Embryology and Larval Development in Gold fish, *Carassius auratus* (Linnaeus, 1758)

Acharya K.V. [1]*, Mulgir M., [2] Shembekar V., [3] Popatwar N., [4] Pethkar M. [5]
*1. Ph.D. Research Scholar, Swami Ramanand Teerth Marathwada University, Nanded Maharashtra, India.
2. Ex. Principal, Sharda Mahavidyalaya, Parbhani.
3. Professor, Head Dept. of Zoology and Fishery science, R.S.M. Latur.
4. Associate Professor, Head Dept. of Fishery science, D.S.M. College Jintur, Dist- Parbhani
5. Asst. Professor Baburao Patil College of Arts & Science, Angar. Tq. Mohol, Dist- Solapur.

***Corresponding author:** Ph.D. Research Scholar, Swami Ramanand Teerth Marathwada University, Nanded, Maharashtra, India.

Abstract: *In the present study Embryology and Larval Development of Gold fish, Carassius auratus (Linnaeus, 1758) were done. Fertilized eggs hatch in 3-4 days depending on water temperature. In present study, hatching is observed on 4 th day after spawning of eggs. The diameter of the fertilized egg capsule ranges between 0.9 mm and 1.1 mm while the yolk sphere ranged from 0.5-0.9 mm in size. Then Cleavage Stages, blastula stage, gastrula stage and further developmental stages of embryo is recorded. 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 was characterized by nutritive contribution of the yolk sac and the stage ends when the larva becomes capable of exogenous feeding. The post larval stage begins immediately upon absorption of the yolk sac and was characterized by autonomous feeding. Developmental time from post fertilization was rounded to the nearest minute until the morula stage and then to the nearest hour. The age of the larvae was denoted as hour after activation.*

Keywords: Gold fish, *Carassius auratus* (Linnaeus, 1758), Embryology, Larval Development, Nanded, Maharashtra.

I. Introduction

Ornamental fishes are often called as ‘living jewels’ due to their colour, shape, behavior & origin. They are peaceful, generally tiny, available in attractive colours & capable of living in confined spaces. Aquarium fish keeping is a centuries-old popular hobby, growing interest in which has resulted in steady

expansion in its trade in more than 125 countries. With the increasing popularity of household aquariums, less than 1% of the global market for ornamental fishes belongs to the public aquaria sector, with the rest still confined to hobbyists. During the last four decades, there has been considerable growth & diversification in the international trade in ornamental fishes. The global trade of ornamental fish is about $ 9 billion dollar of which 85% are freshwater species and the rest are marine species. The ornamental fish is one of the fastest growing sectors in fisheries with an annual growth of over 10% in the world. The domestic growth of ornamental fish trade is also about 20% per annum. There are about 300 freshwater ornamental fish varieties that are available in the market and being traded with different trade names. Among ornamental fish, gold fish (*Carassius auratus*) is considered to be the most popular and attractive pet fish due its many variations such as colour, fins, tail, shape, size and body structure. Goldfish, a member of the Cyprinidae family, is the leading ornamental fish species in the aquarium sector in terms of its popularity and economy (Mischke, 2012). The Common Goldfish (*Carassius sp.*) are hardy fish that are well known by all aquarists. They are colorful, inexpensive, and readily available. These fish are a favorite pet for a multitude of keepers because they can be quite personable and are delightful to watch. The goldfish of today are descendants of a wild carp fish known as the Prussian Carp, Silver Prussian carp, or Gibel Carp *Carassius gibelio* (syn: *Carassius auratus gibelio)* which was described by Bloch in 1782. For many years it was believed that goldfish had originated from the Crucian Carp or Golden Carp *Carassius auratus auratus* described by Linnaeus in 1758, but more recent research is pointing toward the former. In Common Goldfish (*Carassius auratus L*.) after that very less work had been done in terms of gold fish varieties; there are more than 100 varieties of gold fish. Numerous varieties with different colours, varied fin patterns and unbelievable shape and forms such as Common (Metallic group), Calico, Fantail, Oranda, Pyukin, Lion head, Pearl scale, Bubble eye, Telescope, etc., are available in the markets and has great demand both in domestic well as international markets. So in present investigation we will spotlight on Induced breeding of Common goldfish variety *Carassius auratus auratus* available in market during investigation. As taking its commercial value in market the breeding is very important factor but it's quite not easy. So Induced breeding increase the chance of breeding. In further investigation we will go for study of induced breeding. Thus, the present study would definitely throw some light on these aspects. Due to commercial and

