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THE EMBRYONIC AND LARVAL DEVELOPMENT OF THE FIREMOUTH CICHLID (*Thorichthys meeki* Brind, 1918)

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** This study is summarized from the first author's master's thesis.*

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Abstract

In this study, it was aimed to investigate the embryonic and larval development of firemouth cichlid (*Thorichthys meeki* Brind, 1918) fish in laboratory environment. The spawning and embryonic development of the eggs of the 5 pairs of broodstock fish used in the study took place at an average water temperature of 27±1°C. Spawning lasted about 60 minutes and the average number of eggs was 1159.40±91.92 pieces. The long axis of the egg was measured as 1.47±0.01 mm on average, and the short axis as 1.14±0.01 mm on average. After fertilization, the first draft of the embryo was seen between 10.45-11.35 hours. Between 12.30-13.45, the first optical capsule is formed. In the embryo, the first somite was seen at 14.00-17.30, the first heartbeat at 18.00-23.30, the first blood circulation at 21.40-30.20 and the first movement at 22.00-31.00. Hatching took place between 38.20-51.55 hours. The average total length of the newly hatched larva was measured as 3.38±0.03 mm. Larva started to swim on the 5th day, consumed the yolk sac on the 8th day and started to take feed. The larva reached the appearance of an adult individual by the end of the 30th day, and on the 30th day the total length of the larva was measured as an average of 11.02±0.36 mm.

Keywords: Firemouth cichlid, *Thorichthys meeki,* embryonic development, larvae, reproduction.

Introduction

In aquaculture, the main objective is to collect information about the early developmental periods of a species, to understand its physiological characteristics and to obtain useful information in order to improve breeding techniques (Divanach et al., 1996). There are many problems related to fertilization, incubation and embryonic development in the breeding of important freshwater and marine fish species. Increasing the information needed about egg activation and fertilization processes in these fish groups will make important contributions to aquaculture (Coward et al., 2002).

Although the aquarium sector has such a wide living potential in terms of species diversity, scientific studies on ornamental fish are quite limited. In particular, research on reproductive behaviors, egg, embryonic and larval development and offspring fertility is very limited (Çelik et al., 2011). One of the most important reasons for the failure in breeding aquarium fish is; the reproductive behaviors of that species, the early and larval development stages are not fully known or understood (Arık, 2013). Information about the larval development of fish is accepted as basic clues about their biology and taxonomy (Reynalte-Tataje et al., 2004).

However, it is believed that there are not enough studies on the embryonic and larval development of cichlid fish, which is a very crowded family. In recent years, individuals breeding aquarium fish have been conducting experiments to produce new species and trying to introduce those species to aquarium enthusiasts in their country. Cichlid fish also constitute the group of aquarium fish that are gaining popularity compared to the past (Güngör, 2012). In the cichlid family, the firemouth cichlid fish enjoys consuming live or dried food (Alpbaz, 1993). This fish, which is native to Central America, exhibits substrate spawning behavior (Hasse, 1981).

In this study, the embryonic and larval development stages of the firemouth cichlid (*Thorichthys meeki* Brind, 1918) fish, which has been increasing in popularity in recent years of the American cichlid family, attracting attention with its visual beauty and appreciated for being a harmonious species, were examined. Due to the fact that there is very little scientific data on firemouth cichlid fish, the research is considered to be important for the aquarium sector. The findings obtained; The characteristic features of the firemouth cichlid fish include its biology and, in particular, the stages of embryonic and larval development within the scope of the breeding period. It is thought that the study will shed light on the producers who want to breed this species and will bring some mobility to the domestic ornamental fish farming.

Material and Method

Material

A total of 14 firemouth cichlid fish (7 females, 7 males) were used in the experiment. The average weight and total length were 27.27±4.88 g and 11.35±0.79 cm for female fish and 34.97±6.43 g and 12.32±0.95 cm for male fish, respectively. In the experiment, a total of 6 glass aquariums were used: 1 (110x70x60 cm) for stocking broodstock fish, 3 (60x50x40 cm) for production, and 2 (35x30x25 cm) for eggs and larvae.

During the research period, cichlid stix-pellet feed (morning-evening) and tubifex as live feed (noon) were used in the feeding of broodstock fish. Nutrient proportions of cichlid stix-pellet feed; crude protein is 46%, crude oil is 8%, crude ash is 10%, crude cellulose is 2% and moisture is 6%. The nutritional content of tubifex, which is used as live food; crude protein is 11.02%,

crude oil is 2.14%, crude ash is 1.83% and dry matter is 18.78% (Yanar et al., 2003). The hatched larvae were given the newly opened *Artemia* from the 8th day of their emergence until the 22nd day and the milled feed of the broodstock fish next to *Artemia* on the 17th day and started to be given together. The nutrient content of Artemia is crude protein 54%, crude fat 12%, crude cellulose 5% and moisture 6%.

In all aquariums, tap water was used, which was rested for 48 hours. Aquariums are siphoned every 4 days to remove excrement and feed residues from the bottom. Hach Lange HQ 30D Flexi portable measuring device was used to measure water parameters in experimental aquariums. An external filter was used in the stock aquarium, an internal and pipe filter was used in the breeding aquarium, and a pipe filter was used in the aquarium where the eggs and larvae were found, and in addition, oxygen was supplied by means of an air motor. During the study, the water temperature in the aquariums was kept constant at 27±1°C using 100 and 200 watt steel heaters. In the study, 12 hours light and 12 hours dark photoperiod was applied.

The length of the broodstock fish was measured with a scale with a millimeter indicator and a precision balance with an accuracy of 0.01 g in weight. Clove oil was used as an anesthetic agent in larval measurements (Güngör, 2012; Arık, 2013). Cubes are placed in aquariums for spawning broodstock fish.

