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Preliminary Studies on the Effect of Prey Length on Growth, Survival and Cannibalism of Larval Snakehead, *Channa striatus* (Bloch, 1793)

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Abstract.- Larval snakehead *Channa striatus* were fed with three cladocerans (*Ceriodaphnia cornuta, Moina micrura* and *Daphnia carinata*) and *Artemia* nauplii at the rate (500 Ind./Fish^{-day}) to record growth, survival and cannibalism. Experiments were carried out for 30 days in 40 L tanks each filled with 30 L water. Fish fed *Artemia* nauplii and *C. cornuta* showed better results during the first 10 days whereas less growth and more cannibalism was seen in the last 10 days of the experimental period. Fish fed *D. carinata and M. micrura* showed the highest weight gain (15.24±0.11mg) and (13.56±1.10 mg), respectively, in the last 10 days of the experimental period but showed significantly less growth and survival (71.66±1.54 %) and (74.66±2.02 %), respectively, during the first 10 days. No cannibalism was observed during the first 10 days of experiment, whereas more cannibalism was seen in the last ten 10 days when compared to the results of first 20 days of the experiment with significant differences between the 4 different live feed organisms used for feeding the fish. It was concluded that with the increase in size, fish prefers large sized prey than the smaller ones and must be provided with prey of larger size to get better results, otherwise it will lead to less growth and more cannibalism. Cannibalism can be reduced at different stages by providing prey of suitable size to the growing fish but cannot be avoided completely unless little size differences are obtained by regular sorting.

Key Words: Larval rearing, *Channa striatus*, live feed, growth performance, cannibalism.

INTRODUCTION

Prey selection in fish larvae is affected by a number of factors related to the characteristics of both larvae and the prey. These factors include visual acuity, visual threshold and spectral sensitivity, prey contrast, shape and mobility, concentration and the presence of chemical attractors and inhibitors (Cunha and Planas, 1999). Several studies have documented size-selectivity of fish towards their invertebrate food (O'Brien, 1987; Qin and Fast, 1998).The relationship between mouth size and prey is considered to be one of the most decisive factors in the capacity of fish larvae to deal with prey of different sizes (Lizawa, 1983). Mouth size largely determines maximal and optimal prey size. Feeding with optimal prey size during larval development is of great value for cultured species, particularly at early stage when the availability of adequate prey determines growth and survival. During this early period, growth rate can be high and prey size needs to be adjusted as mouth size increases. Prey width not length, is the critical measurement in determining prey size limitations because fish larvae generally swallow oblong prey heads first (Hunter, 1981).Yasuda (1960) suggested that the height of the mouth plays an important role in the capture of the prey while mouth width limits the size of the captured prey. Shirota (1970) found that larval growth rate is determined by the relationship between mouth size and fish length, concluding that larvae with small mouth/body ratio grow more slowly. This is probably a consequence of greater effort necessary to ingest a large quantity of small prey to generate a given amount of biomass. Successful larval rearing of many fishes has been reported including cladoceran species (Mollah *et al.,* 2009; Mehrajuddin *et al.,* 2010).

Murrels commonly called snakeheads are one of the best and excellent table size fish in India as well as in South East Asia. Snakehead (*Channa striatus*) is an obligate air breather native to Asia and Africa. Characteristics of this fish that make it a desirable cultivable fish include high market value, rapid growth, tolerance of high stocking rates, medicinal value and utilization of atmospheric oxygen for respiration in oxygen depleted water

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(Zakaria *et al.,* 2007; Mollah *et al.,* 2009). It is cultured commercially in Thailand, Taiwan, the Philippines and India. Even though the aquaculture of this species is growing worldwide, information regarding its nutritional needs is still limited and inconsistent, because its aquaculture is still dependent on fry and fingerlings bred in the wild (Aliyu-Piako *et al.,* 2010). Moreover, this practice may seriously deplete natural stocks in the near future. Further because of harmful effects of pesticides, chemicals and industrial wastes natural spawning grounds are destroyed day by day (Mollah *et al.,* 2009). Indian fish farmers are unable to culture murrels due to non availability of seeds as well as feed. Larviculture of murrels is a Herculean task, since they are carnivorous, piscivorous and cannibalistic (Haniffa, 2010).

