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Journal of Biological Studies
ISSN 2209-2560

JBS
An Open Access Peer Reviewed Journal

Research Full-Text Paper

Embryonic and larval development of the commercially important freshwater fish gobi, *Glossogobius giuris* (Hamilton, 1822)

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Received: May 28, 2022; **Accepted:** June 7, 2022; **Published online:** August 30, 2022

Abstract: The present study was carried out to investigate the embryonic and larval development of the commercially important freshwater fish gobi (*Glossogobius giuris*) in laboratory conditions at the Mini Hatchery cum Breeding Complex of the Department of Fisheries Biology and Genetics under the Faculty of Fisheries, Bangladesh Agricultural University (BAU), Mymensingh. Healthy broodstocks of both female and male gobi were collected from the grow-out ponds. Matured eggs and sperms were obtained through the induction of spawning by the injection of PG (pituitary gland) hormones. Fertilization was done by the mixing of a few drops of sperm suspensions to the egg mashes in a small plastic bowl and washed several times to remove the excess sperm and unfertilized eggs. Fertilized eggs were then collected and incubated in a mini circular cemented tank with the provision of continuous water supply. At least 10 fertilized eggs undergoing embryonic development were continuously monitored for studying the daily changes in their development. Fertilized eggs were collected randomly up to morula stage at every 4-5 h, and then after every 1 h interval until hatching and every 4 h after hatching. Soon after fertilization, the eggs were swelled, extended longitudinally, and became adhesive and light brownish to transparent in color. The unfertilized egg did not change in size and shape, rather turned into whitish in color and became demersal. At fertilization, the length of eggs was increased from 0.6 to 3.0 mm and width from 0.3 to 0.5 mm, having a tendency to attach on the substrates or the shelters provided. The first cleavage of eggs was occurred within 1.3-2.5 h at 27.0 ± 1.0 °C. The

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development of the embryos of Gobi was occurred about 15 h post-fertilization at 27.0-29.0 °C. The stages of embryonic development were observed with cleavage, followed by morula, blastula, gastrula, yolk plug stage, organogenesis and until hatching of non-pigmented larvae. Hatching started from 35 to 48 h post-fertilization and completed within 5-6 h at the same temperature range, as all embryos did not hatch out at a time. Newly hatched larvae were measured to be 0.50-0.60 mm in length. The yolk sac was completely absorbed at 48-50 h during larval development and when the hatchlings reached 1.60 ± 0.02 mm in total length; they were then started feeding within 48-60 h post-hatching. The findings of the present study have not only provided the valuable information on the embryonic and larval development of gobi (*G. giuris*) but would immensely be helpful towards the establishment of large scale seed production technique for aquaculture and conservation of this important fishery.

Keywords: Gobi, Glossogobius giuris, Induced breeding, Fertilization, Embryos, Larvae, Development, Hatchling

1 Introduction

The freshwater fish Gobi, *Glossogobius giuris* (Hamilton, 1822), locally known as baila or belia or bele belongs to the family Gobiidae of the order Perciformes. The sub-families like Oxudercinae, Amblyopinae, Sicydiinae, Gobionellinae and Gobiinae are recognized. It contains 212 genera and 1875 species. The bele (*G. giuris*) is native to fresh, marine and brackish water from the Red sea and East Africa through South Asia and the Indian Ocean to China, Australia and the islands of the Pacific Ocean. They are mainly marine and brackish water inhabitants, while some species are catadromous and are distributed mostly in tropical and subtropical areas. This species is widely distributed in the freshwater and estuaries of Bangladesh, India, Pakistan, Myanmar and Far East. It is commonly found in estuarine areas and freshwater throughout Bangladesh, the Punjab, Ceylon, India, Myanmar, Malaysia and Far East (Bhuiyan, 1964; Srivastava, 1968). This species is not yet found in IUCN Red list.

Glossogobius giuris has a special preference in the diet of the people of Bangladesh because of its special taste, low fat and high protein content (Islam and Joadder, 2005). The largest fish has been found to reach a length of 40 cm (standard length) and the smallest about 3 cm (Hoese, 2008). At times, 2-3 adult of the species make a kilogram and normally 10-20 adult make a kilogram yet one should not be astonished if he finds 50-150 adult individuals fail to make a kilogram. This species is very essential food fish, especially to the low-middle class and poor people, because of being relatively cheaper but sometimes very expensive to them (Islam, 2004). Different kinds of delicious food item like "jhuri" can be made with the eggs of bele fish.