Method

Female and male broodstock fish are placed in separate aquariums so that they do not see each other for about a month. During this period, 3 meals a day are fed ad libitium. Then the fish were taken to breeding aquariums for mate keeping.

During the trial, morphological changes and reproductive behaviors of broodstock fish were carefully observed. The counting of fish eggs was carried out according to the counting method with the photographic technique (Çelik, 2008; Erik, 2012; Arık, 2013). According to this method; The collective eggs were photographed with the camera and their numbers were determined by marking them in the computer environment (Figure 1). Thus, the number of eggs laid by broodstock fish in each abdomen was determined.

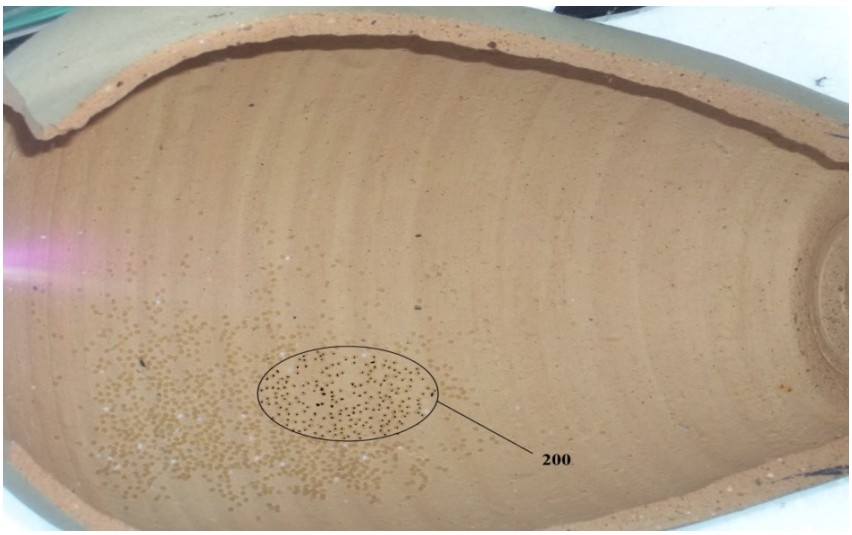

Figure 1. Counting of eggs with photographic technique

As a result of three preliminary studies, the average time intervals of sampling were determined. In the study, the embryonic and larval development stages of a total of 5 spawning (except for three pre-repetitions) obtained from the fish that performed mate selection were examined and evaluated. Care has been taken to ensure that the water temperature in aquariums prepared for eggs and larvae is the same as the water temperature in the breeding aquarium (27±1ºC). To determine the stages of embryonic development, the eggs were taken to petri dishes with pastor pipettes and examined under a stereo microscope. The Nikon SMZ 800N stereo microscope was used to image the embryonic and larval developmental stages of eggs, to measure eggs and larvae, and to take photographs. In order to make a homogeneous sampling in the measurements made under the microscope, the eggs were taken from different parts of the substrate. At least 10 eggs were taken in each sampling, and their short and long axes were measured and photographed.

In order to get clearer images from the moving larvae, approximately 0.03 ml of clove oil was added to 10 ml of water taken from the aquarium and the larvae were anesthetized (Güngör 2012; Arık 2013). In each sampling, 10 larvae were taken and placed in petri dishes. In order to more clearly detect the development of the larvae under the microscope, the head, body, tail and other body areas were also imaged in detail. The physical and morphological changes of the hatched larvae were examined daily until the 15th day and in 5-day periods from the 15th to the 30th day. The yolk sac lengths (short axis, long axis) and total lengths of the larvae were measured. Microsoft Office 2007 Excel Program was used to analyze the data (average, standard error and mathematical operations, etc.).

Results

Findings of water parameters in aquariums

The average values of the water parameters measured in all aquariums during the trial period are given in Table 1.

Table 1. Average values of water parameters in trial aquariums (mean±SE)

Trial Aquariums		Temperature (ºC)	pH	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)
Broodstock	min.	26.8	6.99	7.86	567
	max.	27.6	7.13	8.00	592
	mean±SE	27.2±0.15	7.04±0.03	7.94±0.02	581.2±4.45
Reproduction	min.	26.5	6.89	7.32	554
	max.	28.3	7.22	8.13	593
	mean±SE	27.3±0.16	7.06±0.02	7.75±0.11	574.67±3.53
Larvae	min.	27.1	7.08	7.60	527
	max.	27.8	7.28	7.91	569
	mean±SE	27.4±0.12	7.17±0.04	7.78±0.05	550.2±6.78

Findings of Broodstock Fish

The breeding period has been particularly pronounced in male fish, with more noticeable morphological changes noted. In particular, it was observed that the red color extending from the mouth and operculum to the abdomen and the black spots on the sides became evident and

exhibited more aggressive movements. During this period, the colors are vivid and bright in males, and more dull and pale in females. It has been established that in female and male broodstock fish, the breeding tubes (genital papillae) become evident during this period. In the study, the weight and total length of the matching broodstock female and male fish were measured and given in Table 2.

Table 2. Length (cm) and weight (g) of broodstock fish

Matching Fish	Female		Male	
	Weight (g)	Length (cm)	Weight (g)	Length (cm)
1	9.25	8.20	10.26	8.50
2	34.05	12.30	46.78	12.80
3	33.88	12.20	47.63	13.80
4	24.36	11.80	32.85	14.10
5	39.54	13.10	43.77	13.40
min.	9.25	8.20	10.26	8.50
max.	39.54	13.10	47.63	14.10
mean±SE	27.27±4.88	11.35±0.79	34.97±6.43	12.32±0.95

Average weight and length of female fish, respectively; 27.27±4.88 g and 11.35±0.79 cm, while male fish are 34.97±6.43 g and 12.32±0.95 cm. When male and female fish were compared, males were found to be larger in weight and height than females.

