauplii verilen balıklar daha fazla kanibalizm ile birlikte daha az gelişme göstermişlerdir. *C. Striatus* larvalarının erken evrelerinde hem kopepodlar ile tek başına hem de karışım halindeki diyetler ile beslenebilecekleri sonucuna varılmıştır. Kuluçkahanelerde yaygın olarak kullanılan *Artemia* nauplii'nin dışalıma bağlı egzotik bir tür olması ve yüksek fiyatı; larval üretimin daha yüksek maliyetini arttırmaktadır. *C. Striatus*'un erken evresinde kopepodların kullanımı larva üretimi için gerekli harcamaları düşürecektir. Yaş ve gelişim arttıkça, balığın daha büyük preyi tercih ettiği gözlemlenmiştir. Büyüyen balığa uygun yem sağlanması ile kanibalizm azaltılabilir.

Anahtar Kelimeler: Larva yetiştiriciliği, *Channa striatus*, canlı yem, kanibalizm.

Introduction

Air breathing fishes form about 13% of the marketable freshwater fishes in India and among them murrels belonging to the genus *Channa* are highly priced all over India (Chakrabarthy, 2006; Aliyu-Piako *et al*., 2009). Murrels are one of the best and excellent table size fish in India as well as in South

East Asia (Zakaria *et al*., 2007). *Channa striatus* is an obligate air breather native to Asia and Africa (Ng and Lim, 1990; Banerjee, 2007). It is cultured commercially in Thailand, Taiwan and Philippines (Wee, 1980; Mehraj *et al*., 2009). Indian fish farmers are unable to culture murrels due to non availability of seeds as well as feed.

Characteristics of this fish that make it a desirable cultivable fish include high market value, rapid growth, tolerance to high stocking rates, medicinal value and utilization of atmospheric oxygen for respiration in oxygen depleted water (Qin *et al*., 1997; Mollah *et al*., 2009). About 28 to 30 *Channa* species have been reported in the global scenario with 8 to 10 species in India. Murrel farming is a very important value chain in Indian scenario, but till date this value chain is missing in Production to Consumption System (PCS) and the only source is capture fisheries.

Larviculture of murrels is a herculean task, since they are carnivorous, piscivorous and cannibalistic. Captive reproduction and larval rearing of snakehead have been accomplished experimentally, but are not done on a commercial scale (Qin *et al*., 1997; Mollah *et al*., 2009). Attempts have been made to develop culture techniques for snakehead in Hawaii, USA (Qin and Fast, 1997). During the early post larval stage it is better to feed them with small plankton like rotifers and *Artemia* nauplii (Qin *et al*., 1997). Although, *Artemia* nauplii and rotifers are the common live food organisms mass cultured for hatchery use, there is growing interest for the production of Cladocera (Adeyemo *et al*., 1994, Sivakumar, 2005; Altaff and Mehraj, 2010a). Successful snakehead culture will therefore ultimately require development of appropriate feeds and feeding methods for successful larviculture (Qin *et al*., 1997). The suitability of wild live food organisms as food in the larval rearing of the fish and prawn larvae was indicated earlier (Altaff *et al*., 2002*)*. Many studies reported the utilization of cultured live food organisms as food (Alam *et al*., 1993; Kumar *et al*., 2005; Mollah *et al*., 2009).

Realizing the importance of live food organisms in aquaculture and the commercial value of *C. striatus*, it was proposed to conduct experiments on the first feeding larvae of *C. striatus* with three different cladocerans as individual and mixed diets, and *Artemia* nauplii to record feed acceptability, survival, cannibalism and growth.

