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Effect of Different Diets on Growth and Survival Rates of Snakehead (*Channa striata* Bloch, 1797) Larvae

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A study was conducted to determine growth and survival rates of snakehead (*Channa striata*) larvae. Live foods such as *Artemia salina* nauplii, *Moina micrura* and bloodworm and artificial diet were given to larvae from 1-15 days after hatching as the 1st phase and from 15-30 days as the 2nd phase. In the 1st phase, the growth and survival rates of larvae fed with *Artemia* nauplii were significantly different from larvae fed with *Moina* ($p<0.05$) with values of 28.5 mg, 49% and 26.7 mg, 31%, respectively. Meanwhile, all larvae fed with bloodworm (*Chironomus* sp.) or artificial diet (49% protein) died within 10 days of experiment. For the 2nd phase, growth of the fry fed with *Artemia* or *Moina* differed significantly from that fed with bloodworm or pellet (200.1, 187.7, 109.6 and 8.2 mg, respectively). Specific growth rate (SGR) of larvae fed with *Moina* was higher than that of larvae fed with *Artemia* (17.9 and 17.4% day^{-1}, respectively) in the 1st phase. In the 2nd phase, SGRs of larvae fed with *Artemia* (12.7% day^{-1}) or *Moina* (11.5% day^{-1}) were significantly higher than those of larvae fed with bloodworm (8.3% day^{-1}) or dry diet (6.1% day^{-1}). Generally, *Artemia* and *Moina* were suitable food for snakehead larvae during the first month of their life, and artificial diet was much less acceptable and resulted in poor growth and survival.

Snakeheads belong to family Channidae; they are also known as murrels and serpent-headed fish. They are native to freshwater systems of tropical Africa and Asia and the important food fish in these areas. They occur naturally in beels, haors, ponds, ditches and swamps. The average size of specimens caught in natural waters is about 200-500 g (Raman, 1989). Their preferred temperature range is 20-35°C. However, they can live at as lower as 15°C (Vivekanandan and Pandian, 1977) and upper lethal temperature of 40°C (Das, 1927). Snakehead can live in acidic and alkaline waters. The range of maximum survival of *C. stiatua* is 4.25-9.40 (Varma, 1979).

First feeding is one of the critical periods in fish larval rearing. Zooplankton such as *Brachionus, Moina* and *Daphnia* are frequently used as food resources in the freshwater larviculture and in the ornamental fish. They contain a broad spectrum of digestive enzymes such as proteinase, peptidase, amylase, lipase and even cellulase, that can serve as exo-enzyme in the gut of the fish larvae (Lavens and Sorgeloos, 1996). The nutritional value of *Moina* is considered to be high. It contains about 93.5% moisture and 6.5% dry matter. On a dry weight basis, *Moina* contains 70% crude protein, 16.4% crude fat, 9.9% crude ash and about 3.7% nitrogen free extract. *Moina* serves as an effective live food for most of the tropical or ornamental fish (Shim, 1988). *Artemia* nauplii contains substantial amount of essential amino acids for larvae development such as histamine, methionine, and phenylanine (Watanabe et al., 1983). The importance of bloodworm as a live food for tropical fish culture is well known in the ASEAN countries. The quantity and quality of food given and the types of food used in each of the developmental stages can also be critical in larval rearing. The most important concern is that they can effect economical aspects. Larval rearing has been successful for freshwater and marine fish larvae using brine shrimp *Artemia* sp (Léger et al., 1986), for walking catfish *Clarias macroceplalus* using *Moina* (Fermin et al., 1991) or for European catfish *Silurus glanis* using *Tubifex* worm (Ronyai and Ruttkay, 1990). It was also reported that some catfish (*Clarias gariepinus* and *Heterobranchus longifilis*) can exclusively be reared on artificial diet (Appelbaum et al., 1988 and Léger et al., 1986). However, dry diets often resulted in lower growth and survival rate than *Artemia* nauplii. So the present

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study aimed at comparing growth performance and survival rate of *Channa striata* larvae fed on *Artemia* nauplii to those fed on *Moina*, bloodworm or commercially prepared dry diet for larval rearing during the first 30 days.