It is well known that gobi (*G. giuris*) is widely distributed in ponds, haors, baors, rivers and estuaries of Bangladesh, and forms an important capture fishery, especially in the Southern part of the country. Owing to the environmental degradation and human interventions in aquatic ecosystems, natural breeding grounds of most of the important fish species including gobi have been degraded. In Bangladesh, there is suitable waterbodies for culturing of this species with

other culture fisheries or can be cultured as a single species in shallow waterbodies and will be exported as a delicious and expensive fish. So, it is a suitable candidate for aquaculture as commercial farming. Sophistication of the breeding technique and mass production of stockable sized seeds remain as an obstacle towards popularizing its culture practice.

Non-availability of required amount of quality stockable sized seeds of a particular species is the main obstacle for sustainable aquaculture. Only a reliable induced breeding, embryonic and larvae rearing technique can ensure a steady supply of quality seeds in aquaculture. Published reports on its induced breeding and rearing are quite scanty and no reports are available on the developmental biology and larvae rearing technique of this species. Information gathered from this research on the induced breeding and embryonic and larvae rearing technique of gobi might be helpful for mass seed production of this species. So, the present research bears practical importance and the findings would be helpful for mass production of quality seeds of this species through induced breeding in the hatchery conditions.

Recent success in induction of breeding of *G. giuris* was performed by using PG (Yeasmine et al., 2021). Considering the enormous importance of *G. giuris*, early life history information is an essential requirement for optimization of large scale seed production, culture and management. The present work is the first ever preliminary attempt and is expected to serve as a basis for further and more intensive future studies. An attempt was made to conduct this study to investigate and to provide the detailed information of the embryonic and larval development of *G. giuris*.

2 Materials and Methods

This study was carried out in the Mini Hatchery cum Breeding Complex and the laboratory of the Department of Fisheries Biology and Genetics under the Faculty of Fisheries, Bangladesh Agricultural University (BAU) Mymensingh. The collected mature broods of bele were injected to spawn through induced breeding described by Yeasmine et al. (2021). The eggs and milt were collected from female and male by stripping. Then eggs were fertilized by milt through mixing by feather. After that, fertilized eggs were washed several times with sterile distilled water and finally transferred in mini circular hatchery (50 L capacity) with continuous water supply throughout the incubation phase.

A set of fertilized eggs were collected very carefully from the circular hatchery by using a dropper and siphoning process for observing the development stages. So, after the collection of eggs, they were observed under the microscope (Olympus CX41) fitted with a software (Magnus MIPS Microsoft Image Processing System) and sequenced based on the changes morphological features, and then taken photographs by a camera (Samsung ST70, China) fitted with a microscope. Photographs of eggs before fertilization and at every 1 h interval after fertilization were captured for further study. Descriptions of the developing stages were done by observing live samples under electronic microscope and microphotographs of the developmental stages of fertilized eggs and larvae were captured. Embryogenesis was studied at different time intervals. To identify the developmental phases of eggs, each sample was observed four times (Haniffa et al., 2003).

The process of development is a complicated sequence of events. The development stages were observed continuously until the embryos started twisting movement and then after hatching. At least 10 fertilized eggs undergoing embryonic development were continuously monitored for studying the daily changes in embryonic development. Fertilized eggs were collected randomly up to morula stage at every 4-5 h, and then after every 1 h interval until hatching and every 4 h after hatching. The hatching of fertilized eggs was accomplished within 48 h. At least five larval samples were collected for the study. The whole works were done at a temperature range of 28-29 ^{0}C. Measurements of the eggs and larval stages were taken by using an ocular micrometer pre-calibrated with a 1 mm stage micrometer.

In the present study, the developmental stages were divided into embryonic, larval and post larval development. The embryonic stages appeared inside the chorion and ends in hatching. The larval stage was differentiated by nutritive contribution of the yolk sac and the stage ends when the larva becomes capable of taking exogenous feeding. The post larval stage was characterized upon absorption of the yolk sac and was distinguished by self-feeding. After, the absorption of yolk sac, the larvae were fed boiled egg yolk 4 times daily for three days and thereafter fed with tubificid worms and mixed zooplankton.

The mean diameter and length of eggs and larvae were analyzed by MS Excel. The statistical data analysis was carried out with the aid of the computerized software SPSS version 11.5.

3 Results and Discussions

The embryonic period starts when the egg is fertilized by the sperm and involves a constant synthesis or the building up of those elements that are vital to the normal process in the development of individual. A brief description of embryonic and larval development in relation to the time is presented below:

3. 1. Unfertilized eggs

The unfertilized eggs of *G. giuris* were a little bit long but smaller in size than fertilized eggs, demersal, opaque and whitish in colour. They were not adhesive and turbid like materials found inside the eggs under microscope. The width of the egg was 0.2 to 0.4 mm and length was 0.6 to 0.8 mm (Figure 1. 1).