One inherent problem with larviculture of *C. striatus* is cannibalism. They can easily consume more than half of their length and high cannibalism occurs in juveniles (Diana *et al.,* 1985; Haniffa, 2010). Qin and Fast (1996) demonstrated that in cannibalistic fish like *C. striatus* that swallow their prey whole, there is a definite maximum prey size for a given predator size. Maximum prey sizes are largely determined by actual predator mouth width and the total length of predators. Several studies demonstrated that cannibalism can be reduced by increasing food availability (Hecht and Pienaar 1993; Qin and Fast, 1998), but little is known about the candidate species. Considering the above realities the present research was aimed to evaluate the effect of three cladocerans (*Ceriodaphnia cornata, Moina micrura* and *Daphnia carinata*) and *Artemia nauplii* on growth, survival and cannibalism of larvae of *C. striatus*.

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. Adults of *C. cornata*, *M. micrura*, and *D. carinata* were separated using a 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 the required quantity was dissolved in distilled water to get suspensions of 500 ppt and was used to fertilize a culture medium for mass culture in 50 L tanks. Five tanks were arranged for every organism in order to obtain the required supply of cladocerans. Cladocerans were inoculated in each culture tank at a rate of 50 Ind./L containing both adults and neonates. The culture experiments were conducted for 30 days. Water change was carried out after every 3 days interval by removing 50% of the water. Food was administered as a function of population density every 3rd day using the formula of Altaff and Mehrajuddin (2010). Cladocerans were collected from the tanks using 100 µm mesh size plankton net. Collected samples were cleaned with fresh water and the required number of organisms (Ind./L) were offered to the fish.

Artemia *culture*

Artemia cysts (GSL strain) were hatched at high light intensity in 5 L conical flasks. Temperature was maintained at 28 °C at vigorous aeration for 24 h. Hatched *Artemia* nauplii were then cleaned with freshwater for a few minutes and were fed yeast until use. After cleaning, the required number 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 spawning by using human chorionic gonadotropin (HCG) hormone injection at a dose of 0.5 mL/kg body weight and immediately after hormone injection the breeding sets were introduced to the breeding tanks (2 m x 2 m x 1m). After the fish spawned (20-30 h), fertilized eggs (100 eggs) were collected from the tank and incubated in 50 L water in 100 L fibre tanks for hatching. Within 20-30 h the fertilized eggs hatched, the yolk sac was absorbed completely after 4 - 5 days of hatching. 5 days old larval fish were 1.24±0.01 mg (wet weight), and 6.4±0.1 mm (total length). In each tank, 50 larvae were stocked and

randomly assigned to one of the five diets (1) *C. cornuta* (2) *M. micrura* (3) *D. carinata* and (4) *Artemia* nauplii for 30 days.

The feed was given at a rate of 500 Ind./Fish^{-} ^{day}) which is above the satiation for the fish larvae (Qin and Fast, 1998). The sediment (unconsumed food, faeces, and pseudofaeces) were siphoned from the bottom and 50% water exchange was carried out daily with least disturbance to the fish larvae.

Data analysis

Fish were sampled at the end of every 10 days during the experimental period (30 days) for evaluation of growth and survival. Length and weight of the 20 individual fish collected at random from the experimental tanks were measured. Dead fish were removed daily and counted. Weight gain, survival, specific growth rate (SGR) and cannibalism were calculated by using the following equations:

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

$$\text{Survival (\%)} = \frac{\text{No. of fish introduced}}{\text{No. of fish survived}} \times 100$$

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, specific growth rate and increase in length was analyzed using one-way AVOVA. The mean values were compared using Tukeys test using SPSS software version10 at $P < 0.05$ level of confidence.

