Taiwania, **52**(1): 84-92, 2007

Embryonic and Larval Development of the Striped Snakehead *Channa striatus*

K. Marimuthu[1,3] and M. A. Haniffa[2]

(Manuscript received 4 February, 2006; accepted 28 May, 2006)

ABSTRACT: The present study elucidated the embryonic and larval development of snakehead *Channa striatus* from fertilization until metamorphosis. The snakehead was successfully bred in the laboratory by injecting ovaprim, a synthetic hormone (0.5 mL/kg body weight). Spawning took place 24-26 hrs after the hormone injection. The fertilized eggs were floating, non-adhesive and straw yellow in color. The average diameter of fertilized eggs ranged from 1.20-1.40 mm. Incubation periods was about 23-24 hr at a temperature of 29 ± 1°C. The percentage of hatching varied from 80-85. The newly hatched larva was 3.4 ± 0.2 mm in length. The yolk absorption was completed within three days after hatching. The larvae metamorphosed into juveniles within 20 days after hatching.

KEY WORDS: ***Channa striatus*, early embryonic, larval development, metamorphosis**.

INTRODUCTION

The primary concern of any fish hatchery system is to produce the maximum number of the highest quality seeds and fingerlings from the available broodstock. This is particularly important in the farming of snakeheads because their wild seed collection is very much limited due to monsoon failure (Haniffa et al., 2000; Marimuthu et al., 2001a, b). Embryonic development and larval development studies besides providing interesting information in itself are imperative and consequential to the successful rearing of larvae for large scale seed production. The observations made after studying fish eggs, embryonic and larval development in fisheries sciences, aquaculture, taxonomy and ecology have been much highlighted (Blaxter, 1974).

The striped snakehead *Channa striatus*, a carnivorous air breather, is one of the valuable food fishes in the inland regions of India and hence has a good culture potential. The candidate species can survive in harse environments with low dissolved oxygen and high ammonia (Ng and Lim, 1990; Qin et al., 1997) and therefore are often cultured in grow out ponds at densities of 40-80 fish/m^2 with annual yields ranging from 7-156 tonnes ha^{-1} (Wee, 1982), although snakehead culture, is not practiced in a well defined way in India as Indian Major Carps. Existing reports on larval development and behavior of *C. striatus* are scarce with the exception of its biology and life history (Parameshwaran, 1975; Parameshwaran and Murugesan, 1976a, b). The larval development of other air breathing fish species viz., *Channa marulius* (Mookerjee, 1945) *Channa punctatus* (Banerji, 1974; Marimuthu., 2002); *Anabas testudineus* (Moitra et al., 1987; Hughes et al., 1986); *Clarias batrachus* (Thakur, 1976 and 1980); *Heteropneustes fossilis* (Thakur et al., 1974) *Monopterus albus* (Singh et al., 1990); *Clarias gariepinus* (Bruton, 1979; Verreth et al., 1992; Segner et al., 1993); *C. macrocephalus* (Mollah and Tan, 1982) have been reported. The embryonic and larval stages are considered very sensitive indicators of environmental disturbances. They are also indispensable in the study on ontogeny and phylogeny of their families (Legendre and Teugels, 1991; Verreth et al., 1992). In addition such studies on larval development of any cultivable species can be useful in directing the husbandry efforts of fish farmer to the specific state and requirements of each larval stage. This is necessary to optimize larval growth and survival. Therefore the present study has been conducted and provides detailed information about the embryonic and larval development of striped snakehead *C. striatus*.

MATERIALS AND METHODS

1. Department of Biotechnology, Faculty of Applied Sciences, Asian Institute of Medicine, Science & Technology, 2, Persiaran Cempaka, Amanjaya, 08000 Sungai Petani, Kedah Darul Aman, Malaysia.
2. Centre for Aquaculture Research and Extension, St. Xavier's College, Palayamkottai, Tamilnadu, 627 002, India.
3. Corresponding author. Email: aquamuthu2k@yahoo.com / kasi_marimuthu@aimst.edu.my

*This article is adopted from Zoological Taiwanica which was joined into Taiwania since 2006.

The fertilized eggs of *C. striatus* were obtained from induced breeding of both male and female by an intramuscular injection of ovaprim at 0.5 mL/kg body weight. Each breeding set consists of two males and one female. Hormone administered fishes were released into earthen breeding pond (3×3×1 m). Aquatic macrophytes like *Eichhornia crassipes* and *Hydrilla verticillata* were provided into the breeding pond for hiding purposes. Spawning behavior of hormonally induced fishes was closely observed. After spawning, the fertilized eggs were carefully collected from the breeding tank using a 500 ml beaker and transferred to a glass aquarium containing 15 L of water under gentle aeration. The water quality parameters including temperature 29 ± 1°C; dissolved oxygen 5.2 ± 0.5 and pH 7.0-7.3 were recorded in the breeding pond and larval rearing tank throughout the experimental period. After yolk sac absorption the larvae were fed *adlibitum* twice per day with zooplankton (predominantly rotifers and moina). Developing eggs were sampled every hour during the first 24 hours and every 4 hours during the next three days and then only once a day until metamorphosis. The sampled eggs and larvae were fixed in 4% formalin for further observations. In the present study, the developmental stages were divided into embryonic, larval and post larval development. The embryonic stage occurs inside the chorion and ends in hatching. The larval stage is characterized by nutritive contribution by the yolk sac and the stage ends when the larva becomes capable of exogenous feeding. The post larval stage begins immediately on absorption of the yolk sac and is characterized by autonomous feeding. The age of the larvae was denoted as hours after activation. Measurements of egg diameter and standard length were made using ocular micrometer. The total lengths of 10 individuals were measured at each sampling time (TL is the length from the tip of snout to the end of the caudal fin; Crawford, 1986). The mean total length was also calculated and recorded. The observation of the larvae was carried out under a binocular microscope (Nikon Eclipse E400) till the end of the larval period.