3. 2. Fertilized eggs

The fertilized eggs of gobi were thick, adhesive, long, demersal and transparent or shiny and attached to broken parts of earthen pots provided as shelters (Figure 1. 2). The fertilization of eggs took place as soon as the sperm entered into the eggs through micropyle and fusion between two nucleic occurred. Almost immediately a cortical reaction closed, the micropyle which denied the entry of more sperm. Soon after fertilization, the eggs were swelling and started to develop. The process of development is a complicated series of procedures. The eggs were too small to observe the change in fertilized eggs without microscope. The fertilized eggs developed the perivitelline space immediately after fertilization (Figure 1. 2) and the contents of

fertilized eggs were clear under microscope. Embryonic development of gobi was very slow. Immediately after fertilization, the length of egg was 0.60 ± 0.002 to 1.50 ± 0.001 mm and width was 0.60 ± 0.001 to 0.80 ± 0.001 mm and swelling was observed. A fertilized egg had a spot (blastodisc) on one pole and was readily recognizable under microscope within 45 minutes of fertilization. Embryonic cell division started and the eggs reached 2, 4, 8, 16, 32 and multi-celled stages as described below.

3. 3. Two cell stage

The first cleavage of eggs occurred within 1.3-2.5 h at 27 ^{0}C. The cleavage of eggs was partial or meroblastic, forming a transitory blastula stage. The blastodisc was divided into two approximately equal distinct cells (blastomeres) by vertical cleavage within 2 h post-fertilization (Figure 1. 3).

3. 4. Four cell stage

The second cleavage was appeared by forming four cells within 3-5 h post-fertilization (Figure 1. 4). The second cleavage was at right angle to the first. Eggs measured 0.70 ± 0.04 mm in mean length.

3. 5. Eight cell stage

The third cleavage forming eight cells was recorded after 4-8 h of post-fertilization. The mean length of the eggs was 0.80 ± 0.03 mm.

3. 6. Sixteen cell stage

The sixteen celled stage was developed within 6-9 h post-fertilization (Figure 1. 5). The length of the eggs was 1.50 ± 0.02 mm.

3. 7. Multi cell stage

These cleavages enhanced the next cleavages. The sixteen celled stage in quick succession transformed into 32, 64, 128 cells stage and so on dividing geometrically within 14-17 h post-fertilization. Further, successive subdivision of these cells formed a many celled blastoderm, which was started with only one layer of cells. It gradually acquired several layers of cells. Each of these cells is termed as the 'blastomere'. The more the cleavage occurred the more the blastomeres were formed. So, it was generally referred to as multi celled stage. Eggs were measured to be 1.60 ± 2.40 mm in length (Figure 1. 6).

3. 8. Morula stage

The blastoderm started to extend invading throughout the yolk in the form of thin layer. The formation of germinal ring around yolk was clearly visible and about half of the yolk was occupied by blastoderm. A cap like structure was seen over the animal pole, which gradually increased in size. At this phase, it looked like a mulberry (morus in Latin) and was then termed as morula stage. Eggs were measured to be 2.50 ± 0.03 to 2.80 ± 0.03 mm in length (Figure 1. 7) and occurred within 18-20 h post-fertilization.

3. 9. Blastula stage

This stage reached in about 21-22 h post-fertilization through repeated cleavage in the blastodisc at the animal pole. With continuing cleavage, the cells in centre began to lose contact with one another and a central fluid-filled cavity (the blastocoel) was formed. This blastocoel was surrounded by a single layer of cells, known as the blastula. The blastoderm was still thick as in the morula stage although it's inner cells were smaller (Figure 1. 8).

3. 10. Gastrula

The blastula stage was followed by the gastrula stage, which began by the blastoderm spreading over the yolk in the form of a thin layer and reached completion when the yolk mass was almost completely encircled by the embryo. Blastoderm covered three fourth (¾th) of the yolk mass and embryonic shield was clearly visible, and optic rudiment in gastrulation stage appeared (Figure 1. 9). Gastrulation stage resulted within 23-27 h post-fertilization.