RESULTS

Average size of the zooplankton organisms offered as feed for the larval rearing of *C. striatus* as a first feed is given in Table I. Average size of the fish and the corresponding mouth size at different lengths is shown in Table II.

Average initial weight and length of the fish was (1.24±0.01 mg) and (6.4±0.1 mm), respectively, at the start of the feeding, fish weights and lengths were significantly greater in *Artemia* nauplii and *C. cornuta*, when compared with the other feeds

Table I.- Size of different live feed organisms fed to fish (*C. striatus*).

Feed	Length of zooplankton (range)
Ceriodaphnia cornuta	258 – 588 µm
Moina micrura	400 – 800 µm
Daphnia carinata	800 – 1500 µm
Artemia nauplii	300 – 400 µm

Table II.- Size of the fish (*C. striatus*) and the corresponding mouth size.

Length of fish	Size of mouth (range)
5 - 10 mm	0.5 – 1.0 mm
10 - 15 mm	1.0 – 1.5 mm
15 - 20 mm	1.5 – 2.0 mm
20 – 25 mm	2.0 – 2.5 mm
25 – 30 mm	2.5 –.3.0 mm

provided in the first 10 days of the feeding trials (Tables III and IV). *D. carinata* and *M. micrura* showed better growth and survival during the last 10 days of the experiment which was comparatively lesser in the first 10 days. Highest weight gain (15.88±0.11) was observed in fish fed *Artemia* nauplii and *C. cornuta* in the first 10 days of rearing while it was highest in fish fed with *M. micrura* (13.56±1.10) and *D. carinata* (15.24±0.11 mg) towards the end of the experimental period (Table IV). An increase of the specific growth rate was shown by the fish fed with *C. cornuta* and *Artemia* nauplii during the first ten days of the experiment and *D. carinata* during the last 10 days of experiment (Table V)

Fish fed *C. cornuta* showed a significantly better survival when compared with fish fed other diets and the least survival was found in fish fed *D. carinata* in the first 10 days of the experiment, whereas survival was higher in fish fed *D. carinata* and *M. micrura* in the last two weeks. After 10 days, average fish mortality was significantly higher in the treatment where *Artemia* nauplii and *C. cornuta* were fed and mortality increased towards the end of the experiment (Table VI).

No cannibalism was observed during the first 10 days of the experiment whereas more cannibalism was observed during the last 10 days of the experimental period (Table VI). Cannibalism

Table III.- Increase in length (Mean±S.E) of *C. striatus* larvae fed different feeds during the experimental period

Diets	Initial L (mm)	After 10 days (mm)	After 20 days (mm)	After 30 days (mm)
C. cornuta	6.4 ± 0.01	13.39 ± 0.01[a]	21.54 ± 0.03[ab]	27.72 ± 0.06 [ba]
D. carinata	6.4 ± 0.01	8.84 ± 0.01[b]	15.23 ± 0.06 [ac]	25.10 ± 0.08 [bb]
M. micrura	6.4 ± 0.01	10.38 ± 0.01[c]	21.29 ± 0.07 [ab]	26.50 ± 0.07 [bc]
Artemia nauplii	6.4 ± 0.01	14.04 ± 0.06[a]	19.66 ± 0.03 [ac]	23.91 ± 0.15 [bd]

Values in each column with different superscripts are significantly different at < 0.05 level of significance.

Table IV.- Weight gain (Mean±S.E) in *C. striatus* larvae fed different feeds in different days of the experimental period.

Weight Gain (mg)	10 days	20 days	30 days
C. cornuta	3.02 ± 0.20 [a]	7.44 ± 1.16 [ab]	9.71 ± 1.13 [ba]
D. carinata	1.01 ± 0.11 [b]	7.98 ± 0.13 [aa]	15.24 ± 0.11 [bb]
M. micrura	1.51 ± 0.33 [c]	8.34 ± 1.03 [aa]	13.56 ±1.10 [bc]
Artemia nauplii	3.29 ± 0.23[a]	6.74 ± 0.15 [ab]	8.19 ± 1.03 [ba]

Values in each column with different superscripts are significantly different at < 0.05 level of significance.