Materials and Methods

Cladoceran Culture

Zooplankton samples were collected from freshwater fish rearing ponds at the Centre for Aquaculture Research and Extension (CARE), St. Xaviers College Palayamkottai, Tamilnadu, India and were brought to the laboratory with least disturbance. The adult *C. cornata*, *M. micrura*, and *D. carinata* were separated using binocular dissection microscope. Chicken manure was collected from a local broiler chicken shop and was dried for 2 days to remove the moisture and stored in plastic jars for further use. Chicken manure was micronized by grinding and required quantity was dissolved in distilled water to get suspensions of 500 ppm and was used to fertilize culture medium for mass culture in 50 L tanks. 4 - 5 tanks were arranged for every organism, so as to get the regular supply of the cladocerans required. Cladocerans were inoculated in each culture tank at the rate of 50 Ind./L containing both adults and neonates. The culture experiment was conducted for 4 weeks. Water change was carried out after every 3 days interval by replacing 50% of the water. Food was administered as a function of population density every 3rd day using the formula of Altaff and Mehraj (2010a). Cladocerans were collected from the tanks using 100µm mesh size plankton net and were counted using Sedgewick rafter cell. The fish were fed with these live feed organisms at the rate of 500 Ind./fish^{-day}.

Artemia Culture

Artemia cysts (GSL strain) were hatched under the high light intensity in 5 L conical flasks. Before hatching the cysts were hydrated for three hours in 500 mL of freshwater and 20 ml of bleach was added in order to disinfect and decapsulate the cysts. Temperature was maintained at 26°C with vigorous aeration for 24 hours. Hatched *Artemia* nauplii were then cleaned with running freshwater for few minutes and they were fed yeast until use. After cleaning, the required numbers of animals were fed to the larvae.

Larviculture

Mature snakeheads (1.5±0.5 kg, one female and two male) were captured from the brood stock rearing pond at (CARE), St. Xavier's College. The fishes were induced to spawn by using Human Chorionic Gonadotropin (HCG) hormone injection at the rate of 0.5 ml/kg body weight. Immediately after hormone injection, the breeding sets were introduced into the breeding tanks (2 m X 2 m X 1 m). After fish spawned (20-30 hrs), fertilized eggs were collected from the tank and incubated in 50 L water in 100 L fibre tanks for hatching. Within 20-30 hours, the fertilized eggs hatched. The yolk sac was absorbed completely after 4-5 days of hatching. 5 days old larvae were 1.24±0.01 mg (wet weight), and 6.3±0.1 mm (Total length). In each fibre tank, 100 larvae were stocked and randomly assigned to one of the five diets (1) *C. cornuta* (2) *M. micrura* (3) *D. carinata* (4) mixed cladoceran diet (*C. cornuta, M. micrura* and *D. carinata*) and (5) *Artemia* nauplii for 4 weeks. The feed was given twice a day at 8.00 and 16.00 hrs at the rate of 500 Ind./fish^{-day} which is above the satiation for the fish larvae (Qin and Fast, 1997). The sediment (unconsumed food, faeces and pseudofaeces) were siphoned from the bottom. Water exchange (50%) was carried out daily with least disturbance to the fish larvae.

Data Analysis

Fish were sampled at the end of every week of the experimental period for evaluation of growth and survival. Length and weight of the 50 individual fish collected at random from the experimental tanks were measured. Weight gain, survival, and cannibalism were calculated by employing the following equations:

Weight gain (g)= Final live weight – Initial live weight

Survival (%)= No. of fish introduced ×100
No. of fish survived

Cannibalism rate (%) = 100- (Survival rate% + Observed mortality %) Increase in length (mm) = Final Length – Initial Length

The influence of different live diets on growth, survival, weight gain, cannibalism and increase in length was analyzed using one-way ANOVA. The data were compared by Tukeys test using SPSS software version10 at P<0.05 level of confidence.

Results

Survival

Snakehead larvae fed *Artemia* nauplii, *C. cornuta* and mixed cladoceran diet showed significantly better survival (88±1.73%), (75.33±1.20%) and (77.33±1.45%) respectively. Least survival (71.66±5.54%) was found in larvae fed *D. carinata* only during the Ist week. Significant difference between fish survival was observed with different feeds in different weeks (Table 1). After 2 weeks, average larval mortality was significantly higher in the treatments where *Artemia* nauplii and *C. cornuta* were fed to the fish.