3. 11. Yolk plug stage

The yolk invasion was completed by gradual spreading over the germ layer. The head (rudimentary brain) was recognized anteriorly and rudimentary tail was recognized posteriorly in the distinct embryonic body. A beak like mass of cells was found in front of the head. Optic bud (rudimentary eye vesicle) was seen on each side of the cephalic end. Yolk plug stage was found within 27-31 h post-fertilization. Eggs were measured from 2.80 ± 0.02 mm to 3.00 ± 0.04 mm in length (Figure 1. 10).

3. 12. Organogenesis

The head and tail end of the embryo were differentiated (Figure 1. 11). The embryo was elongated and encircled the yolk materials. Both tail and head ends were clearly differentiated and the beating heart was observable. Heart rudiment, pectoral fin buds, otocysts and gill rudiment showed one by one. The pectoral fin was appeared first of all among the fins as a bud and then the fin rays were formed. At this phase, pigment was found in eyes, the notochord in cellular structure became visible within 31 to 36 h post-fertilization, and auditory and optic vessels developed.

3. 13. Thirty-eight to forty-six hour old embryo

At 38-46 h post-fertilization, embryo occupied one fourth of the egg and mesodermal somites increased in number and became more distinct and pigmentation was developed in the somites. The embryo further elongated and gradually differentiated. Tail was found to develop at this stage and gradually became detached from the yolk mass (Figure 1. 12). Rudiments of the caudal fin rays could be seen and spleen was recognized as a small globule dorsal to gut tube. The tubular heart was seen underneath the head and the heart was vibrating actively and the blood circulation was started.

3. 14. Just before hatching

This stage was observed after 40 to 48 h of fertilization. The somites increased in number in the embryo. Tubular rod like notochord appeared and embryo started showing occasional

twisting movement inside the egg and continuously beat the egg shell by the caudal region, especially around the middle part of the body (Figure 1. 13). During the last days of foregoing the hatching, the embryo was mobile and its pigmentation gradually increased. This movement progressively became vigorous and the egg capsules were weakened. Then, the embryos ruptured the egg shells by the continuous movement and the middle part of the embryo was gradually disconnected from the egg capsule. The egg membrane was broken down from the caudal region and the larva emerged with its tail portion first in 35 to 48 h of post-fertilization. Hatching continued for 15-20 h at 27-29 ^{0}C because all the embryos did not hatch out at a time. Newly hatched larvae were measured to be 0.50-0.60 mm in length.

Figure 1. 1: Unfertilized egg of gobi (*G. giuris*).

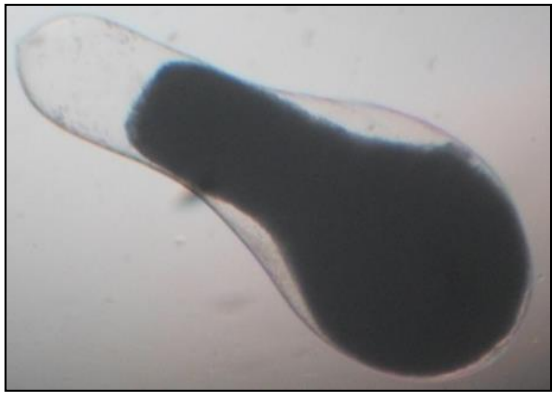

Figure 1. 2: Fertilized egg of gobi (*G. giuris*) showing micropyle region (mi), chorion (ch), and the perivitelline space (ps).

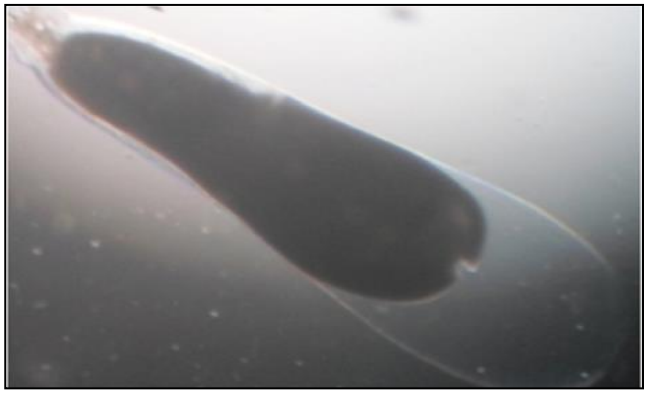

Figure 1. 3: Two celled stage embryo of gobi (*G. giuris*) at 2 h post-fertilization.

