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Effect of Feed Quality on Growth and Survival of Striped Snakehead, Channa striatus (Bloch, 1793) Hatchlings

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Present study focuses on growth performance of C. striatus using different feeding regimes of live feed and formulated feed. Murrels, belonging to the family Channidae, are widely known as snakeheads. Larviculture of murrels is a herculean task as they are carnivorous and piscivorous with cannibalistic behaviour. Artemia nauplii and rotifers are required for the best survival and growth of C. striatus during the early nursery management, and a combination of fish meal, Artemia nauplii and zooplankton was considered as the overall best diet for larviculture of murrels.

[**Keywords:** *Striped murrel, larviculture, snakeheads*]

Introduction

Murrels, commonly known as snakeheads, are acclaimed all over Southeast Asia, especially in India, for their taste, flavour, some intramuscular spines and medicinal and recuperative attributes[1,2]. Striped murrel, *Channa striatus* (Channiformes: Channidae), is a commercially important ubiquitous species; it is widely preferred by consumers and occupies the top rank among other edible murrels such as *C. marulius*, *C. punctatus* and *C. gachua*[3].

In the entire life history of fish, larval stage needs great care. After complete yolk sac absorption, the post larvae need small live feed such as rotifers during first exogenous feeding[4]. Chen[5] found 9 mm snakehead larvae feeding on rotifers, naupli and other organisms. Fish farmers in India are unable to culture murrels due to non-availability of seeds and feeds[6]. Unlike rearing of carp fry that has been standardised, feeding post larvae is a herculean task and no readymade feed has been either formulated or recommended for murrels in India till date.

The aim of larviculture of murrels is mass production and supply of healthy and high-quality of fingerlings for stock enhancement at stakeholder's aquafarm. Mass seed production from captive brood stock and effective larval rearing decide the success of any hatchery[7]. In aquaculture industry, cost of feed is the major operating expenditure in intensive practices, and availability of appropriate feed is one of the major limiting factors in fish culture, as it is directly responsible for their growth and surviva[l8]. However, availability of suitable feed for larval forms is still a bottleneck in commercial seed production of fish[9,10]. At the beginning of the exogenous feeding, the larvae have an advanced digestive system with a functional pancreas and liver, but without a functional stomach. During this period, the crucial problem encountered is the food quality[11]. During the endo-exotrophic phase, larvae utilise nutrients from both yolk sac and their surrounding environment[12]. This period starts soon after hatching, especially in larvae with small yolk sac[13]. This first feeding period is critical for larval survival and, therefore, successful synchronisation between exhaustion of indigenous reserves and first feeding must occur. Enhancement of feeding efficiency at first feeding can reduce the risk of starvation during the first phase of development[14].

Successful rearing of fish larvae using live zooplankton has been reported for several species[15], and rotifers, cladocerans and copepods are used in fish larviculture as starter feeds. Among the various species of zooplankton, the genus Moina (cladoceran) is suitable as an initial feed for Chanos chanos[16] and Clarias macrocephalus[17]; Mesocyclops for Poecilia reticulata[18] and Cryptocyclops for Gambusia affinis[19].

Hung et al.[20] reported larval rearing of the Asian catfish Pangasius bocourti using alternative feeds (Artemia nauplii, cladocerans and red-blood worms) as weaning diet. The present study deals with larviculture of *C. striatus* using different live feeds and formulated feeds to find out their growth performance and survival under laboratory conditions.

Materials and Methods

Mature males and females of striped snakehead C. striatus (1 ± 250 Kg) were collected from the broodstock rearing pond of Centre for Aquaculture Research and Extension (CARE) of St. Xavier's College, Palayamkottai, Tamil Nadu, India. Their maturity was assessed by sexual dimorphism and hand stripping[21]. They were induced to spawn by injecting luteinizing hormone-releasing hormone analogue (LH-RHa) at a dosage of 70 µg/Kg body weight, and the breeding sets were introduced into the breeding tanks (1 m X 1 m X 1m). After the fish spawned (22–24 hrs), fertilised eggs were collected from the tank and incubated in aquarium tanks (capacity 100 L) for hatching. Within 22-26 hrs, the fertilised eggs hatched and the yolk sacs were absorbed completely after 3-4 days of hatching.