Growth

The larvae readily consumed all the diets but there was significant difference in the weight gain during different weeks and different diets (Figure 1). Fish weights and lengths were significantly greater in *Artemia* nauplii, and *C. cornuta*, when compared with the other feeds provided, in the first two weeks of feeding trials. *D. carinata* and *M. micrura* showed significantly better growth and survival during IIIrd and IVth week. Fish fed *Artemia* nauplii showed better results in first two weeks while the growth and survival decreased as the fish increased in size and weight. *C. cornuta* supported good growth and survival in the first 2 weeks, but less growth during last 2 weeks. Fish fed *M. micrura* and *D. carinata* showed higher growth and survival in the IVth week of the experiment (Figure 2). With regard to weight gain, highest weight gain (15.88±0.11 mg) was observed in fish fed *Artemia* nauplii in the initial days of rearing. Highest weight gain in fish fed with *M. micrura* (16.01±0.16 mg) and *D. carinata* (15.45±0.16 mg) was observed during the last week of experiment.

Cannibalism

No cannibalism was observed during the first 7 days of experiment where as higher cannibalism was observed during the last 2 weeks. Cannibals were swimming vigorously, around the tank, ignoring live feed and targeting their siblings. Initially the attack was restricted to biting, targeting eye and abdomen. Cannibalism, however, was significantly lower in fish fed mixed cladocerans (9.66±0.88%) and *D. carinata* (9.33±0.88%) while it was highest in fish fed *Artemia* nauplii (16.33±0.88%) and *C. cornuta* (11.33±1.20%) in the IVth week of the experiment. Cannibalism and

Table 1. Observed Mortality, Survival, and Cannibalism shown by *C. striatus* larvae during the experimental period (Mean±S.E)

Time	Diets	*C. cornuta*	*D. carinata*	Mix. diet	*M. micrura*	*A. Nauplii*
1st Week	Observed Mortality %	24.66±1.20^{aa}	31.66±2.72^{ab}	25.33±2.02^{ac}	22.66±1.45^{ad}	12.00±1.73^{ae}
	Survival %.	75.33±1.20^{ba}	71.66±5.54^{bb}	74.66±2.02^{ba}	77.33±1.45^{bd}	88±1.73^{be}
	Cannibalism%	0	0	0	0	0
IInd Week	Observed Mortality%	11.33±1.20^{ca}	19.33±1.45^{cb}	15.00±1.15^{cc}	12.66±1.45^{ca}	12.00±1.15^{ca}
	Survival %.	85.33±4.25^{da}	80.66±1.45^{da}	81.66±3.52^{da}	87.33±1.45^{db}	88.00±1.15^{db}
	Cannibalism%	4.33±0.33^{ea}	2.66±0.66^{eb}	2.66±0.33eb	2.33±0.88^{eb}	4.66±0.88^{ea}
IIIrd Week	Observed Mortality%	7.00±1.00^{ga}	16.66±1.66^{gb}	12.33±1.20^{gc}	10.33±2.18^{gd}	7.33±1.66^{ga}
	Survival %.	83.33±1.20^{ha}	83.66±1.45^{ha}	83.33±0.88^{ha}	84.66±1.20^{hb}	77.00±1.15^{hc}
	Cannibalism%	10.66±1.20^{ia}	5±1.15^{ib}	7.33±0.88^{ic}	7.33±0.88^{ic}	14.66±0.88^{id}
IVth Week	Observed Mortality%	6.00±0.00^{ja}	11.33±2.60^{jb}	16.66±1.85^{jc}	7.33±0.88^{jd}	8.33±0.33^{je}
	Survival %.	84.66±1.20^{ka}	86.66±0.88^{kb}	83.33±1.85^{kc}	84.33±1.76^{kc}	78.00±0.57^{kd}
	Cannibalism%	11.33±1.20^{la}	9.33±0.88^{lb}	10.33±1.33^{lc}	9.66±0.88^{lb}	16.33±0.88^{ld}