RESULTS

Description of fertilized eggs

The spawning was noticed within 24-26 hrs after the hormone injection. Fertilized eggs of *C. striatus* were free floating, spherical, non-adhesive translucent and straw yellow in color (Fig. 1). The diameter of the fully swollen fertilized eggs varied from 1.20-1.40 mm. The egg proper is brownish in color having an average diameter of 850 ± 10 µm. The yolk is capped by a distinct blastodisc and contains an oil globule liable to disintegration to 4-6 globules, unequal in size (Fig. 2). The detail of the development of fertilized eggs until hatching is elaborated in Table1.

Embryonic development

The first cleavage that divides the blastodisc into two blastomeres occurred within 15-20 min after fertilization. The segmentation was typically meroblastic. The second cleavage followed within 15 min and within another 30 min the 16 celled stage was reached. As successive cleavages occurred the blastomeres decreased in size and the morula stage was reached between 1.30-2.0 hr after fertilization (Fig. 3). At about 5-6 hrs of fertilization the embryo attained blastula stage. After half an hour, the spread of blastoderm was evident and 6 hrs after fertilization it was flattened at the top resulting in the formation of the germinal ring (Fig. 4). Embryonic shield appeared within next 2 hrs and by that time more than half of the yolk was invaded and at this stage the head and tail ends of the embryo became clearly distinguishable. Gastrulation was in progress approximately 9.30 hrs after fertilization and the blastopore was evident. In another 30 min yolk invasion was completed and the blastopore was almost closed.

Differentiation of embryo

Neural stage

Observation made at 10.30-11.00 hrs revealed that antero-posterior axis was distinguishable, cephalic portion being broader and embryonic rudiment became distinct with two somites. The anterior protuberance formed a head fold and the posterior part elongated further to form tail fold. By the time maximum diameter of the coiled embryo was 0.958 mm. The eye vesicles were demarcated. About 6-8 somites were formed after 14 hrs and optic cups were clearly distinguished (Fig. 5). In the 15-16 hr embryo, more than three fourth of the egg peripherical space was occupied by the embryo. Number of mesodermal somites gradually increased from 8 to 10 and pigmentation was noticed in somites. Notochord was more clearly seen and the fore mid and hind brain region were also noticed. Cephalic portion was broadened and embryo was embedded in the yolk mass all over its length. At 18 hr old embryo, the whole space inside the egg was fully occupied by the embryo. The mesodermal somites ranged from 12-15 in numbers. Blood circulation was observed. Ectodermal thickening to form lens of the eye was indicated. The caudal tail region started to detach from the yolk mass. Embryonic fin fold appears, and

Table 1. Embryonic development of *Channa striatus.*

Time after spawning	Stage	Description
0 min	Fertilized egg	Eggs were free floating, spherical, non adhesive, transparent and straw yellow in color. The diameter of the fertilized eggs varied from 1.20 mm-1.40 mm.
15 – 20 min	2 Cell stage	First cleavage
30 – 50 min	16 Cell stage	Fourth cleavage
1.30 – 2.0 hr	Morula	Blastulation progresses to form a multicellular blastodisc.
5.00 – 6.00 hr	Blastula	Embryonic shield formed, more than half the yolk invaded, anterior and posterior differentiation evident.
8.00 – 9.00 hr	Gastrula	Gastrulation converts the embryo into a two- layered structure, with an outer epiblast and inner hypoblast.
9.00 – 9.30 hr	Post gastrula	The germinal ring and embryonic shield get established, yolk invasion completed.
9.30 – 10.00 hr	Early neurula	Cephalic region broader with distinct fore brain.
10.30 – 11.00 hr	Neurula somite	Embryonic rudiment becomes distinct, two myotomes and optic vesicle are demarcated.
13.00 – 14.00 hr	Late neurula	Melanophores appear, six myotomes formed, notochord laid, heart rudiment visible.
15.00 – 16.00 hr	10 Myotome	8-10 myotomes, demarcation of brain, cephalic region broadened.
17.00 – 18.00 hr	15 Myotome	12-15 myotomes laid, eyelens formed in the rudimentary eyes kupfer's vesicle clearly in visible.
20.00 hr	22 Myotome	18-20 mytomes formed, eye lens fully formed in the olfactory vesicle indicated, heart formed and blood circulation commenced, heartbeats at the rate of 142-147/min, a few melanophores appear over the yolk sac.
22.00 hr	Pre hatched embryo	The embryo encircled the entire yolk. Olfactory pits and the concretions on the auditory vesicles formed, blood colorless, kupfer's vesicles has disappeared, heartbeats at the rate of 180/min, a few melanophores appeared all over the body embryo makes frequent twitching movements.
23.30 – 24.0 hr	Hatching	Hatching of embryo starts.