biological importance of this species has attracted much attention of the researchers for its biological studies. The 'family branch' of *Cyprinidae* divides into numerous smaller branches- the genera- and these further divide into the species. The genus in which we are interested is the one called *Carassius;* it contains two species- *Carassius Carassius* (Crucian Carp) and *Carassius auratus* (Common Goldfish). *Carassius auratus auratus* (Common Goldfish) belonging to Kingdom: Animalia, Phylum: Chordata Class: Actinopterygii Order: Cypriniformes, Family: *Cyprinidae* Genus: Carassius, Species: *C. auratus* Subspecies: *C. auratus auratus* Synonym:- *Carassius auratus auratus*, (Linnaeus, 1758) *Carassius carassius auratus*, (Linnaeus, 1758) *Cyprinus auratus*, (Linnaeus, 1758) *Cyprinus mauritianus*, (Bennett, 1832) *Cyprinus langsdorfi*, (Cuvier & Valenciennes, 1842) *Cyprinus thoracatus*, (Valenciennes, 1842) *Carassius gibelioides*, (nonCantor, 1842) *Carassius encobia*, (Bonaparte, 1845) *Leuciscus auratus*, (Mauduyt, 1849-51) *Carassius chinensis*, (Gronow, 1854) *Cyprinus maillardi*, (Guichenot, 1863) *Carassius auratus cantonensis*, (Tchang, 1933) Global Invasive Species Database (GISD 2015).

II. Materials and methods

Mature, healthy gold fish brooders about 114 fish specimens in the size range of 12.5 to 16.2 cm. Total length (TL.) Wt. (30.1- 69.4gm.) Samples were procured from local Ornamental fish shop at Nanded, Maharashtra fork nightly, during period of February 2017 to January 2018.

III. Profile of the study area

Specimen of *Carassius auratus auratus*, (Linnaeus, 1758) commonly known as Gold fish. Samples were procured from local Ornamental fish shop at Nanded, Maharashtra. The experiment was conducted in Laboratory of Fisheries department of N.E.S. Science College, Nanded. All preparation needed for Embryology and Larval Development of gold fish were done in the laboratory. Aquarium set up, water supply facilities, working space etc. were assured before the breeding program. The study period was from during February 2017 to January 2018.

IV. Experimental design

There were two broad parts of the activities in this experiment. The first part of the activity concerned with the collection of brood fish. The second part of the experiment was performed in the laboratory to carry out the embryonic and larval stage development.

V. Brood fish selection, collection and conditioning

Mature, healthy gold fish brooders about 114 fish specimens in the size range of 12.5 to 16.2 cm. Total length (TL.) Wt. (30.1- 69.4gm.) were selected by sexual dimorphism for breeding experiments. The brood fish were selected on the basis of size and colour pattern. Female is usually easier to spot, as the belly of a mature female is generally plump, whereas male remains streamlined body. When males are ready for spawning, they develop breeding tubercles on the head and pectoral fins, principally along the bones of the pectoral fin rays. These are used during breeding, when the male nudges the female with its head and fins to induce her to spawn. About selected 114 specimens (38 males, 76 Females) brood fishes were collected from the local aquarium fish market. To increase the diversity among the parents and to select healthy brood fish, it was collected from the diversified sources. Avoiding inbreeding problem was also a major objective of selection of brood fish from diversified sources. The brood fishes were carried to the laboratory within 30 minutes and kept in the aquarium (4×1.5×1.5 ft). The brood carrying pack was submerged into the aquarium water for 10 minutes. Then the brood were unpacked and released into the well aerated aquarium (D.O: 4.5-5.5 mg/L, pH: 7.2-7.4; temperature: 14-18 ^{0}C). The brood was kept 3-5 days here before the breeding program. They were fed daily with artificial fish pellets and live tubifex worms / mosquito larvae at the rate of 10% of their body weight.