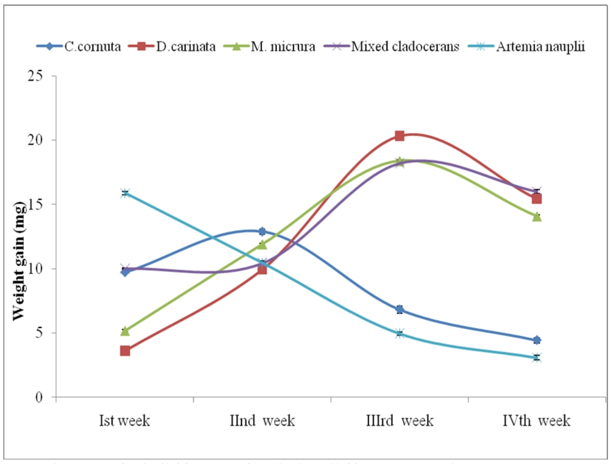

Figure 1. Weight gain in *C. striatus* larvae fed different feeds in different weeks.

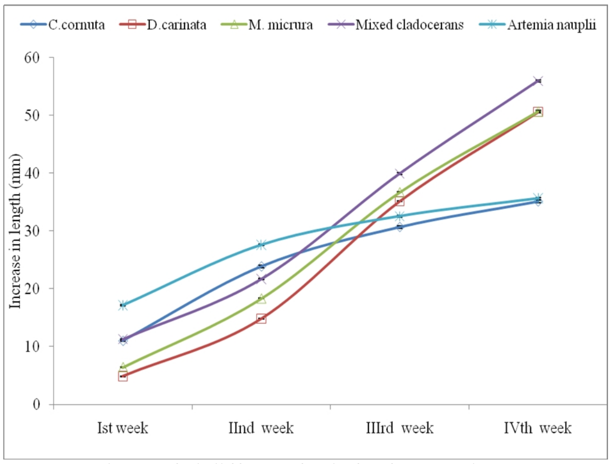

Figure 2. Increase in length of *C. striatus* larvae fed different feeds for four weeks.

Observed mortality was significantly different in different diets during different weeks of the experimental period (Table 1).

Discussion

The need for large quantities of live food organisms in aquaculture and the increasing need for valorizing organic wastes, such as animal manures and agro-industrial residues, have been the major initiatives for research on the culture of live feed organisms (DePauw *et al*., 1980; Shrivastava *et al.,* 2006). Chicken manure is a waste produced in poultry farms in large quantities and is cheap in price. It has several advantages in comparison with other live foods (e.g. microalgae). It is available in large quantities and can be purchased easily at low price. It can be used directly after drying and stored for longer periods (Altaff and Mehraj, 2010a). According to Banerjee *et al.* (1979) it is a complete fertilizer with characteristics of both organic and inorganic fertilizers. Ray and David (1969) opined that chicken manure fertilized medium produce a large population of cladocerans quicker than cattle manure and the plankton biomass increased with the increase of its dosage. Different culture techniques are being developed to increase yield of cladocerans by employing different organic waste products as food sources (Punia, 1988; Shrivastava *et al*., 2006). Zooplanktons are rich in essential amino and fatty acids and should be sufficient as the first source of nutrients required by fish for growth (Kanazawa *et al*., 1979). These organisms serve as living capsules of nutrition for sustenance and replacement of tissues as well as maintenance of metabolism and optimal growth of cultivable species (Alam *et al*., 1993; Suresh Kumar, 2000).