Findings of Egg Incubation

A total of 5 broodstocks were recorded from 5 pairs of mates throughout the research, and the eggs were taken to a separate aquarium and examined in order to determine the embryonic and larval development stages. In addition, the average number of eggs laid by 5 pairs, egg opening rates and incubation periods are calculated and given in Table 3.

Table 3. The average number of eggs laid by broodstocks fish (pcs.), hatching rates (%) and incubation times (hours)

	Female fish weight (g)	Female fish length (cm)	Number of eggs (pcs.)	Number of eggs opened (pcs.)	Egg hatch rate (%)	Incubation time (hours)
1	9.25	8.20	864	803	92.94	51.55
2	34.05	12.30	1293	1078	83.37	48.33
3	33.88	12.20	1045	1022	87.80	38.20
4	24.36	11.80	1218	1043	85.63	39.05
5	39.54	13.10	1377	1186	86.13	48.57
min.	9.25	8.20	864	803	83.37	38.20
max.	39.54	13.10	1377	1186	92.94	51.55
mean±SE	27.27±4.88	11.35±0.79	1159.40±91.92	1026.40±62.58	89.17±2.68	45.14±2.72

Findings of the Embryonic Development Period

In microscopic examinations of the eggs, it was determined that they were sticky, transparent, light orange in color and oval shaped. The findings of the embryonic developmental periods of the eggs of the firemouth cichlid fish are given in Table 4 and the photographs of these periods are given in Figure 2.

Table 4. Signs of embryonic development of firemouth cichlid fish (*Thorichthys meeki* Brind, 1918) at 27±1ºC

Duration (hours:minutes)	Describing	Shape
0-0.10	Newly fertilized egg (zygote). Eggs have a sticky, oval, transparent and light orange color. The averagelong axis diameter of fertilized egg was 1.47±0.01 mm and the average short axis diameter was 1.14±0.01 mm. Perivitellin cavity is clearly observed. Blastodisc formation has been observed. The cytoplasm began to be drawn towards the animal pole.	2.a
0.10-0.28	Form with 2 blastomeres. The stage in which the first mitosis division occurs. The division took place vertically.	2.b
0.28-0.36	Form with 4 blastomeres	2.c
0.36-1.01	Form with 8 blastomeres	2.d
1.01-1.35	Form with 16 blastomeres	2.e
1.35-2.06	Form with 32 blastomeres	2.f
2.06-2.21	Form with 64 blastomeres	2.g
4.20-6.30	Blastoderm cells have been found to cover 25% of the yolk (25% epiboly).	2.h
7.30-8.40	Blastoderm cells have reached 50% of the yolk. The embryo began to have a ring appearance (50% epiboly).	2.i
9.00-10.25	Blastoderm cells cover 75% of the yolk (75% epiboly).	2.i
10.45-11.35	The embryo has begun to become evident.	2.j
12.30-13.45	The optic capsule was formed and the lens of the eye began to form in the head of the embryo.	2.k
14.00-17.30	The somites began to appear.	2.l- 2.m
18.00-23.30	The heart was formed and it was determined that the heartbeat had begun.	2.n
21.40-30.20	The first blood circulation and otolith were observed.	2.n
22.00-31.00	It has been observed that the larvae moves for the first time.	2.n
32.00-45.00	It is established that in the egg the contractions of the embryo increase, and the heartbeat accelerates (129 per minute).	2.n
38.00-51.55	The hatching of the larvae from the eggs has been observed.	2.o