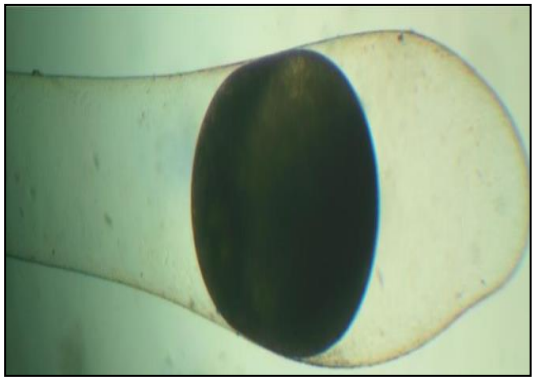

Figure 1. 4: Four celled stage embryo of gobi (*G. giuris*) at 3-5 h post-fertilization.

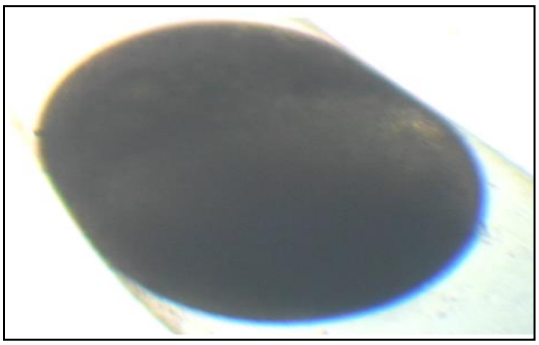

Figure 1. 5: Sixteen celled stage embryo gobi(*G. giuris*) at 7-9 h post-fertilization.

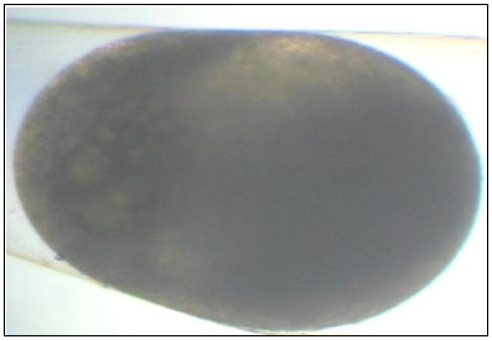

Figure 1. 6: Multi celled stage embryo gobi(*G. giuris*) at 14-17 h post-fertilization.

Figure 1. 7: Morula stage embryo of gobi (*G.giuris*) at 18-20 h post-fertilization.

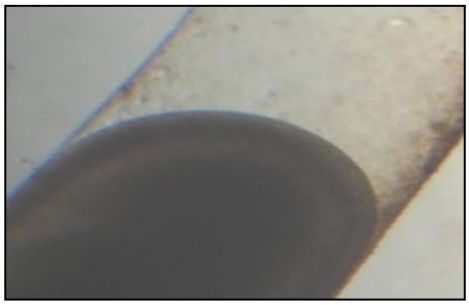

Figure 1. 8: Blastula stage embryo of gobi(*G. giuris*) at 21-22 h post-fertilization.

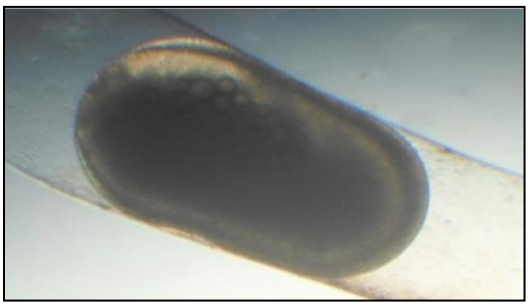

Figure 1. 9: Gastrula stage embryo of gobi (*G. giuris*) at 23-27 h post-fertilization.

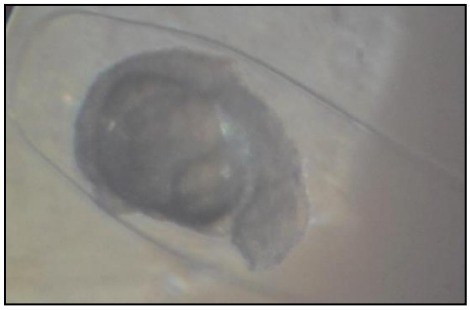

Figure 1. 10: Yolk plug stage embryo of gobi (*G. giuris*) at 27-31 h post-fertilization.

Figure 1. 11: Organogenesis stage embryo of gobi (*G. giuris*) at 31-36 h post-fertilization.