Results of the Ist week of feeding trial indicated higher growth and survival of snakehead larvae fed on *Artemia* nauplii and *C. cornuta* than those fed on *M. micrura and D. carinata.* Qin *et al*. (1997) also reported better growth and survival of larval *C. striatus* in the early days when fed with *Artemia* nauplii. Better performance of snakehead larvae with regard to their growth and survival when fed with *C. cornuta* might be due to the suitability of this species for the early stage larvae of *C. striatus*. Suresh Kumar (2000) and Shrivastava *et al*. (2006) reported that *C. cornuta* is preferred as live food organism by early larval fish due to its smaller size and higher locomotive behaviour than other cladocerans. The poor performance of snakehead larvae with regard to their survival and growth in the first two weeks could be attributed to the incompatibility of the size of the feed and mouth size of the larvae. The smaller mouth size (57±2 µm) of larvae at this stage makes it difficult to consume the fairly larger sized *D. carinata* and *M. micrura*. Occurrence of such feeding limitations related to mouth size and gill racker spacing in many fish larvae was reported by Wankowski (1979), O'Brien (1987) and Qin and Fast (1996).

Many previous reports indicate that the critical stage in the larval development of many fishes is the transition from endogenous to endoexogenous to exclusively exogenous feeding (Santamaria *et al*., 2004; Sivakumar, 2005). Provision of suitable live feed during this stage is vital and determines the rate of survival of the larvae. It is also reported that artificial feeds are not preferred by the larvae during this stage (Qin *et al*., 1997). The functional status of the digestive system of the larvae at this stage with regard to digestibility of feed need to be assessed for successful larval rearing. According to Govoni *et al.* (1986) assimilation efficiency may be lower in larvae than in the adult fishes, due to the lack of morphological and functional stomach in larvae. It is suggested that initial digestion in the fish larvae is carried out by enzymes present in the live prey (Govoni *et al*., 1986). The better growth performance in fish fed mixed cladoceran diet in the present study may be due to the supply of all the required essential nutrients and digestive enzymes for better digestibility and assimilation. Besides their high nutritional value, live feed organisms can relatively swim up to 5-6 hours in freshwater before sinking to the bottom and die, thereby extending its availability for larval consumption (Hoff and Snell, 1989; Rottmann, 2003).

Most fish larvae are visual, raptorial planktivores regardless whether their adult counterparts are indiscriminant filter-feeder, pelagic carnivore, or benthic pickers. In the present study it was observed that as the fish grew in size it preferred larger zooplankton than smaller like *Artemia* nauplii and *C. cornuta.* Larvae begin feeding on large phytoplankton and small zooplankton and follow feeding on increasingly larger zooplankton (Hunter, 1981; Qin and fast, 1997). Our results show that *C. striatus* larvae are selective feeders and prefer bigger zooplankton as they grow in size. This diet shift can be due to the increase in the gill racker spacing or short gill rackers. According to Qin and Fast, (1997) the changes in the gill racker morphology of *C. striatus* as the fish grows made it difficult for large fish to capture small prey. They also observed that when snakehead grow from postlarvae to fry, their prey capturing ability became more acute and they shifted from smaller, slow moving, to larger and faster organisms. Lower growth and survival was observed in fingerlings of *C. striatus* when fed with live feed and suggested that live feed may not be sufficient for the fingerling stage of this fish (Mehraj *et al*., 2009). According to Shirota (1960), the growth rate of first feeding larvae are directly affected by mouth width and larval length, in our experiments we found that with increase in length of the fish after 1st week, the fish fed *Artemia* nauplii and *C. cornuta* showed less growth and more cannibalism. Fish fed *D. carinata*, and *M. micrura* showed higher growth and survival. It seems logical that larvae with bigger mouths are able to ingest bigger prey at each strike relative to their biomass and consequently save energy that can be used for growth. In case of small prey size (less biomass) they have to spend more energy to capture them which will affect their growth.

It is concluded that *C. striatus* larvae can be successfully reared on cladocerans until they switch to formulated feeds. Larval *C. striatus* can be fed with live cladocerans during early days, and then gradually fed with formulated diets in combination with cladocerans to get better results until they get trained to accept formulated diets.

Acknowledgements

The authors are thankful to ICAR-NAIP for providing funds to carry out this research work under the project (F. No.1 (5)/2007-NAIP dt. 22 Aug. 2008)

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