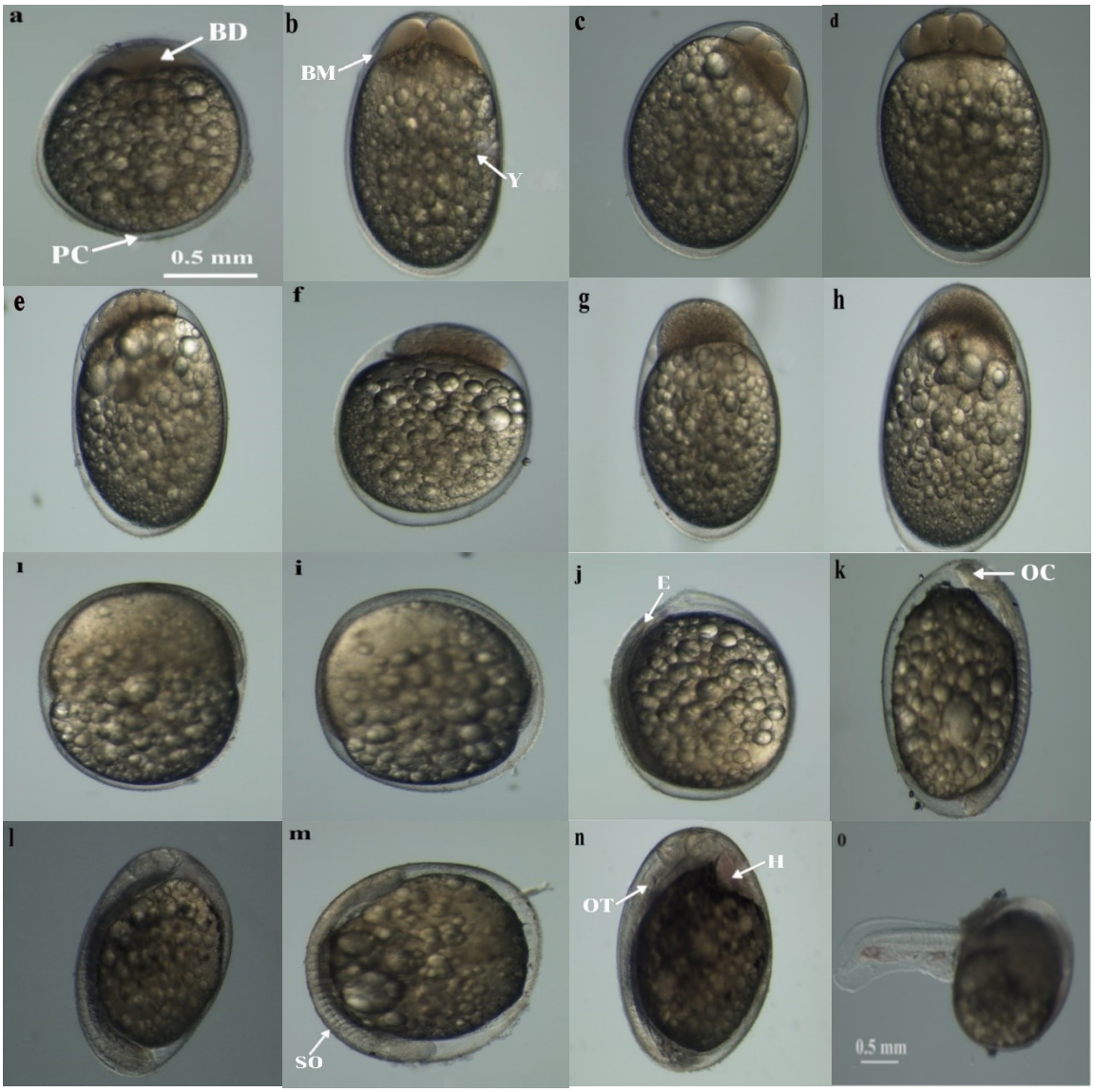

Figure 2. Embryonic developmental stages in firemouth cichlid fish (*Thorichthys meeki* Brind, 1918) (BD: blastodisc, BM: blastomere, E: embryo, H: heart , OC: optic capsule, OT: otolith, PC: previtelline cavity, SO: somite, Y: yolk)

Findings of the Larval Developmental Period

The development findings of the larvae from the 1st day to the 15th day after hatching are daily, and the development findings from the 15th to the 30th day are given in 5-day periods in Table 5, the developmental stages of this period are given in Figure 3 and Figure 4. Since the developmental stages of the larvae after the 15th day are slower, they are shown in 5-day periods.

Table 5. Signs of larvae and fry development of firemouth cichlid fish

Days	Descriptions
1	The average total length of the newly hatched larvae is 3.38±0.03 mm, the diameter of the yolk sac was measured as 1.45±0.03 mm on the long axis and 0.93±0.03 mm on the short axis. Adhesive glands on the head are prominent. Pigment cells were seen throughout the yolk sac and body. The eye is not yet colored, somites are evident. The otolith is clearly visible, but the anus is not more prominent. The blood circulation has a distinct but transparent appearance (Figure 3.a).
2	The average lenght was 3.99±0.10 mm, the diameter of the yolk sac was measured as 1.41±0.02 mm on the long axis and 0.85±0.03 mm on the short axis. Pigmentation has started in the eye. The digestive tract has begun to form, but the anus has not opened. The first red blood circulation and the tip of the notochord are seen but not yet folded. The skull bone is visible and the mouth is not yet opened. The heart has turned red, blood circulation is visible. The yolk sac decrease and tail fin rays begin to form (Figure 3.b).
3	The average lenght was 4.27±0.11 mm, the diameter of the yolk sac was measured as 1.27±0.03 on the long axis and 0.83±0.02 mm on the short axis. Adhesive glands and digestive tract began to appear. The anus is closed. The notochord tip has started to curl and mouth opening has not been formed. Pigmentation has increased in the eye and yolk sac, and the tail fin continues to develop (Figure 3.c).
4	The average lenght was 4.39±0.07 mm, the diameter of the yolk sac was measured as 0.75±0.02 on the long axis and 0.62±0.01 mm on the short axis. Mouth opening became prominent, gill arcs and heart shape began to take. The swim bladder has started to form, the anus has not yet opened. Tail fin rays are clearly visible. Adhesion glands decrease and notochord tip fold became more prominent. The blood circulation is coloured, intensified and the eye pigment has increased even more compared to the previous day. The otolith disappeared due to increased pigmentation in the head (Figure 3.d).
5	The average lenght was 4.61±0.09 mm, the diameter of the yolk sac was measured as 0.67±0.08 on the long axis and 0.53±0.05 mm on the short axis. The mouth opening and the swim bladder have become clear, the anus has opened, the eye has taken its full shape and the pupil has started to form. The larvae is free swimming. Pectoral fin became prominent, caudal fin rays increased in number, anal and dorsal fins began to form (Figure 3.e).
6	The average lenght was 4.73±0.08 mm, the diameter of the yolk sac was measured as 0.53±0.07 on the long axis and 0.45±0.06 mm on the short axis. The heart has taken its place and is located behind the gill arches towards the ventral region. The pupil is clearly visible. The lower and upper jaws became prominent and the yolk sac became smaller (Figure 3.f).
7	The average lenght was 4.88±0.10 mm, the diameter of the yolk sac was measured as 0.38±0.03 on the long axis and 0.29±0.02 mm on the short axis. The yolk sac is almost completely withdrawn and the fins are developed. Adhesive glands have completely disappeared. The swim bladder became prominent and the pigmentation spread throughout the body (Figure 3.g).
8	The average lenght was 4.97±0.09 mm, the yolk sac diameter was measured as 0.27±0.01 on the long axis and 0.20±0.01 mm on the short axis. Larvae consumed the yolk sac and took the first food (larvae were given newly opened *Artemia salina*). Colored pigment cells were seen on the first feces output and on the operculum (Figure 3.ğ).
9	The average lenght was measured as 4.98±0.10 mm. While the dorsal and anal fins are developing, the coloration continues throughout the body (Figure 3.h).
10	The average length of the larvae was measured as 5.05±0.09 mm. Colored pigment cells were seen in the eye and pupil, lower and upper jaw and back region (Figure 3.ı).
11	The average lenght was measured as 5.12±0.09 mm. Feed intake is at a very good level and development continues at full speed (Figure 3.i).
12	The average lenght was measured as 5.21±0.13 mm. Pigmentation began to intensify at the tips of the dorsal, anal and caudal fins (Figure 3.j).
13	The average lenght was measured as 5.28±0.16 mm. Dorsal fin rays began to harden (Figure 3.k).
14	The average lenght was measured as 5.37±0.17 mm. Anal fin rays begin to harden. Pectoral and pelvic fins are very prominent (Fig. 3.l).
15	The average lenght was measured as 5.52±0.21 mm. The gill filaments were red and clearly visible. Dorsal and anal fin rays are prominent (Figure 3.m).
20	The larvae reached an average length of 6.76±0.44 mm. In the larvae, cross-sectional bands began to become evident on the body. The towards tail fin has started to develop a black spot-like appearance (Figure 3.n).
25	The total length of the larvae was measured as 8.64±0.39 mm. Cross-sectional bands are evident. The tips of the dorsal fin have started to turn orange. Light brown pigmentation has begun throughout the body (Fig. 3.o).
30	The larvae reached an average length of 11.02±0.36 mm. The larvae reached the adult individual form within 1 month from its hatching and completed its development. Cross-sectional bands on the body and spots on the tail stem and gill arch were formed (Figure 3.ö).