Eight experimental diets (A-H) comprising Artemia nauplii, indigenous zooplankton and fish meal and their various combinations were prepared as the test starter diets. Newly hatched Artemia nauplii from the cysts by using salt water and vigorous aeration as described by Viveen et al.[22] were considered as Diet A. Diet B comprised a mixed population of cultured zooplankton consisting of mainly cladocerans (60%), copepods (32%) and rotifers (8%). Diet C was an artificial feed (powdered fish meal with 65.4% crude protein) and diet D comprised a mixture of diets A and B (i.e. Artemia and zooplankton in equal concentrations). A mixture of Artemia and fish meal was represented as diet A+C, while diet F was a mixture of zooplankton and fish meal (B+C). Diet G was a combination of all the three ingredients (A+B+C) in equal concentrations; fish in treatment H were not fed at all. Thus, treatments G and H served as positive and negative controls, respectively. Eight diet treatments were randomly allocated to glass aquaria in triplicates to form a complete randomised design provided with aeration facilities.

Before the commencement of the feeding trial, larvae from an induced breeding experiment were collected (when they were at their 3rd day of life) and stocked in the glass aquaria (100 fish per tank) and were acclimatised for one day. The larvae were fed ad libitum at morning and evening daily. The aforementioned diets were given at 200 to 300 individuals per fish per ring the first week, 300 individuals in the second week and about 500 individuals in the 3rd and 4th week following the methodology of Madu et al.[23] to ensure that surplus food was available to the fish all the time. The number of Artemia or zooplankton fed to the fish was estimated using "Sub-sampling Technique" as described by Wetzel and Likens[24].

Powdered fish meal (diet C) was fed directly to the fish at 15% of the body weight per day in the first week and 10% thereafter till the end of the experiment. This practice was followed to ensure to feed the test fish without polluting the water[23]. Uneaten food and dead fish were removed from the tanks, and 50% water was changed every morning before feeding the fish and taking their length and weight measurements. Subsequent weight and length measurements were taken weekly. Fish weight was measured using an electronic balance (sensitivity 0.01 g). Mortality was determined weekly during the experimental tenure of 4 weeks. In each tank, water quality parameters such as water temperature, dissolved oxygen (DO) measure with DO meter and pH measured with pH meter (Dhayarreshwar labs, Pune, India) were recorded daily.

Results and Discussion

Dissolved oxygen contents of water in various treatments were relatively similar and never decreased below 5.4 mg/l. Water temperature ranged between 27^{o}C and 29^{o}C with a mean daily temperature of 28.07±0.65^{o}C while pH ranged between 6.5 and 7.5; these records were within the limit of good water quality for aquaculture as recommended by Boyd and Lichtkoppler[25].

The test fish larvae responded positively by their active movements to most of the diet treatments. They were seen darting about during each feeding period and trying to snap at the food. Their stomach soon became visibly swollen up, and later, they settled at the bottom of the tanks where most of the food items had concentrated.

Table 1 shows the growth responses as a function of diets in terms of body weight increase, total length increase, specific growth rate and mean

growth rate over a period of 28 days.