VI. Results and Discussion

Embryonic and larval development of gold fish

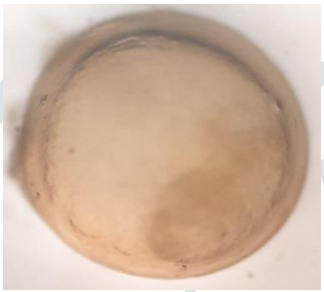
Characteristics of the egg: - Fertilized eggs hatch in 3-4 days depending on water temperature. In present study, hatching is observed on 4th day. The diameter of the fertilized egg capsule ranges between 0.9 mm

and 1.1 mm while the yolk sphere ranged from 0.5-0.9 mm in size. Cleavage Stages: Development of the fertile egg follows a set pattern. Upon penetration by the spermatozoon, oily droplets contained with the egg fall to the bottom of the egg, leaving the yolk clear. The yolk granules drift to the top of the eggs, forming a bump on the surface. In the meantime, the eggs shell becomes slightly larger, hardens and lifts away from the eggs. The surface bump quickly divides into two cells; these two cells divide and double in number again. Each call so produced continues to divide and double itself, eventually forming two distinct layers of cells. The size of the multiplying cells get smaller and the number greater, until a rounded cap is produced in the area of the animal pole. This stage is known as the blastula, and becomes flatter as tiny cells continue to increase and move down over the yolk. As they progress towards the vegetal pole, the cells lift slightly to form gap (the blastocoele) between themselves and the yolk. Before long about one- third of the egg surface becomes covered by the blastoderm, and they being to build up at the advancing margin. This 'piling-up' at the lateral margins of the blastoderm forms the 'germ-ring', and is the start of gastrulation. Gastrulation involves the cells in the thickened germ ring moving underneath the blastoderm. The cells form a band which progressively elongates at the end nearest the vegetal pole, to produce the embryonic shield. The gastrula expands to almost cover the surface of the yolk, and a band of cells forms the embryonic keel in the centre of the shield. As development continues optic vesicles form, which eventually become the eyes, and the main division of the brain appear as bulges on the dorsal surface of the keel. The head of the embryo lifts away from the yolk and soon slight contractions of the embryonic heart being. The embryo grows substantially to cover about half the circumference of the egg, and the tail lifts off the yolk. The notochord, which will become the backbone vertebrae, becomes visible, as do the pigmented eyes. The pectoral fins form completely, but the only other fin is a combined dorsal/caudal/anal fin. This latter fin will split into the separate fins after hatching. The pelvic fins form after the pectorals. The embryo which had increased considerably in size and shape occupying almost of the perivitelline space. Rhythmic movements are occurred freely within the egg capsule. Shortly before hatching the embryo makes violent movements inside the egg shell. These movements, aided by an enzyme which softens the shell, enables the fry to break free. The tail first emerges from the egg shell, followed by the head. On emergence from the egg shell the fry is measure approximately 1/5 inch (5 mm) long, and appears as a tiny glass- like splinter. The dorsal region is

slightly greenish and has irregular dark spots of pigment. The most prominent feature is the yolk-sac, carried abdominally. At this stage the fry hang by a sticky secretion to any firm surface, occasionally laboring towards the water surface. After a time the fry will manage of struggle to the surface of the water, and the tiny air-bladder will become inflated. Newly born larva of 1.3-1.7 mm in size was found. The larvae took a sessile form and did not show free movement. Which depicted in Table no. 01 and fig, 01 to fig no.16.

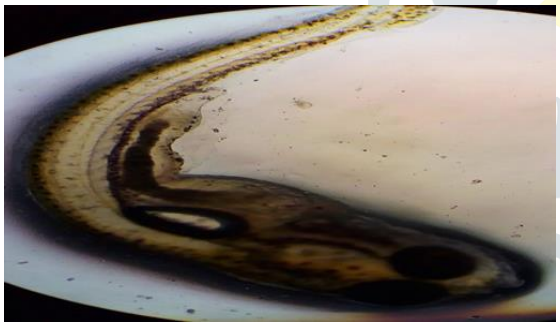
Microscopic Images of Embryonic and Larval Development of Gold fish (*C. auratus*)

Zygote stage



fertilized egg.