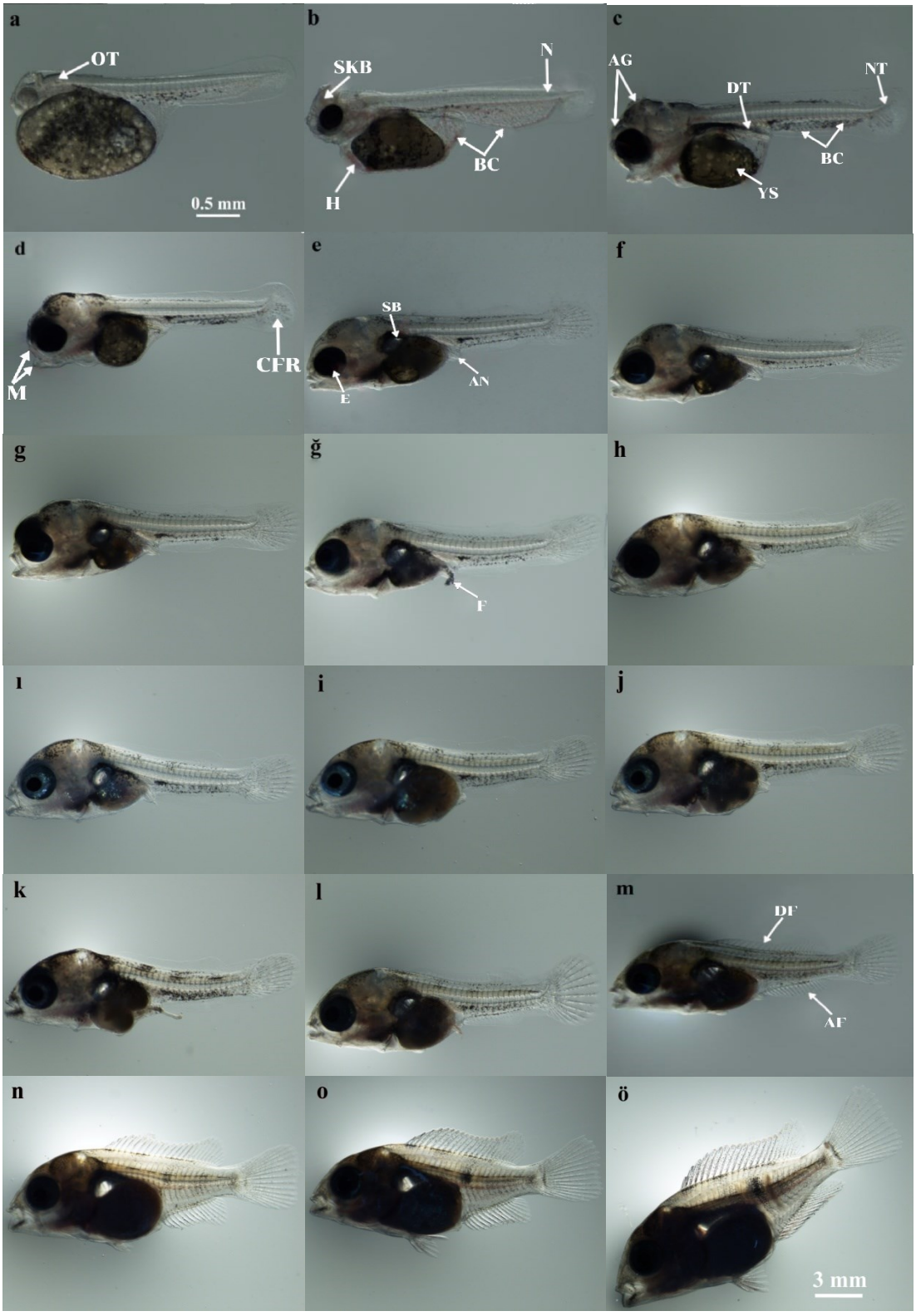

Figure 3. Larval and juvenile developmental stages in firemouth cichlid fish (*Thorichthys meeki* Brind, 1918) (AF: anal fin, AG: adhesive glands, AN: anus, BC: blood circulation, CFR: caudal fin ray, DF: dorsal fin, DT: digestive tract, E: eye, F: feces, H: heart, M: mouth, N: notochord, NT: notochord tip, OT: otolith, SB: swim bladder, SKB: skull bone, YS: yolk sac).