Table 1— Growth responses and survival rate of striped snakehead *Channa striatus* larvae fed various test starter diets

Diet	Composition	Mean weight gain (mg)	Mean total length increase (mm)	**Specific Growth Rate (% Wt gain/d)	***Mean Growth Rate (mg/g/d)	Mean survival (%)
A	*Artemia* only	220.1±3.32	29.9±1.18	18.94±1.4	70.69±0.86	74.0±3.32 [a]
B	Zooplankton only	183.2±2.45	27.3±0.87 [a]	17.98±1.14 [a]	70.51±1.08 [a]	72.0±3.59 [a]
*C	Fish meal only	1.4 ±0.10[a]	2.6±0.06	3.35±0.54	31.25±0.76	0.0 [b]
D	Artemia + zooplankton	197.9±2.83	27.9±1.22 [a]	18.25±0.82 [a]	70.57±1.14 [a]	74.0±4.84 [a]
E	Artemia + fish meal	283.1±3.68	35.5±1.54	20.97±1.36 [b]	71.05±1.82 [b]	76.0±4.23
F	Zooplankton + fish meal	234.6±4.25	31.6±1.96	19.17±1.53	70.77±1.45	71.0±1.24 [a]
G	Artemia + zooplankton + fish meal	293.8±4.36	39.3±1.13	21.10±1.12 [b]	71.04±1.84 [b]	74.0±2.66 [a]
*H	No Feeding	1.1±0.02 [a]	1.6±0.04	3.09±0.18	29.54±0.42	0.0 [b]

Values in the same column and having similar subscripts are not significantly different ($P > 0.05$). *All fish died after one week.
Values are for one week only. **Specific growth rate (% Wt gain/d) = 100 (Ln W2 – Ln W1)/t, ***Mean growth rate (mg/g/d) = 1000 (W2 – W1)/0.5(W1 + W2)t
Where W1 = Initial weight, W2 = Final weight, t = Culture period in days (Wuthisangh and Davis, 1977)

The highest increase in body weight (293.8±4.36 mg) and total length (39.3±1.13 mm) were recorded as a function of control diet G (Artemia + zooplankton + fish meal) followed by treatment E (Artemia + fish meal) with 283.1±3.68 mg and 35.5±1.54 mm, respectively, while the least increase (1.1±0.02 mg and 1.6±0.04 mm) was obtained in treatment H (no feeding). Values obtained in treatments B (zooplankton only), D (Artemia + zooplankton), C (fish meal only) and H (no feeding) were not significantly different ($p \geq 0.05$). A similar trend was observed for specific and mean growth rate values as a function of different diets. Treatment G had the highest specific and mean growth rates (21.10±1.12 and 71.09±1.84), whereas treatment H showed the lowest rates (3.09±0.18 and 29.54±0.42), respectively. The growth rates (mean and specific) of fish in treatment G (Artemia + zooplankton + fish meal) were; however, not significantly different ($p \geq 0.05$) from those of treatment E (Artemia + fish meal).

Fig 1 shows the growth pattern of fish as a function of different treatments.

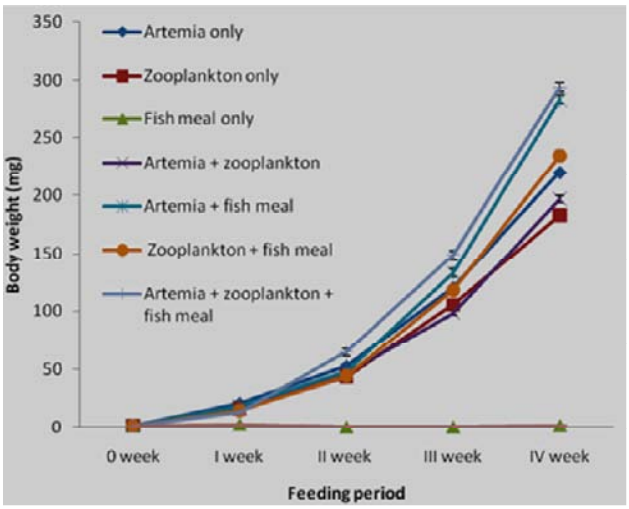

Fig. 1— Growth pattern of *Channa striatus* starter fed various diets for 4 weeks.