Table V.- Specific growth rate (Mean±S.E) in *C. striatus* larvae fed different feeds during the experimental period.

SGR (%)	10 days	20 days	30 days
C. cornuta	30.23 ± 1.38 [a]	27.22 ± 1.32 [aa]	12.38 ± 1.33 [ba]
D. carinata	10.15 ± 1.06[b]	29.91 ± 1.19 [ab]	30.82 ± 1.16 [bb]
M. micrura	15.11 ± 1.35[c]	31.71 ± 1.56 [ac]	25.20 ± 1.35 [bc]
Artemia nauplii	32.9 ± 1.56 [d]	23.72 ± 1.33 [ad]	7.30 ± 1.12 [bd]

Values in each column with different superscripts are significantly different at < 0.05 level of significance.

Table VI.- Observed mortality, survival, and cannibalism shown by *C. striatus* larvae during the experimental period (Mean±S.E).

Duration		*C. cornuta*	*D. carinata*	*M. micrura*	*A.* nauplii
1-10 days	Mortality%	24.66±1.20[a]	31.66±2.72 [b]	27.33±1.20 [c]	12±1.73 [d]
	Cannibalism%	0	0	0	0
	Survival%	75.33 ±1.09 [ab]	71.66 ±1.54 [ac]	74.66±2.02[ab]	88±1.73 [ad]
10-20days	Mortality%	16.67 ±1.13 [ba]	16.33±1.11 [ba]	16.66±0.88[ba]	23±1.15 [bb]
	Cannibalism%	10.66 ±1.17 [ca]	5 ±1.15 [cb]	9.33±0.33 [ca]	14.66±0.89 [cc]
	Survival%	83.33 ±2.23 [da]	83.66±1.66 [da]	83.34±2.38[da]	77±1.15 [db]
20-30 days	Mortality%	15.33 ±1.21[ea]	16.33±0.88 [eb]	16.66±1.85[eb]	22±0.57 [ec]
	Cannibalism%	11.33 ±1.03 [fa]	9.34±0.87 [fb]	10.33±1.33[fa]	16.32±0.89 [fc]
	Survival%	84.67±2.33 [ga]	86.66±2.29 [gb]	83.33±1.85[ga]	78±0.57 [gc]

Values in each row with different superscripts are significantly different at < 0.05 level of significance.

was significantly different in different diets during different weeks of the experimental period. Highest cannibalism was seen in the fish fed *Artemia* nauplii and *C. cornuta* during the last 10 days of the experiment and less cannibalism in fish fed *D. carinata* whereas lowest cannibalism was observed in fishes fed *C. cornuta* and *Artemia nauplii* during the initial period of the experiment. Lowest cannibalism was observed in the fish fed *D. carinata* during the last days of the experimental

period.