Materials and Methods

Experimental design

Phase I

The 1st experiment was carried out on free-swimming larvae for fifteen days following the method of Hung et al. (1999) with some modifications. Four treatments (*Artemia* nauplii, *Moina*, Bloodworm and pellet) with three replicates were used in aquarium of hatchery. Larvae were weighed and measured at 1st, 5th, 10th, and 15th days of experiment. Larvae were stocked at 10 inds.L^{-1}. Foods were given daily at 0800H, 1200H, 1600H and 2000H. Waste and remaining food were siphoned out twice a day.

Phase II

The 2nd experiment was also set up as in the 1st phase for 15 days (from 15th to 30th day after free swimming). Larvae were fed with *Artemia* larvae from the 1-15 days. Then they were fed with experimented feeds. Larvae were weighed and measured at 15th, 20th, 25th, and 15th days of experiment. Stocking density was 5 larvae L^{-1}.

In both experiments, tap-water was stocked in big concrete tank for at least 24 h in order to remove chlorine before use. The aquarium was well aerated. Temperature was set at 26±1°C.

Experimental animals and diets

Larval source

Snakehead larvae were collected from a wild swamp. When the yolksac was absorbed and fry began free-swimming and eating exogenous food, the experiments started.

Live foods and artificial diet

Artemia salina nauplii have a size of 0.1256-0.1464 mm in width and 0.251-0.348 mm in length. Cysts were soaked in freshwater for 1 h. They were then incubated in 10% saline water for 24 h at the temperature of 28°C. Newly hatching *Artemia* were kept in aerated saline water. Nauplii were fed to snakehead larvae for 24 h.

Moina micrura were separated from zooplankton population in earthen pond. They were raised in raceway fed with chicken manure and eel powder (32% protein). They were collected in early morning and stocked in a small tank. Before feeding, *Moina* were treated with 4% formaldehyde for 1-2 min to eliminate disease germ. The size of *Moina* varied from 0.605-1.355 mm in length and 0.321-0.717 mm in width.

Bloodworms (*Chironomus sp*) were frozen in plastic bag by Ng Seow Kim Trading (Malaysia). Before feeding, they were thawed and cut in to small sizes. The fragments of bloodworm sized 0.8-1.2 mm in length and 0.586-0.695 mm in diameter.

Pellet named Momizi Tropical (Yeast, Japan) used for small fish were fed to larvae. The size of feed particles was 0.3-0.6 mm. The artificial diet composed of fishmeal, yeast, wheat flour, soybean meal, wheat germ, krill meal, *Spirulina*, kelp meal minerals and vitamins. The approximate composition of dried diet was 49% protein, 5% crude fat, 3% crude fiber and 16% crude ash.

Data analysis

The results were analyzed using ANOVA at 5% level of significance followed by Duncan's new multiple-range test for comparison of the means obtained using SPSS software version 9.05.

Results

The growth of snakehead from the 1-15 days old is presented in Table 1. The weight of larvae fed with *Artemia* did not differ significantly ($p<0.05$) from larvae fed with *Moina* in at the 5th, 10th and 15th day with values of 7.4, 14.9, 28.5 mg comparing with 7.4, 14.6, 26.7 mg, respectively. Meanwhile, at the 5th day, larvae fed with *Artemia* and with *Moina* differed significantly at $p<0.05$ with larvae fed with Bloodworm and Pellet with the values of 7.4, 7.4, 4.3 and 3.3 mg, respectively.

The weight of larvae used for the 2nd phase fed with *Artemia, Moina*, bloodworm and pellet during the first 15 days was not significantly different at $p<0.05$ with value of 28.0, 33.4, 31.3 and 32.0 mg, respectively (Table 2). After 5 days fed with different foods, the weight of larvae fed with *Artemia, Moina* and bloodworm were 63.3, 57.5 and 50.3 mg and differed significantly from Pellet (25.6 mg) at $p<0.05$. Meanwhile, at the 10th day, the

Table 1. Growth and survival rate of snakehead larvae (1-15th day) fed with different diets