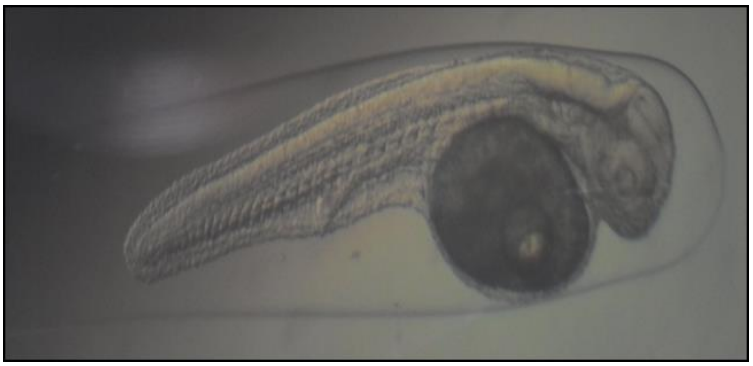

Figure 1. 12: Thirty eight-forty six h old embryo of gobi (*G. giuris*).

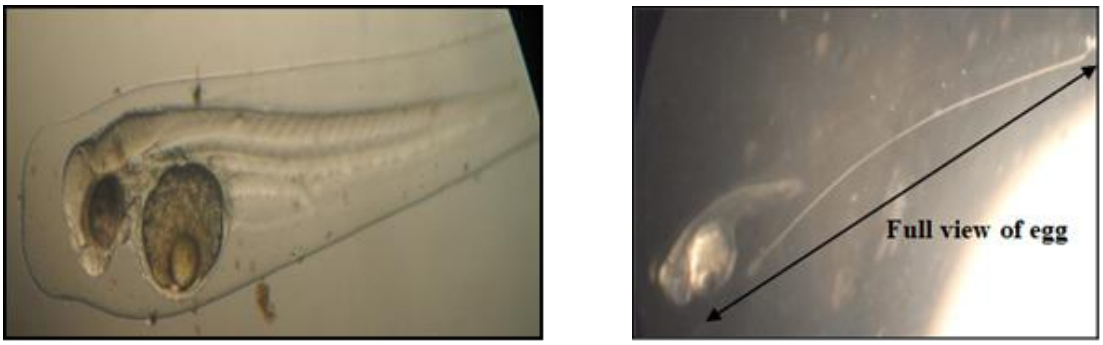

Figure 1. 13: Just before hatching 48 h old embryo of gobi (*G. giuris*)

3. 15. Hatchling at zero-hour post-hatching

Newly hatched larvae were straight, transparent, laterally compressed and gradually tapering towards the tail. Hearts of the larvae were functional in between head and the anterior margin of the yolk. The newly hatched larvae were 0.70 mm in length. The hatchlings had pigmented eyes and devoid of distinct mouth and fins, the head was very small and the yolk sac was oval in shape (Figure 1. 14). In this stage, a larva had a functional heart. The larvae could not swim and floated passively on the water and occasionally showed vertical movement.

3. 16. Eight-hour old larva

Melanophores appeared on the head, around the yolk sac or on the yolk sac. The anterior part began to thicken. The colour of the yolk sac was yellowish brown. The total length of larva was 0.75 mm. Mouth was not yet developed but only a conspicuous depression identified the position of the mouth. A depression at the posterior end of the yolk sac was visible, which was identified as anal pore. Heart became more distinct and circulation of body fluid was continued (Figure 1. 15).

3. 17. Sixteen-hour old larva

The larva reached 0.80 ± 0.03 mm in mean length after 16 h of hatching. Pectoral fin bud appeared. Melanophore bands were very much prominent at the posterior end of the body. A large number of melanophores also appeared above the eye and around the yolk sac. Heart and brain were clearly distinct. A tube like structure within the body represented the alimentary

canal (Figure 1. 16).

3. 18. Twenty four-hour old larva

The mean total length of one-day old larva was 1 ± 0.05 mm with about 50% reduced yolk sac. The eye spot with a dark pigmented area appeared on the anterior part of the head. Pectoral fin buds were found. Mouth was not opened, although the opening became distinct and the anal pore was still closed. Pigmentation gradually extended all over the body. Blood circulation system was fully developed. At the end of this stage, yolk sac reduced to half (Figure 1. 17).

3. 19. Thirty-six hour old larva

Dark pigmented eyes with spherical shape were visible. Distinct heart was seen and functioned actively. Blood flow was seen around the heart region. Brain lobe was visible. Pectoral and pelvic fin fold were well developed. Mouth was formed as an opening and anal pore also opened. Vigorous movement of the larva was observed. At this stage, the mean length of the larva was 1.30 ± 0.03 mm. Partial yolk sac was still present (Figure 1. 18).