18-somite stage embryo.



Mouth opening of hatching stage larvae

Hatching stage

Newly-hatched larva with yolk sac 21.4 mm. stage

Table no.01 Embryonic development of gold fish (*C. auratus*)

Time after the Fertilization in (hrs.)	Progress in development
00.15	Fertilized egg
00.30	2 cell stage
00.40	4 celled stage
00.45	16 celled stage
00.55	Morula
3.05	Half, Yolk invasion completed
5.25	Yolk invasion completed
7.35	Somites were formed
9.40	12-14 somites were present
14.30	22-24 somites were present, optic lens were formed
14.55	26-30 somites were present; lens formed in the eye, heart was completely formed.
23.00	The embryo encircles the whole of the yolk, vigorous twisting movements seen.
31.50	Lens was completely formed, pectoral fins developed.
33.50	Hatching was started
34.00	Hatching was completed.

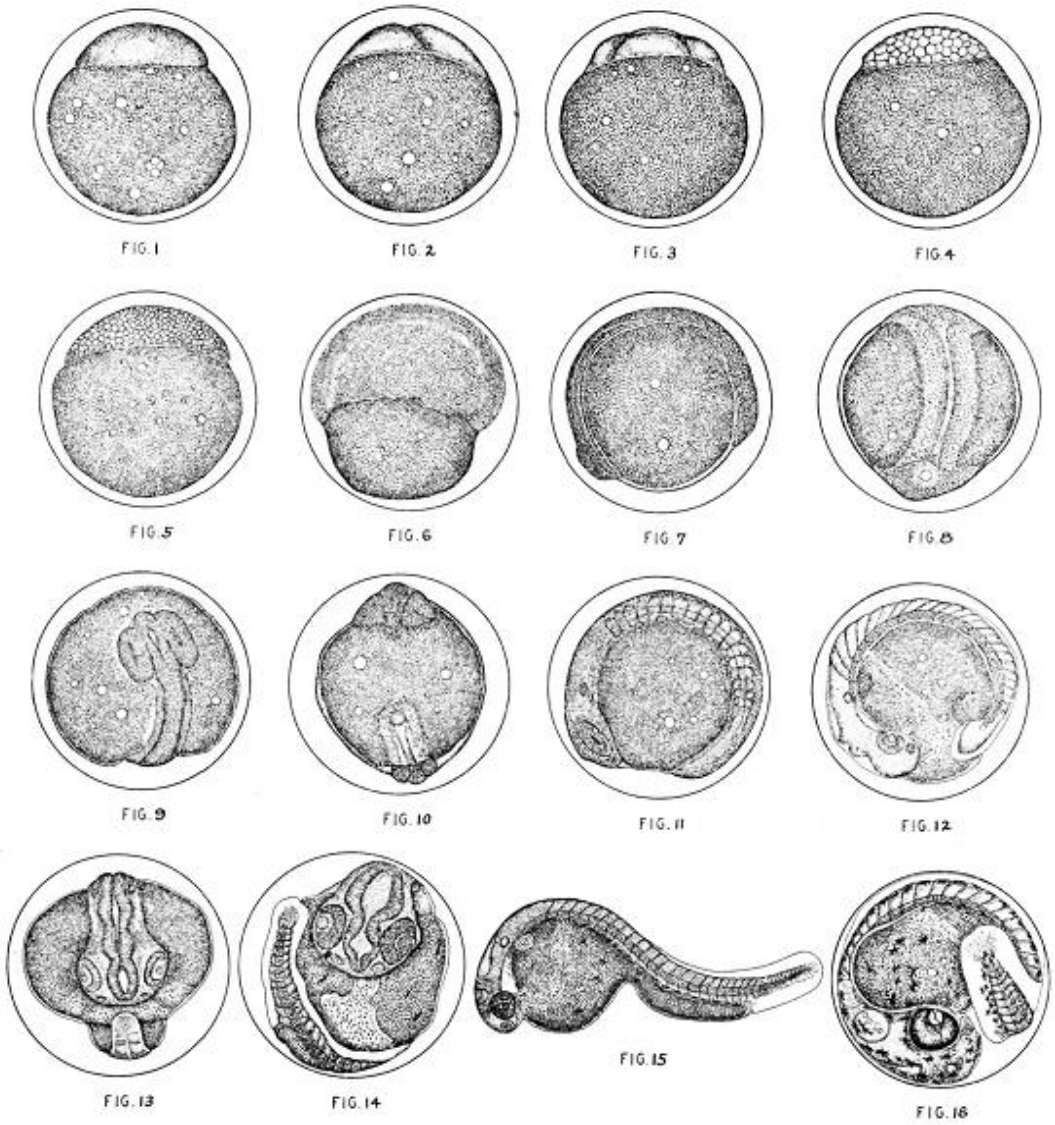


Fig 1. Recently fertilized egg., Fig 2. First cleavage division, Fig 3. Second cleavage division ,Fig 4. Many-celled blastoderm ,Fig 5. Advanced blastoderm , Fig 6. Yolk mass half over grown by blastoderm ,Fig 7. Early embryo, lateral aspect., Fig 8. Early embryo, dorsal aspect., Fig 9. Later embryo with optic vesicles ,dorsal view ,Fig 10. Later embryo with optic vesicles, ventral view,Fig11.Embryo of 18 somites ,Fig 12.Embryo of 25 somites., Fig 13. Embryo of 25 somites, Fig 14. Embryo of 32 somites., Fig 15. Embryo of 32 somite., Fig 16. Advanced embryo.

VII. Development of the larva and post larva:

Newly-hatched larva freed itself by violent lashing movements of the tail which eventually rupture the egg capsule. Total length was measure about 1.3-1.7 mm. No visible pigmentation was found on body surface. The yolk sac beard large scattered melanophores more