Kupfers vesicle was noticed. Motility in the embryo was observed with 18-20 contractions per minute. In the 20 hrs old embryo 18-20 somites were observed. Embryonic fin fold on the ventral side extended upto the 11th somite. Eye lens was fully formed in the eye. Olfactory placode was indicated. Blood circulation commenced over the yolk into the rudimentary heart lying anterior to the yolk sac. The heartbeat ranged from 142-147 beats per minutes. Few dendritic melanophores appeared over the yolk.

In 22 hr old embryo, somites number increased to 24-25. The yolk was completed encircled by embryo. The tail end was free from the first 2 somites. The olfactory pits and auditory resides were prominently visible. Melanophores appeared in scatter above neural chord over the trunk and caudal regions. Heartbeat ranged from 175-180 per minute. Frequent embryonic twitching movements were observed. Hatching took place about 23-24 hr after fertilization. The embryo showed vigorous movements and lashed its tail vigorously against the capsule, there by rupturing the capsule towards the head region and finally emerged out from the capsule (Fig. 6).

Larval development

Details of the larval development and average body measurements are elaborated in Table 2.

Hatchling

The newly hatched larvae were transparent and faintly brown in color with 3.4 ± 0.2 mm in length. The hatchlings had unpigmented eyes and devoid of distinct mouth and fins. Since the head was very small, it was not distinctly separated from the yolksac. There was a functional heart and the blood circulation was noticed but the blood was unpigmented. The head and the yolksac together appeared as a bulb like structure when viewed from the above. The larvae floated passively on the water surface and occasionally swam upside down in inclined manner (Fig. 7).

4 hrs old larva

Average length of the 4 hr old larvae was about 3.5 mm and brownish in color. The mouth was not yet developed and the anal invagination appeared on the ventral side. A conspicuous depression identified the position of the mouth. Eyes were unpigmented. The heart was two chambered. Circulation of body fluid was seen around the notochord in addition to the brain and yolk. Blood corpuscles were reddish yellow showing formation of hemoglobin (Fig. 8). The pigmentation darks in anterior region and malanophores are scattered on the yolk sac and are present on the unpaired fin. Larvae were converged in cluster and few started swimming to long distances. They covered a distances of 30 cm^2 and swam in a spiral fashion.

8 hrs old larva

Average length of 8 hr old larva was about 3.9 mm. Bulged yolk became gradually elongated at this stage. The larva displayed dorso-ventral unpaired fin. Some melanophores appeared on the head region, ventral side of the notochord and dorsal side of the body. Organs like heart and brain were clearly distinct. Ray like markings was faintly noticeable at

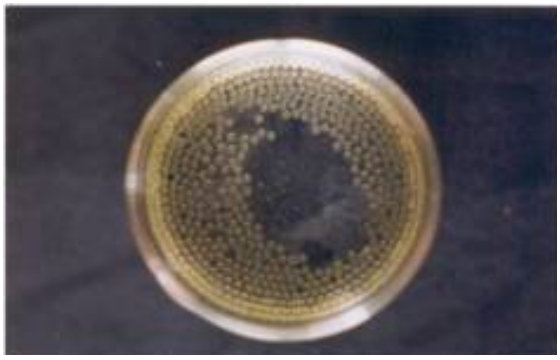

Fig. 1. Fertilized eggs of *C. striatus.*

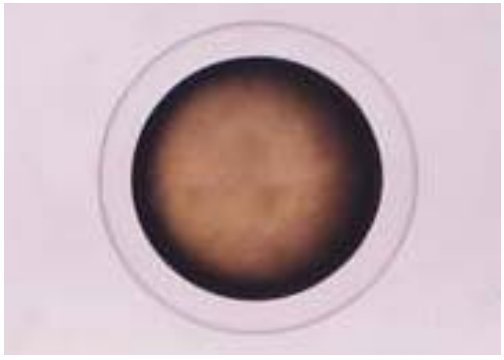

Fig. 2. Fertilized egg.

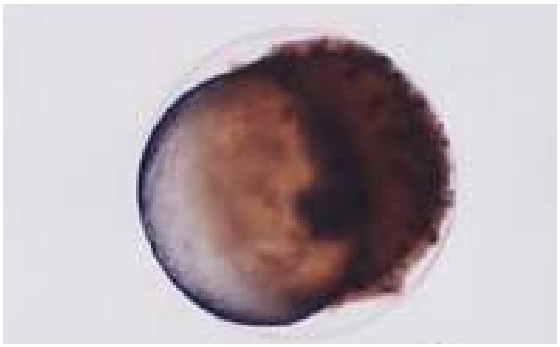

Fig. 3. Morula stage.