3. 20. Forty-eight hour old larva

Dorsal region became dark due to the formation of numerous chromatophores and the transparent ventral region was seen. Pectoral fin folds became distinct and the rudimentary rays developed in the caudal fin. The alimentary tract became short, straight and distinct and a small pouch like stomach was formed. Blood circulation was distinct in the head, heart and tail region. The average length of the two days old larva was about 1.60 ± 0.02 mm and at the end of this stage, yolk sac was observed to be much reduced and the larvae were seen to swim vigorously and feeding exogenously (Figure 1. 19).

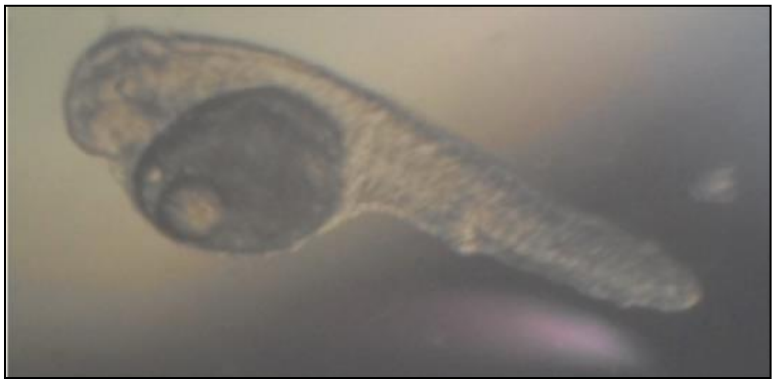

Figure 1. 14: A 0 h post-hatching larva of gobi (*G. giuris*)

Figure 1. 15: An 8 h old larva of gobi (*G. giuris*)

Figure 1. 16: A 16 h old larva of gobi (*G. giuris*)

Figure 1. 17: A 24 h old larva of gobi (*G. giuris*)

Figure 1. 18: A 36 h old larva of gobi (*G. giuris*)

Figure 1. 19: A 48 h old larva of gobi (*G. giuris*)

3. 21. Discussion

Embryonic studies provide phylogenetic development by presenting supportive proofs to determine an organism's ancestral forms. As soon as the egg is fertilized by a sperm, the zygote is formed and embryonic development starts and ends up at hatching. There is no information on the embryonic and larval development of gobi *(G. giuris*), so it was felt necessary to conduct proper study of its various phases of embryonic and larval development. In this section, embryonic and larval development of *G. giuris* was examined. After fertilization, embryonic developmental stages in eggs were summarized as follows: fertilized egg, cleavage, morula, blastula, gastrula, embryonic body formation, optic and auditory vesicle formation, tail

formation and hatching stages. The larval development after hatching, until the end of the yolk sac absorption period (pre-larvae) and subsequently until the end of metamorphosis (post-larval) formations was observed.

In the present study, the morphology of unfertilized eggs of gobi was opaque white or whitish in colour and smaller while the fertilized ones were transparent, demersal, long, very much adhesive in nature and watery in colour, which agreed with the findings of Puvaneswari et al. (2009) except the reported brownish green colour of the eggs. Haniffa et al. (2007) also observed that the fertilized eggs were adhesive and transparent. Sunobe (1995) found that eggs of three Gobiid fish, *Trimma okinawae*, *Trimma grammistes* and *Trimmatom* sp. were elliptic and with a bundle of adherent threads at the base. The fertilized eggs were adhesive and long, which is the special character of *G. giuris* and had tendency to stick with some substrate. The eggs of gobies are demersal and for most species they are pear shaped (Russell, 1976), but those of the common species of the genus *Gobius*, *Gobius paganellus*, *Gobius cobitis* (Gil et al., 1997) and *Gobius cruentatus* (Gil et al., 2002) are elongated and fusiform. So, the elongation form of eggs of gobi seems to be the common feature of various species of *Gobius.*

The embryonic and larval development of bele *(G. giuris*) was studied at an ambient temperature of 26 to 29 ^{0}C. The first cleavage took place within 1.45 h post-fertilization at the water temperature of 27 ^{0}C but in *Clarias gariepinus* and *Mystus cavasius* first cleavage took place within 40-50 min post-fertilization as reported by Khan and Mollah (1998), and Rahman et al. (2004) at the temperature of 28.5 and 26 ^{0}C, respectively. The two cells, four cells, eight cells, sixteen cells and multiple cells stage of bele were found within 2, 3- 5, 4-8, 6-9, and 14-17 h post-fertilization. Mookerjee (1945) observed these cleavage series at 35, 45, 70, 95 and 135 min post-fertilization in case of *Labeo rohita*. In the present study these cleavage time took more than *Labeo rohita*

In the present observation, morula stage reached within 18-20 h post-fertilization and gastrula stage was found in gobi *(G. giuris*) at 23 to 27 h of fertilization at 27-28 ^{0}C. Puvaneswari et al. (2009) observed the gastrula stage in *Heteropnuestes fossilis* at 7 h post-fertilization. Haniffa et al. (2006) and Balon (1995) found morula stage at 4 h 40 min in case of koi carp and 3 h post-fertilization in case of common respectively. This change might be due to temperature and species variances.