Parameter	Treatments			
	Artemia	*Moina*	Bloodworm	Pellet
Initial weight (mg)	1.9	1.9	1.9	1.9
5-day old weight (mg)	7.4^a	7.4^a	4.3^b	3.3^b
10-day old weight (mg)	14.9^a	14.6^a	-	-
15-day old weight (mg)	28.5^a	26.7^a	-	-
Specific growth rate (%/day)	17.9^a	17.4^a	-	-
Survival rate (%)	49^a	31^a	0	0

Values in the same row having the same superscript are not significantly different at $P<0.05$

Table 2. Growth and survival rate of snakehead larvae (15-30th day) fed with different feeds

Parameter	Treatments			
	Artemia	*Moina*	Bloodworm	Pellet
15 day old (mg)	28^a	33.4^a	31.3^a	32.0^a
20 day old (mg)	63.3^a	57.5^a	50.3^a	25.6^b
25 day old (mg)	147.8^a	148.1^a	79.6^b	11.2^b
30 day old (mg)	200.1^a	187.7^a	109.6^b	8.2^b
Specific growth rate (%/day)	12.7^a	11.5^a	8.3^b	6.1^b
Survival rate (%)	94^a	76^{ab}	52^{bc}	10^d

Values in the same row having the same superscript are not significantly different at $P<0.05$

weight of larvae fed with *Artemia* (147.8 mg) was not significantly different from *Moina* treatment (148.1 mg) but differed statistically from larvae fed with bloodworm (79.6 mg) and pellet (11.2 mg) at $p<0.05$. Similarly, larvae fed with *Artemia* and *Moina* differed significantly from larvae fed with bloodworm and pellet with values of 200.1, 187.7, 109.6 and 8.2 mg in weight, respectively.

In the 1st phase, the specific growth rate (SGR) of larvae fed with *Moina* was higher than those fed with *Artemia* with the values of 17.9 and 17.4 % day^{-1}, respectively. In the next phase, the SGR of larvae fed with *Artemia* (12.7% day^{-1}) and *Moina* (11.5% day^{-1}) differed significantly with that of larvae fed with bloodworm (8.3% day^{-1}) and dry diet (6.1% day^{-1}).

The survival rate tended to decline from 1st to 15th day. It decreased quickly from the 5th day. All larvae died on the 9th day of bloodworm treatment and on the 10th day