During the first week of the experiment, diet A (Artemia only) was leading in growth performance followed closely by diet E (Artemia + fish meal), whereas treatment C (Fish meal only) and H (no feeding) showed poor performance. Within the second week, diet G (Artemia + zooplankton + fish meal), which previously ranked fourth in performance, overtook diet A, D and E to emerge as the overall best diet. Diets A and D showed poor results after the first

week, whereas diet F (zooplankton + fish meal) showed remarkably increased performance.

All fish in treatment C (fish meal only) and H (no feeding) died after one week of the experiment. Survival in the other treatments were high ranging from 71.0±1.24% in treatment F to 76.0±4.23% in treatment E, but there were no significant differences ($p \geq 0.05$) among the mean survival values (Table 1).

The long-term success of any fish culture operation depends upon the proper domestication of the cultured fish species. The larvae of snakehead C. striatus can be successfully weaned by feeding them with live plankton and with combined diet (live feed and formulated diet) during the fry stage[26].

The best growth responses (in terms of body weight, total length and mean and specific growth rates) obtained as a function of diet G (Artemia + zooplankton + fish meal) might be attributed to the fact that the diet contained different food ingredients of various sizes and textures that provided the fish a wider spectrum to choose from. It is, however, important to note from the growth curves (Fig. 1) that the highly performed diets (G, E and F) were coincidental; the diets that had fish meal as one of the components suggested that fish meal is unavoidable and could form an important component of the diet of striped murrel hatchlings. The fishy flavour and the high content of good-quality protein in fish meal are usually a major factor in fish nutrition[27].

However, it was also observed from the growth curves that these diets containing fish meal (artificial feed) started performing well only after the first week of the trial. They were, therefore, not suitable during the first week. This is evident from the total mortality of all fish fed fish meal alone (diet C). The best diet during the first week was the Artemia (diet A), but the growth performance was reduced remarkably from the second week onwards. Evidence from the stomach content analysis of *C. striatus* larvae showed that within the first week of life, the food of striped murrel larvae was predominantly zooplankton. Therefore, availability of live food, especially at the early days of the larvae, was considered as one of the most important factors in deciding the success of nursery management of larviculture of murrels.

The total mortality of fish observed in treatment C (fish meal only) could be due to non-acceptance of the artificial feed by the fish. Hence, all the fish died as in treatment H where the fish were starved. This agreed with the observation of Madu et al.[23] on the food and feeding habits of mudfish hatchlings. According to the authors, artificial feed started appearing inside the fish gut on the 9th day of life and increased progressively as the fish increased in age. However, the fact that the majority of the fish survived up to the 5th/6th day of the trial showed that newly hatched striped murrel larvae could stay alive without food up to the 9th/10th day of life.

For the best growth and survival of hatchlings during the early nursery management of *C. striatus*, Artemia nauplii could be considered as the most suitable first food up to 10 to 12 days. A combination of fish meal, Artemia nauplii and zooplankton (as in diet G) was observed as the overall best diet for the rest of the indoor management. Many previous reports indicate that the critical stage in the larval development of fish is the transition from endogenous to endoexogenous and ultimately to exclusively exogenous feeding[28]. Provision of suitable live feed during this stage is vital, and it determines the rate of survival of the larvae. It is also reported that artificial feeds are not preferred by the larvae during this stage[29]. Assimilation efficiency may be lower in larvae than that in the adult fish due to the lack of morphological and functional stomach in the former. It is suggested that initial digestion in the fish larvae is carried out by enzymes present in the live prey[30]. Zooplankton is rich in essential amino acids and fatty acids (eicosapentaenoic acid and docosahexanoic acid also known as EPA and DHA) and should be sufficient in the feed as the primary source of nutrients required for growth of the fish[31]. 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[32,33]. Zooplankton contains many digestive enzymes such as proteases, carbohydrases and lipases, which might assist the digestion process in the gut of fish larvae[34]. From the present results, it is possible to conclude that the early nursery management of *C. Striatus* requires Artemia nauplii and rotifers for best survival and growth, and a combination of fish meal, Artemia nauplii and zooplankton is considered as the overall best diet for larviculture of murrels.

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