Galman (1980) found the initiation of gastrulation within five hours in case of *Tilapia nilotica* at 26 to 27 ^{0}C. However, in the present study, time required for morula and gastrula stage in *G. giuris* was more than those found in case of *Heteropnuestes fossilis*, *Rita rita and Tilapia nilotica*. This variation might be species specific and temperature dependent.

The heart rudiment, gill rudiment and pectoral fin buds of bele *(G. giuris*) were observed within 31 to 36 h post-fertilization whereas, Rahman et al. (2009) found the same characteristics in 32.3, 33.00 and 32.10 h post-fertilization in case of *Mastacembelus pancalus*. Sunobe (1995) reported embryo to form by 10 h, 14 h and 23 h post-fertilization in case of three Gobiid fish, *Trimma okinawae*, *Trimma grammistes* and *Trimmatom* sp, respectively, which were less than that observed in *G. giuris*. So, the time required to show the various cleavage stages in different fish is species specific. Environmental factors, especially temperature have also been reported to have strong effect on embryonic development.

The embryo of gobi showed twisting movements inside the egg capsule just 1-2 h before

hatching. The similar hatching behaviour was found in different fishes reported by Puvaneswari et al. (2009), Khan and Mollah (1998) and Osman et al. (2008). In the present study, hatching commenced from 40 to 48 h post-fertilization and continued for 20-24 h at 27-29 ^{0}C. Singh Kohli and Vidyarthi (1990) stated that in *H. fossilis* at a temperature of 26 ^{0}C, the incubation period of the eggs varied from 16-18 h. Marimuthu and Haniffa (2007) observed to occur hatching in *Channa striatus* within 20-23 h post-fertilization. In the present study, hatching took place about 35-48 h after fertilization. The hatching period of three Gobiid fish *Trimma okinawae*, *Trimma grammistes* and *Trimmatom* sp were 107, 101 and 126 h after fertilization, respectively as observed by Sunobe (1995), which is more than the time required for bele *(G. giuris*). Although the duration of total embryonic development is more in this species than *Channa striatus* and *three* Gobiid fishes.

Length of the newly hatched larvae of *G. giuris* was around 0.7 mm which is a little bit too small compared to other fishes. Variation in length of the newly hatched larvae was measured by several scientists. According to Ogunji and Rahe (1999), the length of newly hatched larvae of *H. longifilis* were varied from 4.09 to 4.90 mm. Ayyar and Kamal (1988) stated that 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,* which are more than the present study. These variations might be related to the species variation and size of the eggs.

Ogunji and Rahe (1999) recorded first feeding in *H. longifilis* larvae to take place at 48 h after hatching and full absorption of yolk sac at 55 h post-hatching. In *Mystus montatus*, yolk sac resorbed fully after 3rd day (Arockiaraj et al., 2003). In the present study, larvae of *G. giuris* started feeding at 48 h post-hatching. The observation in the present study revealed that the larvae of this species had non-pigmented eyes, undeveloped mouth and fins when they were hatched out. These observations are similar with larvae of other species. For example, Oliver and Lam (1973) through their study of induced breeding and early development of the marble goby stated that the eyes, mouth, fin and jaws of the marble goby larvae also were not fully developed at the time of hatching. The newly hatched larvae of Gobiidae showed a typical shape, slender and elongate with a prominent gas bladder (Borges et al., 2003). Most larvae hatch with functional mouth and anus that allow exogenous feeding and pigmented eyes and developed pectoral fins that allow active swimming immediately after hatching (Gil et al., 1997; Gil et al., 2002). The newly hatched larvae of gobi were straight, and had oval-shaped yolk sacs and pigmented eyes but no functional mouth and fins were observed. They occasionally exhibited vertical movement.

4 Conclusion

This study provided the detailed information about embryonic and larval development of bele *G. giuris*). Furthermore, it is suggested to conduct other breeding related studies on this high-valued fish species to establish a sustainable breeding and seed production technique.

Acknowledgments

We would like to thank the anonymous reviewers for their valuable comments and suggestions to improve the quality of the paper.

Conflict of interests

The authors declared that there is no conflict of interests regarding publication of this paper.

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