In the study, the yolk sac of firemouth cichlid fish larvae was consumed in 8 days. The average long axis length of the yolk sac was 0.84±0.17 mm and the average short-axis length was 0.59±0.10 mm from the 1st day to the 8th day when the larvae hatched. The change in the long and short axis lengths of the yolk sac during this period is given in Figure 4.

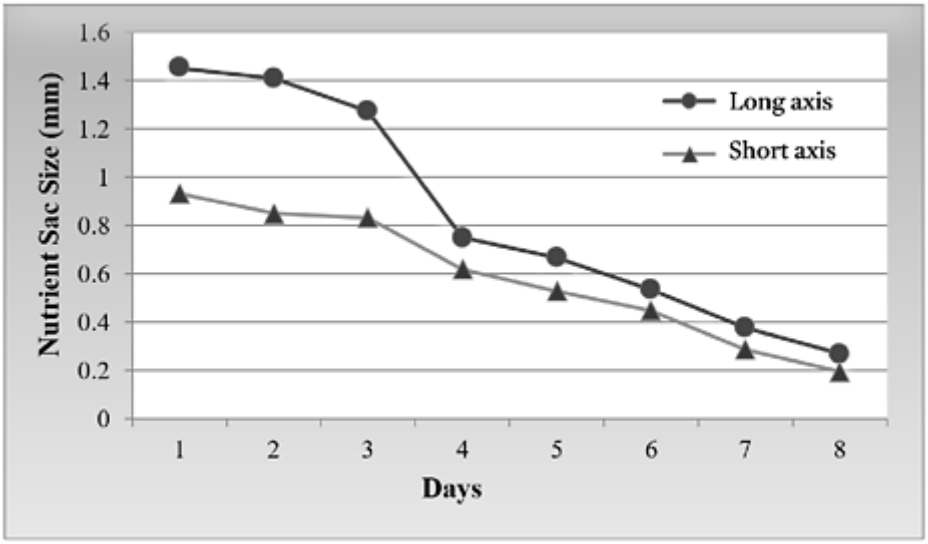

Figure 4. Change in the process until the day the larvae consumes the yolk sac

From the egg hatching until the development of the mouth opening is completed and the yolk sac is consumed, no external feeding is done. Newly opened *Artemia* was given to the larvae that consumed the yolk sac from the 8th day. Looking at Figure 4, it is seen that the larvae consumes the yolk sac quickly during the period until it takes food from outside. During the research, the total length of the larvae that hatched from the egg was measured for 30 days and the daily total length growth change of the larvae is shown in Figure 5.

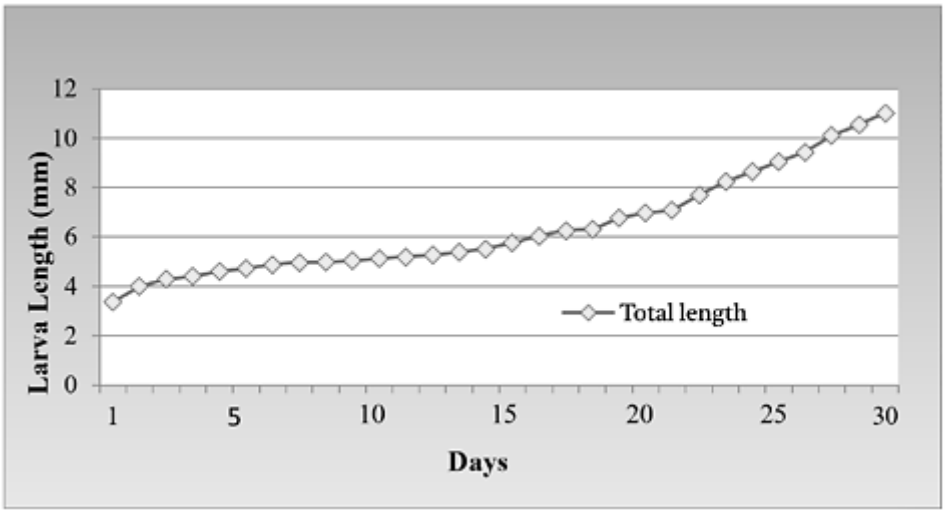

Figure 5. Total length growth graph of the larvae in the 30-day period

It is seen that the growth of the larvae, whose growth in length was examined for 30 days, increased rapidly from the 8th day to the 30th day when they started to take food from outside.

Discussion and Conclusion

The subject of this research has been studied for the first time in the firemouth cichlid fish species. In the study, the embryonic findings from fertilization to hatching are given in Table 6 in comparison with the findings of other researchers.

Looking at similar studies on cichlid fish; Meijide and Guerrero (2000) *Cichlasoma dimerus* at 25±0.5°C, Bayraklı et al. (2001) *Cichlasoma nigrofasciatum* at 26±2°C, Fujimura and Okada (2007) *Oreochromis niloticus* at 28±1°C, Korzelecka-Orkisz et al. (2012) *Pterophyllum scalare* at 28°C, Güngör (2012) *Aequidens rivulatus* at 25.1±1°C, Erik (2012) *Symphysodon* spp. at 28.3±0.04°C, Bindu and Padmakumar (2012) studied *Etroplus maculatus* at 27°C, and Arık (2013) *Parachromis managuensis* at 25±1°C. In this study, *Thorichthys meeki* was studied at 27±1°C and the water temperature seems to be similar to other studies.