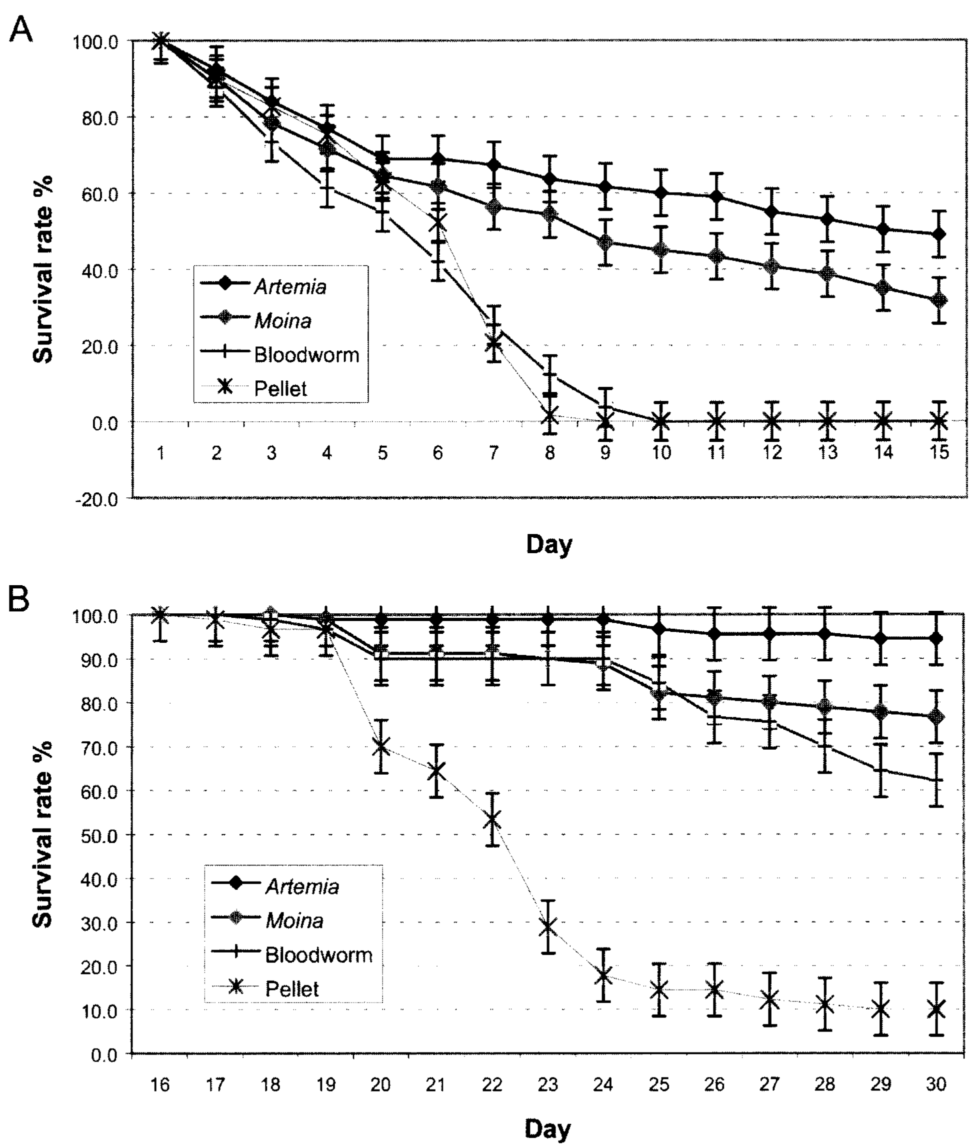

Fig. 1. A, Survival rate of snakehead larvae fed with different diets from 0-15 day old. B, Survival rate of snakehead larvae fed with different diets from 15-30 day old.

of pellet treatment (Fig. 1A). However, the mortality rate of larvae in *Artemia* and *Moina* treatments was also higher than 50%. The survival rate of larvae fed with *Artemia* (49%) was significantly higher than larvae fed with *Moina* (31%) at $p<0.05$ (Table 1). In phase II, the survival rate of larvae fed with *Artemia* was not significantly higher than larvae fed with *Moina* but differed statistically ($p<0.05$) from larvae fed with bloodworm and pellet with values of 94, 76, 52 and 10%, respectively (Fig. 1B). Meanwhile, the survival rate in *Moina* treatment was neither significantly lower nor higher than the rates in *Artemia* and Bloodworm treatments. Besidely, the survival rates of larvae fed with *Artemia, Moina* and bloodworm were significantly higher than the rates of larvae fed with pellet at $p<0.05$.

Discussion

Snakehead larvae (Phase I) after absorption of yolksac could not accept pellet and bloodworm, although pellet contains high protein and essential vitamins and minerals. It might be due to poorly developed digestive organ and cannivorous feeding habit. Lavens and Sorgeloos (1996) reported that many small fish larvae produced no enzyme for digesting non-living diets and that enzymes present in their live prey carried out digestion in the fish larvae. They also mentioned that proteases in live Artemia nauplii commonly fed to many larval fish species were responsible for successful rearing of white fish (Coregonus lavaretus) larvae. In the present study, Artemia and Moina treatments always had high survival and growth rates. Some advantages of using Artemia cyst as larval fish food includes: (1) the nutritional value is high, (2) its size (0.28 mm) is suitable for most fish larvae, and (3) fish larvae easily adapt to eating non-motile Artemia cyst. Besides their high nutritional value, live Artemia nauplii can actively swim for up to 5 h in fresh water before sinking to the bottom and dying (Qin et al., 1997).

Carps provided with bloodworm as supplementary food gained more weight and the growth rate was more uniform (Shim, 1988). During phase II of our study *Channa striata* larvae (15-30 day old) could accept pellet and blood worm. During this period, larvae have the enzymes for digesting the pellet. Moreover, larvae can eat bloodworm easily. However, the weight gain with bloodworm treatment was lower than *Artemia* and *Moina* treatments.