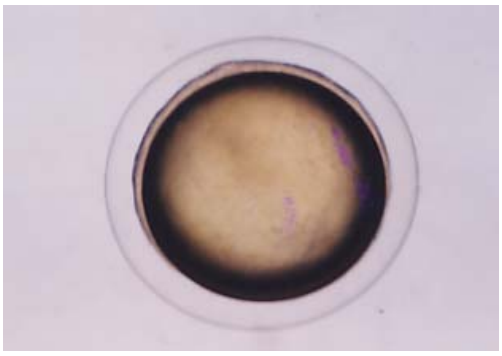

Fig. 4. Six hrs old embryo.

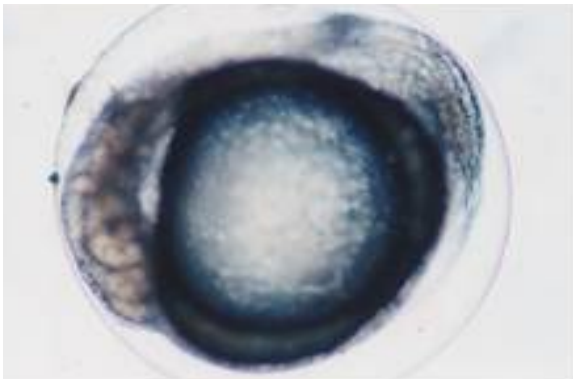

Fig. 5. Fourteen hrs old embryo.

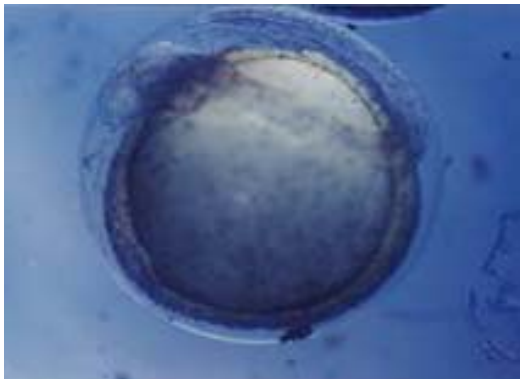

Fig. 6. Twenty-two hrs old embryo.

the end of the caudal region. Circulation was conspicuous at the optic region. Some pigments were visible on the iris. The heartbeat at 150/minute was observed. At this stage many larvae became active and passively to the water surface and negatively phototrophic and they were very sensitive to light (Fig. 9).

16 hrs old larva

The average length of the 16 hr old larvae measured about 4.2 mm. The auditory capsule near the eye became prominent and the pulsation of the heart was clear (Fig. 10).

24 hrs old larva

The average length of the 24 hr old larvae measured about 4.8 mm. Dark pigmented and prominent eyespot appeared on the anterior part of the head. At this stage 32 myotomes were seen. Buccal invagination appeared but was not connected with pharyngeal tube. Pectoral fin buds were seen as a small protuberance and the alimentary tract was distinct. The air sac was differentiated as small tube below the pectoral fin bud. Eyes were fully pigmented. The heart was seen in front of the yolk. Pigmentation extended to the yolksac both dorsally and ventrally, whereas melanophores were scattered on the dorsal fin fold and trunk region.

Table 2. Larval development of *Channa striatus.*

Time after hatching	Description and behavior
0 hr (at hatchling)	Just hatched embryo, dull brown in color, well defined yolk sac, with a transparent fin fold encircling the body. Heart was functional, mouth and anus are absent. Body dark brown in color. Total average length 3.4 mm. Larvae started a nonstop tail wagging movement, moves with ventral side up clings to sub merged weed roots. The larvae could not swim very well.
4.00 hr	3.5 mm long, un pigmented eyes a conspicuous depression identified the position of the mouth. Larvae converged in cluster, few started swimming to a long distance. They cover a distances of 30 cm^2 swimming in a spiral fashion.
8.00 hr	Length 3.9 mm, displays dorso ventral unpaired fin, heart, brain and ventricles distinct, few small sized melanophores appeared on the head region, ventral side of the notochord and the dorsal side of the body. Many larvae became active and would passively to the water surface and negatively phototrophic. They were very sensitive to bright light.
14.00 hr	Average length 4.2 mm, dark prominent eyespot on the anterior part of the head, caudal fin begins to separate. Buccal invagination appeared. Pectoral fin buds and swim bladder formed, heart positioned in front of the yolk.
36.00 hr	Average length 5.1 and post anal length 2.6 mm, pectoral fin round shaped, mouth formed as a terminal opening, the lower jaw is less developed, vent formed. Rudimentary gill opening and nartial pits differentiated, thick band of melanophores run from the post -orbital region to the base of the pectoral.
48.00 hr	Average length 5.4 mm and anal length 2.8 mm pectoral fins paddle shaped, mouth formed with well-developed lower jaw. Vent and gill rudiments clearly visible. Larvae move horizontally in shoals and swam haphazardly to the water surface. Larvae feeding exogenously.
3 day	Average length 5.8 mm and post anal length 2.9 mm, head prominent, pectoral fin flap like, yolk sac absorbed, body bilobed, and larvae swam vigorously.
6 day	Average length 7.8 mm and post anal length 3.5 mm, yellow pigments on the dorsal and lateral sides appear as bands, pectoral fins clearly recognizable. Eyeballs are large and distinct.
10 day	Average length 12.8 mm and post anal length 6.2mm, color bands are more distinct, five caudal fin rays. Dorsal fin separate from caudal fin, ventral fin buds formed, fry come to water surface to gulp air.
15 day	Average length 16.6 mm and post anal length 8.4mm. Basal thickening appears in the dorsal and ventral fin folds. Eight caudal fin rays distinguished. Silver and greenish pigments appeared on the orbital rim and on the postorbital regions.
20 day	Average length 40.8 mm and post anal length 20.2 mm, fry assumes adult character, dorsal, anal and caudal fins clearly differentiated. Larvae continuously hunt for feed with only few hours of rest. These behaviors continued till the end of larval period.