Zygote stage (0-0.10); Meijide and Guerrero (2000), Bayrakli et al. (2001), Fijumura and Okada (2007), Bindu and Padmakumar (2012), Erik (2012), Arık (2013), and Nath et al. (2021)'s findings are similar. In this study, 2-blastomere stage (0.10-0.28); Bindu and Padmakumar (2012), Korzelecka-Orkisz et al. (2012), Arık (2013) and Nath et al. (2021), 4-blastomere stage (0.28-0.36); Korzelecka-Orkisz et al. (2012) and Arık (2013), 8- blastomere stage (0.36-1.01); with Arık (2013), the 16- blastomere stage (1.01-1.35); Arık (2013) and Gomathi et al. (2021), 32 blastomer stage (1.35-2.06); with Arık (2013), 64- blastomere stage (2.06-2.21); It showed similar results with Arık (2013). 25% epiboli stage (4.20-6.30); Bindu and Padmakumar (2012), Arık (2013), and Gomathi et al. (2021), the 75% epiboli phase (9.00-10.25); Korzelecka-Orkisz et al. (2012).

The first somite (14.00-17.30), the first heartbeat (18.00-23.30) and the first movement (22.00-31.00) in the embryo were observed earlier than the findings of other investigators. The range of first blood circulation (21.40-30.20); Nath et al. (2021), the first hatching is seen (38.20-51.55); Bindu and Padmakumar (2012), Arık (2013), and Millot et al. (2023) are similar to the findings. The sighting of the first embryo (10.45-11.35) in the conducted studies, are similar with the findings of the Sahoo et al. (2017) and was found earlier than most of the other findings. Appearance of the first optic capsule (12.30-13.45); often observed earlier than the findings of other researchers.

Table 6. Comparison of embryonic development findings with literature

Species name	zygote	2 blast.*	4 blast.*	8 blast.*	16 b blast.*	32 blast.*	64 blast.*	25% epiboli	50% epiboli	75% epiboli	embryo	optic capsule	somite	Heart beat	blood circulation	first movement	hatching	References
Cichlasoma dimerus	0.10-1.25	1.45	2.05	2.45	-	-	4.55	16.20	19.00	21.00	23.00	28.00	26.00-36.00	36.00	36.00	-	53.00	Meijide and Guerrero (2000)
Cichlasoma nigrofasciatum	0-1.00	11:00	-	-	-	-	-	-	-	24.00	24.00	40.00	-	55.00	55.00	-	56.00	Bayrakli et al. (2001)
Oreochromis niloticus	0-1.5	1.5-2	2	3	4	-	-	-	22-26	26-30	30.00-40.00	40.00-44.00	30-40	48-60	60-72	-	90-110	Fujimura and Okada (2007)
Etroplus maculatus	0	0.15	0.45	1.15	-	-	-	6.30	24.45	37.45	21.00	28.45	29.30	30.00	33.55	35.15	48.00	Bindu and Padmakumar (2012)
***Symphysodon* spp.**	0-1.00	1.25	1.45	2.05	2.30	2.55	3.15-3.20	21.00	25.00	27.00	31.00	33.00	-	44.00	44.00	49.00	57.00	Erik (2012)
Aequidens rivulatus	0.25	2.00	2.25	3.15	4.00	-	-	17.00	26.00	28.00	36.00	36.00	-	49.00	64.00	68.00	75.50	Güngör (2012)
Pterophyllum scalare	-	0.21	0.28	0.35	0.41	-	-	-	7.00	9.48	10.16	-	12.10	15.24	-	16.20	21.28	Korzelecka-Orkisz et al. (2012)
Parachromis managuensis	0-0.15	0.15-0.35	0.35-0.55	0.55-1.28	1.28-1.54	1.54-2.15	2.15-2.35	6.10-9.30	11.30-12.10	12.30-14.10	15.30-17.00	17.30-19.00	23.20-24.20	30.00-33.00	35.00-45.00	37.00-47.00	49.40-70.00	Arık (2013)
Horabagrus brachysoma	0.35	0.49	1.12	1.28	2.01	2.22	2.46	-	-	-	10.58	-	-	-	-	20.06	20.46	Sahoo et al. (2017)
Pethia shalynius	0.10	0.15	0.20	0.25	0.36	0.50	1.06	-	4.00	-	-	10.29	7.00	25.48	25.48	-	26.00	Nath et al. (2021)
Lethrinus lentjan	-	0.45	0.56	1.05	1.15	1.30	1.53	5.20	6.39	7.00	8.00	8.42	-	13.21	-	14.10	15.40	Gomathi et al. (2021)
Sciaena umbra	0.30	0.50	1.15	1.37	1.58	2.19	2.38	-	12.29	-	-	17.20	-	28.20	-	-	41.20	Millot et al. (2023)
Thorichthys meeki	0-0.10	0.10-0.28	0.28-0.36	0.36-1.01	1.01-1.35	1.35-2.06	2.06-2.21	4.20-6.30	7.30-8.40	9.00-10.25	10.45-11.35	12.30-13.45	14.00-17.30	18.00-23.30	21.40-30.20	22.00-31.00	38.20-51.55	In this study

The characteristics of broodstock fish, eggs and larvae in the study are shown in Table 7 in comparison with the findings of other researchers.