Using *Artemia* for larval rearing has been reported for several species. The SGR in food fish larvae ranged in good values of 12.4% day^{-1} in *Clarias macrocephalus* and *C.batrachus* (Fermin and Bolivar, 1991; Knud-Hensen et al., 1990); 31-40% day^{-1} in African catfish *Heterobranchus longifilis* (Kerdchuen and Legendre, 1994) and in Mekong catfish *Pangasius bocourti* (Hung et al., 1999). For *Carassius carassius* larvae only fed with *Artemia* the SGR value of 21.4% day^{-1} was obtained (Abi-Ayad and Kestemont, 1994). In the present study, *Artemia* nauplii and *Moina* proved to be an excellent feed for larval rearing of *Channa striata* in 1st phase with the SGR of 17.9-17.4% day^{-1}. On the other hand, in the 2nd phase, the SGR tended to reduce in *Artemia* and *Moina* treatments (12.7 and 11.5% day^{-1}). Meanwhile, the SGR with bloodworm and pellet treatments were low (8.3 and 6.1% day^{-1}, respectively). All values of SGR in both phases obtained in *Channa striata* were lower than other fish species. Thus, *Artemia* was an excellent food for *Channa striata* larvae during the first month.

Larvae fed with *Moina micrura* had the SGR higher than larvae fed with *Artemia* nauplii (Table 1). Similarly, the SGRs of other two catfishes, *Heterobranchus bidorsalis* and *Clarias gariepinus*, fed with *Moina dubia* are higher than those fed with *Artemia* nauplii with values of 6.1 and 5.1% day^{-1} (Adeyemo et al., 1994). *Heterobranchus longifilis* larvae fed with *Moina* showed lower growth because of the presence of numerous undigested ephippial eggs in the digestive tract of the larvae (Kerdchuen and Legendre, 1994). On the other hand, the fish had the SGRs of 31% day^{-1} in *Pangasius bocourti* for *Moina dubia* (Hung at al., 1999) and 23% day^{-1} in *Clarias macrocephalus* for *Moina macrocopa* (Fermin and Bolivar, 1991).

Bloodworm has been used as live food for nursing fishes. The minced bloodworm is still too large for larvae. In the current study, the larvae died gradually with in 9 days in the 1st phase (Table 1). In the next phase, *Channa striata* larvae could accept *Chironomus* but they had lower growth (Table 2). Actually, bloodworms contain too much water and are smelly, so larvae either eat less or not at all. So the study established that bloodworm was not a suitable feed for *Channa striata* during the first month.

The dry diet led to poor growth and survival rates. A commercial trout starter diet resulted in good survival rates with value of 12% in *Clarias gariepinus* (Fermin and Bolivar, 1991), 32% in *Heterobranchus longifilis* (Kerdchuen and Legendre, 1994) and 67.5% in *Pangasius bocourti* (Hung et al., 1999). In the current study, the larvae died gradually within 10 days. The growth and survival rates were lower than the other treatments in the 2nd phase. This may be related to the quality and digestibility of the dry diet or lack of some digestive enzymes in the first feeding. Hence, *Channa striata* larvae could not ingest dry diet during the first month feeding.

In fishes, cannibalism is usually associated with heterogeneous size variation, lack of food, high density, lack of refuge area and light condition. Among these variables, size variation and unsuitable food are considered the primary causes of cannibalism. Cannibalism was reported in most larval rearing especially under artificial diet. For example, the cannibalism in *Clarias gariepinus* larval rearing contributed to mortality that was higher than the natural mortality (Hecht and Appelbaum, 1987). In this study, *Channa striata* displayed high cannibalism in the dry diet treatment, as the survival rates were 0% in the first 15 days and 10% in the next 15 days. The low survival rate may be related to snakehead behavior. Conversely, *Pangasius bocourti* larvae had low cannibalism even in the artificial feeding treatment (Hung et al., 1999).

The results presented in Table 1 and Table 2 demonstrated that *Moina* could replace *Artemia* during the 1st month. Larvae could ingest bloodworm from 15 to 30 days but their growth was poorer than larvae fed with *Moina* or *Artemia*. The larvae could not digest pellet in the first month.

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