especially anterior regions are seen. Swimming movements were somewhat restricted owing to the mass of yolk material along the body. After 11- 13 hours of hatching of larva the fin folds were clearly seen continue around the tail. The vent and gill rudiments were then formed. Gut was straight to slightly curve in anterior portion. Air bladder was shallow, behind pectoral region, which develop into two chambers in the post larval stage. After 2 to 4 days the total length of the larvae was measure about 2.5- 2.9 mm in length. There was showed distinct reduction in the size of the yolk sac which almost becomes almost tubular in shape, due to its greater absorption anteriorly. The pigmentation are resembled that of the recently hatched larva except for an increase in density especially in the eye, and the appearance of heavy masses of yellow pigment spots (xanthophores) along the dorsal surface and over the head regions. After 7-8 day's Total length of the larvae was measure about 4.4- 4.8 mm. in length. The mouth has enlarged and the lower jaw moves rhythmically. After 15-18 days the Total length measures about 5.8- 6.5 mm in length. The caudal fin had forked into dorsal and ventral lobes supported by unbranched fin rays. After 35 days the median fin fold was beginning to disappear completely from dorsally between the dorsal and the caudal fins and between the caudal and anal fins ventrally. The anal and pectoral fins had developed distinct rays. The pelvic fins had appeared as minute lateral from the body wall midway between the pectorals and the anus. From that stage on the fry become free- swimming, and will commence to search for very fine food. At this point many will die unless sufficient food is made available.