36 hrs old larva

The 36 hr old larva measured an average length of 5.1 mm and post anal length 2.6 mm. The eyes were dark pigmented. Pectoral fin was a round shaped membranous flap and it was actively used for free movement. Heart was distinctly visible and located behind the head and showed regular beats. Mouth was formed as a terminal opening. The lower jaw was less developed. Vent was just formed. Rudimentary gill opening and nartial pits were differentiated. A thick band of melanophores run from the postorbital region to base of the pectoral. The yolk reserve was further diminished (Fig. 11).

48 hrs old larva

The larva was measured about 5.4 mm in length and post anal length 2.7 mm. The eyeball was dark and prominent; the mouth cleft was well formed with well developed lower jaw. The yolk reserve was further diminished. The pectoral fin became paddle shaped with undulating dorsal margin. The anal aperture and opercula were well formed and distinct. The alimentary canal was distinct and larva started feeding exogenously.

3 days old larva

When 3 days old, the larva measured an average length of 5.8 mm and post anal length of 2.9 mm. The pectorals, which were seen to move vigorously, have been vascularised with a distinct circular vessel running across them. The head was prominent and free movements of the eyeball were observed. Melanophores were scattered on both the sides of the vessel. The reserved yolk material was completely absorbed. The abdomen appeared as heart shaped when viewed from the ventral side. The body was brownish in color. Blood circulation was observed in the opercula, heart and tail region. The caudal fin beard 5 rudimentary rays and the pectoral fins were flap like and vascularised. Pigments are more concentrated in the anterior region, however the density decreased gradually. Larvae exhibited vigorous movements and close to the water surface and occasionally sank to the bottom. At this stage shoaling behavior of larvae was observed.

6 days old larva

The average length of 6 days old larva was measured about 7.8 mm. The body was brownish in color. Yellow pigments were observed on the patched clear of melanophores on the dorsal side and lateral sides appeared as bands. Eyeballs were large and distinct. Pectoral and caudal fin rays were clearly noticeable. Groups of larvae tend to assemble at the bottom of the aquaria.

10 days old post larva

Average length of 10 days old larvae measured

12.8 mm and post anal length of 6.2 mm. Dorsal and anal fins were clearly demarcated and were almost separated from the caudal fin. The color bands were distinct. The caudal fin rays were clearly seen and five in number and hypurals were indicated as basal thickening. Ventral fin buds were formed. The young ones frequently came to the water surface to gulp the air.

15 days old post larva

Average length was measured about 16.6 mm and post anal length of 8.4 mm. The characteristic yellow bands and dark lateral bands were prominent. Basal muscle thickening appeared in the dorsal and ventral fin folds. Caudal fin rays were distinguished and eight in number, the middle showing articulation.

20 days old fry

Average length 40.8 mm and post anal length 20.7 mm was measured. At this stage organogeny was completed and the fry assumed nearly the adult stage, except the color pattern. The anal and the dorsal fins were confluent with caudal by narrow flanges. The fry moved actively in shoals (Fig. 12).

DISCUSSION

The present observations on the morphology of fertilized eggs of *C. striatus* were similar to those reported by Parameshwaran and Murugesan (1976b). In *H. fossilis*, the first cleavage began in about 30 min after fertilization and the 16 celled stage in about 70-80 min and the morula stage in about 100 min was attained (Thakur et al., 1974). In *Channa punctatus* after 45 min of fertilization eggs reached the 16 celled stage (Banerji, 1974). In the present observation the gastrula stage was reached at 9 hrs after fertilization. Banerji (1974) and Datta Munshi and Hughes (1991) reported that in *C. punctatus*, the blastula stage appeared after 2-3 hrs and the yolk invasion was completed at 9 hrs after fertilization. In *A. testudineus*, invasion of the yolk by the blastoderm was completed about 10 hrs after spawning (Datta Munshi and Hughes, 1991).