DISCUSSION

The food value of live food organisms for a particular fish species is primarily determined by its size and form. While a small food organism was desirable for fish larvae in terms of digestibility, the use of larger organisms was more beneficial when the size of the food organisms did not interfere with the ingestion mechanisms of the predator (Merchie, 1996). Fish would take a long time to get saturated if fed with smaller live food organisms, and this would result in a poor growth due to inefficient feeding and waste of energy. Nutritional quality of live food in aquaculture is important for survival and growth of larvae (Szyper, 1989; Murugesan *et al.,* 2010). Zooplankton is a valuable source of amino acids, fatty acids, minerals and enzymes. Live zooplankton contains enzymes (amylase, protease, exonuclease and esterase), which play important roles in larval nutrition and is easily digestible. The live food organisms have a high food value as a protein source of fish (Ogino, 1963; Murugesan *et al.,* 2010). In our experiments, larvae fed *Artemia* nauplii and *C. cornuta* showed higher growth and survival than fish fed *M. micrura* and *D. carinata* in the first 10 days. According to our results the larvae of this fish preferentially ingest prey of smaller size in the initial days of exogenous feeding. This may be because of the inability of the larvae of this fish to ingest bigger prey due to the small size of the mouth at the beginning of exogenous feeding (Tables I, II). Larval *C. striatus* were reported to show better growth and survival in the early days when fed with *Artemia* nauplii (Qin *et al.,* 1996) which are almost of the same size as *C. cornuta*. Smaller prey may be particularly suitable for smaller first feeding larvae as it is easy to capture and thereby giving more feeding incidences in these larvae. *C. cornuta* is a preferable food item of the first feeding larvae of many freshwater fishes due to their suitable size (258-588 µm) for mouth gape affected larvae. Due to the smaller size and higher locomotory behavior, *C. cornuta* becomes a most preferable species of the fish larvae (Altaff and Mehrajuddin, 2010) which in turn results in frequent encounters thereby increasing the ingestion rate. The poor survival of snakehead larvae fed *D. carinata* and *M. micrura* in the first 10 days might be related to the bigger size of *D. carinata* and *M. micrura* which may be difficult for the fish to consume, because of the smaller size of the mouth (0.57±0.02 mm) in the initial days of larval life. Wankowski (1979) and Qin and Fast (1998) also reported that feeding limitations occur in many fish larvae related to mouth gape width and gill raker spacing. The ability of snakehead *C. striatus* to ingest *Artemia* nauplii (350 µm) and copepod nauplii (220 µm) declined when fish exceeded 15 mm (Qin and Fast, 1996; Mehrajuddin *et al.,* 2010). Fish fed *M. micrura* and *D. carinata* showed better growth and survival in the last ten days of the 30 days experimental period. Fish larvae usually change feeding strategies as they grow, such as feeding more or larger prey and foraging on different prey. Larvae begin feeding on large phytoplankton and small zooplankter and follow feeding on increasingly larger zooplankter (Hunter, 1981), which was also observed in the present study as the fish grew in size it preferred larger zooplankton than smaller like *C. cornuta,* which was evidenced by less growth shown by the larvae fed these diets in the last 10 days.

Our results show that *C. striatus* larvae are selective feeders and prefer larger zooplankton as they grow in size as revealed by the better results shown by the fish with increasing size of the prey as it grows, hence application of larger sized prey in the course of time will give much better results. This diet shift can be due to an increase in the gill raker spacing or short gill rakers, the changes in the gill raker morphology of *C. striatus* as the fish grows made it difficult for large fish to capture small prey, their prey capturing ability became more acute and they shifted from smaller, slow moving, to larger and faster organisms (Qin and Fast, 1998). In nature different sizes and type of animals provides all the requirements to the growing fish in terms of nutrition as well as by providing prey of suitable size. This might be the reason for fish that grow in natural places grow much faster than under experimental conditions.

Fish growth is generally related to availability and density of optimal prey (Mittelbach, 1981). 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 while as in case of small prey size (less biomass) they have to spend more energy to capture them which will effect their growth, thereby showing reduced growth when compared to the fish fed large sized prey.

Cannibalism is the most common problem leading to low survival during snakehead larviculture. They can easily consume a smaller fish of more than half of its length (Diana *et al.,* 1985). In our experiments there was no significant difference in the fish fed at different concentrations of these organisms, but less cannibalism was found in the fish fed *M. micrura* and *D. carinata* in the last two weeks and more in fish fed *C. cornuta*. Folkvord and Ottera (1993) suggested that coefficient of variance could be an indicator of size dependent cannibalism in fish. It was found that substantial cannibalism occurred even in the fish fed at the higher densities of the prey. Qin and fast (1996) reported that low levels of food supply might trigger cannibalism and showed that cannibalism was reduced from 86% to 36% by increasing the food supply. Further they also reported that food supply alone could not completely stop cannibalism. Cannibalism can be reduced by providing the suitable size prey to the growing larvae and by sorting out the larger fishes regularly thereby maintaining least size difference which seems to be the major controlling factor.

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