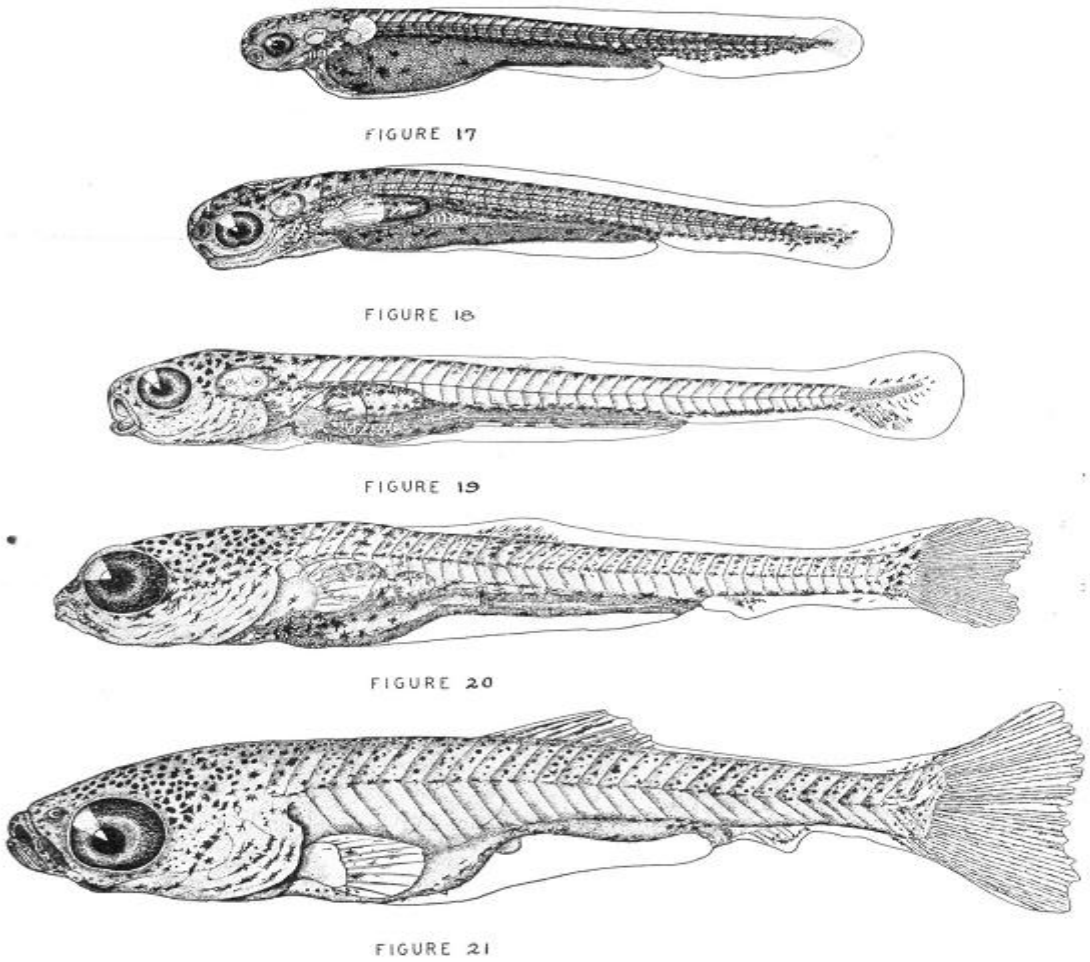


Fig.17. Newly-hatched larva.,Fig.18. 5.8 mm. stage., Fig.19.6.8 mm. stage., Fig.20.7.9 mm. stage., Fig.21.9.4 mm. stage.

Larval development of gold fish (*C. auratus*)

Larval age (days)	Length (mm)	Characters
0	Just hatched (1.3- 1.7 mm.)	Transparent with round thick, yolk sac and active blood circulation
1	2.6-2.7	Yolk sac tightly observed, with active blood circulation
3	2.7- 2.9	Yolk sac absorbed.
6	3.1-3.5	Yolk fully observed started exogenous feeding.
15	5.5-6.5	Fins are well developed.
20	9.0-12	The entire body dark brown in color
30	17-21	Different color was observed.

VIII. Conclusion

In the present study, Mature, healthy gold fish brooders about 114 fish specimens in the size range of 12.5 to 16.2 cm. Total length (TL.) Fertilized eggs hatch in 3-4 days depending on water temperature. In present

study, hatching is observed on 4th day. The diameter of the fertilized egg capsule ranges between 0.9 mm and 1.1 mm while the yolk sphere ranged from 0.5-0.9 mm in size. Newly-hatched larva freed itself by violent lashing movements of the tail which eventually rupture the egg capsule. Total length was measure about 1.3-1.7 mm. After 35 days the median fin fold was beginning to disappear completely from dorsally between the dorsal and the caudal fins and between the caudal and anal fins ventrally. The anal and pectoral fins had developed distinct rays. The pelvic fins had appeared as minute lateral from the body wall midway between the pectorals and the anus.

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Conflicts of interest: The authors stated that no conflicts of interest.

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