In the present study hatching took place about 23-24 hr after fertilization. Kohli and Vidyarthi, (1990) reported in *H. fossilis* at a temperature of 26ºC the incubation period of the eggs varied from 16-18 hrs. Ramanathan et al., (1985) reported in *Mystus punctatus* at a temperature of 28.5 ± 1.8ºC the incubation period of the eggs varied from 18-24 hrs. Banerji (1974) reported hatching of *C. punctatus* took place 24 hr at a temperature of 28ºC. Datta Munshi and Hughes (1991) reported the incubation period in *A. testudineus* was around 10.5 hr after fertilization.

The newly hatched larva of this candidate species was 3.4 mm in length. According to Parameshwaran and Kamal (1988) the length of newly hatched snakehead hatchlings were as follows: (3.88-4.47 mm) in *C. marulius*, (2.81-3.22 mm) in *C. striatus*, (2.49-2.70 mm) in *C. punctatus* and that of the yolk absorbed larva were (6.8-7.1) in *C. marulius*, (5.3-6.1) in *C. striatus* and (4.6-4.9) in *C. punctatus.* Observation made on the newly hatched larvae in *H. longifilis* recoreded the length of 4.09-4.9 mm by Ogunji and Rahe (1999) but females of different ages and sizes may produce larger larvae. Mookerjee and Mazumdar (1950) reported a mean length of 5.8 m for *C. batrachus*, while Bruton (1979) reported 3.6 mm for *C. gariepinus*. These variations can be related to the size of eggs. According to Bagarinao and Chua (1986) eggs diameters are positively correlated with larval length and weight at hatching. In newly hatched larvae the mouth did not open but the heart was functional. The heart of C. *punctatus* became distinct and the anal invagination appeared on the ventral side 3 hrs after hatching (Datta Munshi and Hughes, 1991). The larvae actively exhibited tail-wagging movements. This may probably be useful to cutaneous respiration and aid to free the larvae from substrate (eggshell), which could be a potential site for bacterial growth and infection (Ogunji and Rahe, 1999).

In the present study mouth was opened on 36 hr after hatching. But in *H. longifils* Ogunji and Rahe (1999) reported the mouth opening 3-4 hr after hatching. Larvae commenced feeding at 5.4 mm length (48 hr), and its first feeding took place 12 hr after the mouth opening. Ogunji and Rahe (1999) also reported first feeding in *H. longifilis* larvae at 48 hr after hatching. In the present study alimentary canal was observed 48 hr after hatching. However it may not have been fully developed physiologically. The yolksac of *H. longifilis* is fully resorbed on 55 hr after hatching, (Ogunji and Rahe, 1999). Complete disappearance of yolksac has been observed in *Clarias lazera* on 4th day (Panjionghua and Zhongwenbiao, 1987), *Clarias fuscus* on third day (Panjionghua and Zhengwenbiao, 1982). In *Mystus macropterus,* commencement of the differentiation of the digestive canal, which is continuous and straight, has been observed on 3rd day (Wang, et al., 1992). The yolksac of Mystus montanus was fully resorbed only after 3rd day when the larvae reached length 5-5.5 mm (Raj et al., 2003). Verreth et al., (1992) observed the morphological and functional development of the stomach was not completed at the onset of exogenous feeding in *C. gariepinus.*

Aerial breathing of larvae was observed on 10th day after hatching. Similarly in other air breathing

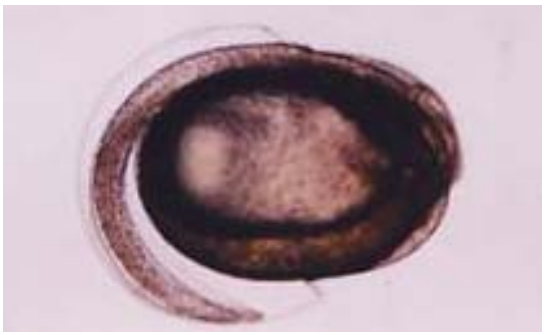

Fig. 7. At hatching.

Fig. 8. Four hrs old larva.

Fig. 9. Eight hrs old hatchlings.

Fig. 10. Sixteen hrs old larva.

Fig. 11. Thirty-six hrs old larva.

Fig. 12. Twenty Days old fry.

fishes the habits was observed from 12-13 days after hatching in *A. testudineus* (Datta Munshi and Hughes, 1991), 14th day in *C. marulius* (Parameshwaran and Murugesan (1976b), 5th day in *H. fossilis* (Kohli and Vidyarthi, 1990) and 10th day in *C. batrachus* (Asha Landge 1995). The movement of larvae and capture of prey was improved when the larvae measured 12.8 mm on the 10th day onwards. This is likely due to the development of caudal fin rays and the emergence of rays on the dorsal fin. Brown (1986) opined that improvement in capture of prey could be due to the maturation of the visual system as well as improvement in locomotive ability. It was noticed in this study that C. *striatus* larvae metamorphosed only when they grew to a total length of 40.8 mm on 20th day.

CONCLUSION

Freshwater aquaculture entrepreneurs and fish farmers in India are fully engaged in carp and other catfish culture. Fish farmers are lacking knowledge about breeding and feeding of early larval stages of snakeheads. The short embryonic period or incubation period and fast organ development and air breathing habits starting at 10th day after hatching of this species *C. striatus* suggest that it is a suitable and potential species for small scale fish farmers and commercial culture.

ACKNOWLEDGEMENTS

The Department of Science and Technology (New Delhi, India) for financial support of this study is gratefully acknowledged.

LITERATURE CITED

Bagarinao, T. and T. E. Chua. 1986. Egg size and larval size among teleosts Implications to survival potential. In: Maclean, J. L., L. B. Dizon and L.V.Holsilos (eds.), The first Asian fisheries forum. Asian Fisheries Society, Manila, Philippines. pp. 651-656.

Banerji, S. R. 1974. Hypophysation and life history of *Channa punctatus* (Bloch). J. Inland Fish. Soc. India **6**: 62-73.

Blaxter, J. H. S. 1974. The early life history of fish. Springer-Verlag, Berlin, Germany. pp.V-VI.

Brown, J. A. 1986. The development of feeding behavior in lumpfish *Cyclopterus lumpus*. J. Fish. Biol. (Supplement A): 171-178.

Bruton, M. N. 1979. The breeding and early development of *Clarias gariepinus* (Pisces: Clariidae) in lake sibaya South Africa, with a review of breeding in species of the subgenus Clarias (Clarias). Trans Zoo. Soc., Lond. **35**: 1-45.

Crawford, C. M. 1986. Development of eggs and larvae of the flounders *Rhombosolea tapirina* and *Ammotectis rotratus* (Pisces: Pleuronectidae). J. Fish. Biol. **29**: 325-334.

Datta Munshi, J. S. and G. M. Hughes. 1991. Air breathing fishes of India. pp. 181-208, 289-204.

Haniffa, M. A., T. Merlin and J. S. Mohamed. 2000. Induced spawning of the striped murrel *Channa striatus* using pituitary extracts, human choronic gonadotropin and luteinzing hormone releasing hormone analogue and ovaprim. Acta. Icht. Piscat. **30**: 53-60.

Hughes, G. M., J. S. D. Munshi and J. Ojha, 1986, Post embryonic development water and air breathing organs of *Anabas testudineus* (Bloch). J. Fish Biol. **29**: 443-450.

Kohli, M. S. P and S.Vidyarthi. 1990. Induced breeding embryonic and larval development in *Heteropneustes fossilis* (Bloch) in the agroclimatic conditions of Maharastra. J. Indian Fish. Assoc. **20**: 15-19.

Legendre, M. and G. G. Teugels. 1991. Development and thermal tolerance of eggs in *Heterobranchus longifilis* and comparision larval development of *H. longifilis* and *Clarias gariepinus* (Teleosei, Clariidae), Aquat. Living Resour. **4**: 227-240.

Marimuthu, K. 2000. Induced spawning in snakehead *Channa sps* using natural and synthetic hormones. Ph.D Thesis, Manonmaniam Sundaranar University, Tirunelveli, Tamilndau, India. pp. 81-97.

Marimuthu, K., M. A. Haniffa, M. Muruganandam and A. J. Arockia Raj. 2001a. Low cost murrel seed production technique for fish farmer. Naga. **24**: 21-22.

Marimuthu, K., M. A. Haniffa, A. Jesu Arockiaraj and M. Muruganandam. 2001b. Spawning and parental behavior in the induced bred murrels. Indian Journal of Fisheries. **48**: 409-411.

Moitra, A., A. Pandey, T. K. Ghose and J. S. D. Munshi. 1979. Spawning behavior, postembryonic development and culture of *Anabas testudineus* (Bloch). In symposim on Inland Aquaculture held at CIFRI Barrackpore, West Bengal. Abst. **3**: 2-3.

Mollah, M. F. A. and E. S. P. Tan. 1983. HCG induced spawning of the catfish *Clarias macrocephalus* (Gunther). Aquaculture. **35**: 239-247.

Mookerjee, H. K. and S. R. Mazumdar. 1950. Some aspects of the life history of *Clarias batrachus* (Linn). Proc. Zool. Soc. Beng. **3**: 71-79.

Mookherjee, H. K. 1945. Life histories of some carnivorous fishes of Bengal. Sci and Cult. **11**: 102-103.

Ng, P. K. L. and K. K. P. Lim. 1990. Snakeheads (Pisces: Channidae): natural history biology and economic importance. In: Chou, L. M. and K. L. P. Ng (eds.), Essays in Zoology. Papers Commemorating the 40th Anniversary of the Department of Zoology. National University of Singapore, Singapore. pp. 127-152.

Ogunji, J. O. and R. E. Rahe. 1999. Larval development of the African catfish *Heterobranchus longifilis* VAL., 1840. (Teleostei; Claridae) and its larval behavior. J. Aqua. Trop. **14**: 11-25.

Pan Jionghua and Zheng Wenbiao. 1982. Observations on the embryonic and larval development of *Clarias fuscus.* Acta Hydrobiologica Sinica **7**: 445-454.

Pan Jionghua and Zheng Wenbiao. 1987. Observations on the embryonic and larval development of *Clarias lazera*. Journal of South China Normal University **1**: 19-27.

Parameshwaran, S. 1975. Investigations on the biology of some fishes of the genus *Channa gronovius*, Ph.D. Thesis. Magadh Univ. Bodh. Gaya, India. p. 299.

Parameshwaran, S. and M. Y. Kamal. 1988. Synoposis of biological data on the giant murrel, *Channa marulius*, and the spotted murel *Channa punctatus,* Central Inland Capture Fisheries Research Institute, Barrackpore, India Bulletin **53**: 77.

Parameshwaran, S. and V. K. Murugesan. 1976a. Breeding season and seed resources of murrels in

swamps of Karnataka state. J. Inland. Fish. Soc. India **8**: 60-67.
Parameshwaran, S. and V. K. Murugesan. 1976b. Observation on the hypophysation of Murrels (Ophiocephalidae). Hydrobiologia **50**: 81-87.
Qin, J., A. W. Fast and A. T. Kal. 1997. Tolerance of snakehead *Channa striatus* to ammonia at different pH. Journal of the World Aquaculture Society **28**: 87-90.
Raj, A. J. A., M. A. Haniffa, S. Seetharaman and S. P. singh. 2003. Early development of a threatened freshwater catfish *Mystus montanus* (Jerdon). Acta Zoologica Taiwanica **14**: 23-32.
Ramanathan, N., P. Natarajan and N. Sukumaran. 1985. Studies on the induced spawning and larval rearing of a fresh water catfish *Mystus punctatus* (Jerdon). Indian Acad. Sci. (Anim. Sci) **94**: 389-398.
Segner, H. Rosch, J. Verreth and U. Wit. 1993. Larval nutritional physiology studies with *Clarias gariepinus, Coregonus lavaretus* and *Scophthalmus mas*. J. World. Aqua. Soc. **24**: 121-134.
Singh, B. R., A. N. Yadav, M. S. Prasad, A. P. Mishra and I. Singh. 1990. Neo-morphic organ for Co_2 elimination in air breathing teleosts. Eur. Arch. Biol. **101**: 257-267.
Thakur, N. K. 1976. On the spawning behavior of *Clarias batrachus* (Linn) Japan J. Ichthyol. **23**: 178-180.
Thakur, N. K. 1980. Notes on the embroyonic and larval development of an airbreathing catfish, *Clarias batrachus* (Linn). J. Inland Fish. Soc. India. **12**: 30-43.
Thakur, N. K., R. N. Pal and H. A. Khan. 1974. Embryonic and larval development of *Heteropneustes fossilis* (Bloch). J. Inland Fish. Soc. India **VI**: 33-44.
Verreth, J., E. Torreele, E. Sparzier and A. Slurszen. 1992. The development of a functional digestive system in *Clarias gariepinus* (Burchell). J. of the World Aqua. Soc. **23**: 286-998.
Wang, D.-S., Y.-G. Zhang and Q.-S. Luo. 1982. Observations on the larval development of *Mystus macropterus* (Bleeker) Bagridae. J. Fish. Biol. **40**: 371-379.
Wee, K.-L. 1982. The biology and culture of snakeheads. In: Muir, J. F. and R. J. Roberts (eds.), Recent advances in aquaculture. Westview Press, Boulder, Colorado, USA. pp. 180-211.

紋鱧胚胎與仔魚的發育

K. Marimuthu[1,3] and M. A. Haniffa[2]

(收稿日期：2006 年 2 月 4 日；接受日期：2006 年 5 月 28 日)

摘　　要

這研究在闡述紋鱧 (*Channa striatus*) 從受精卵到變態成稚魚的胚胎與仔魚發育過程。紋鱧在注射合成激素 ovaprim 後 (體重每公斤注射 0.5 mL) 即養在實驗室中，在注射激素後 24-26 小時會開始產卵，受精卵成淡黃色，是浮性卵且不附著，平均直徑 1.20-1.40 mm。培養在溫度攝氏 29 ± 1℃ 中，受精卵在 23-24 小時後孵化，平均孵化率 80-85%，剛孵化的仔魚 3.4 ± 0.2 mm 長，卵黃在孵化後三天完全吸收掉。孵化後 20 天內，仔魚會變態成稚魚。

關鍵詞：紋鱧、早期胚胎、仔魚發育、變態。

1. Department of Biotechnology, Faculty of Applied Sciences, Asian Institute of Medicine, Science & Technology, 2, Persiaran Cempaka, Amanjaya, 08000 Sungai Petani, Kedah Darul Aman, Malaysia.
2. Centre for Aquaculture Research and Extension, St. Xaviers College, Palayamkottai, Tamilnadu, 627 002, India.
3. Corresponding author. Email: aquamuthu2k@yahoo.com / kasi_marimuthu@aimst.edu.my