Table 7. Demonstration of the characteristics of broodstok fish, eggs and larvae in comparison with the findings of other researchers

species name	number of broodstock (pairs)	ovulation time (minutes)	egg shape	number of eggs (pcs)	egg diameter/short-long axis (mm)	larvae length (mm)	free swimming (days)	yolk sac consumption (days)	adult appearance (days)	References
Cichlasoma dimerus	-	-	-	-	1.25±0.05 - 1.65±0.05	3.32±0.10	7-8	9	40-42	Meijide and Guerrero (2000)
Cichlasoma nigrofasciatum	1	-	oval	136	1.22±0.08 - 1.61±0.09	3.46±0.07	6	5-6	-	Bayraklı et al. (2001)
Etroplus maculatus	-	-	-	140-231	1.60	3.90	4	3	-	Bindu and Padmakumar (2012)
***Symphysodon* spp.**	6	60-90	-	72-258	1.19±0.02-1.77±0.02	3.03±0.04	4	7	30	Erik (2012)
Aequidens rivulatus	4	75-90	oval	527±70	1.45±0.05-1.86±0.04	4.26±0.14	7	-	-	Güngör (2012)
Pterophyllum scalare	-	-	oval	-	1.17-1.43	2.60±0.09	-	-	25	Korzelecka-Orkisz et al. (2012)
Parachromis managuensis	5	75-90	oval	1236±187.40	1.47 ± 0.03-1.92±0.05	4.02±0.53	6	10	30	Arık (2013)
Horabagrus brachysoma	-	-	round	-	1.1-1.4	3.1-4.4	6	3	12	Sahoo et al. (2017)
Pethia shalynius	-	-	round	-	0.75–0.80	2.32 ± 0.11	-	-	-	Nath et al. (2021)
Lethrinus lentjan	-	-	round	-	0.69	1.39 ± 0.08	-	2	35	Gomathi et al. (2021)
Sciaena umbra	-	-	round	-	1.25 ± 0.03	3.14 ± 0.13	-	3	35	Millot et al. (2023)
Thorichthys meeki	5	60	oval	1159.40±91.92	1.14±0.01-1.47±0.01	3.38±0.03	5	8	30	in this study

In the studies, it is seen that the number of broodstock varies between 1-6 pairs, the ovulation time varies between 60-90 minutes and the egg shape varies between oval and round. The average number of eggs obtained in the study (1159.40) is lower than the study of Arık (2013); and higher compared to the studies of Bayrakli et al. (2001), Bindu and Padmakumar (2012), Erik (2012) and Güngör (2012). In the study, the average short axis length of the egg was 1.14±0.01 mm and the long axis length was 1.47±0.01 mm, Meijide and Guerrero (2000), Bayraklı et al. (2001), Erik (2012), Güngör (2012), Korzelecka-Orkisz et al. (2012), Arık (2013), Sahoo et al. (2017) and Millot et al. (2023), similar to the findings; smaller than the finding of Bindu and Padmakumar (2012); Nath et al. (2021) and Gomathi et al. (2021) was found to be greater than the findings. These differences in egg diameters are thought to be due to broodstock age, broodstock size, water temperature, number of eggs and species difference. In the study, the average length of the newly hatched larvae (3.38±0.03 mm); Meijide and Guerrero (2000), Bayrakli et al. (2001), Bindu and Padmakumar (2012), Erik (2012), Sahoo et al. (2017) and Millot et al. (2023), similar to the findings; Korzelecka-Orkisz et al. (2012), Nath et al. (2021) and Gomathi et al. (2021), higher than the findings; It is lower than the findings of Güngör (2012) and Arık (2013). In this study, it was observed that the larvae started their first free swimming on the 5th day. When compared with the findings of other researchers; It is seen that the transition times of the larvae to free swimming are mostly close to each other. It was determined that the larvae that emerged from the egg consumed their yolk sacs on the 8th day. This value is lower than the data in the study of Meijide and Guerrero (2000) and Arık (2013); higher than other studies. In this study, it was observed that the larvae reached the adult appearance on the 30th day. This value is similar to the findings of Erik (2012) and Arık (2013); Sahoo et al. (2017) and Korzelecka-Orkisz et al. (2012) higher than the findings; was found to be lower than in other studies. In this study; while the findings such as the size of the newly hatched larva, when it first started free swimming, the day the larva consumed the yolk sac, and the time it took to reach the adult individual appearance, it was seen that while it was close to some studies, it was not compatible with others. Demir (2006), this difference; water temperature, oxygen, light, amount of vitellus, fish species and also reported that it varies according to the environmental conditions within the same species.

By determining the embryo and larval development characteristics, it is primarily possible to have an idea about the broodstock quality. These ideas can directly help to make the production protocols of the broodstocks put into production more efficient. Next, water quality, light, feeding, etc. larval production protocols can be adapted according to the effects of environmental factors on embryo and larval development (Çelik, 2011). Fish farming should be supported by the continuous supply of high quality fish larvae to the industry (Goyard et al., 2008).

Abnormal embryo development during the embryonic development stage can result in reduced hatchability and high mortality in fish embryos. In addition, knowledge about the development of fish embryos plays an important role in increasing larval growth and larval survival (Puvaneswari et al., 2009).

Cichlids, which have a special place among aquarium fish with their social behavior, are species with high economic value in our country. With its beautiful colors and interesting movements, the firemouth cichlid fish is a popular cichlid species. At the beginning of the most common problems in the production of cichlid fish; Problems such as not spawning, not being able to hatch offspring from eggs and fungusing come.

Unfortunately, aquarium fishing is a sector that has been left alone in our country. Production trials are carried out with mostly hearsay information. Cichlid-culturing enterprises try to achieve production success through trials, although they do not have sufficient production knowledge. However, it is a well-known fact that they stop their production activities by experiencing losses because they do not have enough information about egg collection and larval hatching from broodstocks. By acquiring knowledge about the reproduction, embryonic and larval development stages of cichlid species, the potential problems in aquaculture can be eliminated and resolved. It is thought that the findings obtained from this study will shed light on the people and producers who are interested in aquarium hobby. As a result, if the reproductive behaviors, embryonic and larval characteristics of fish are known, most of the problems that will be encountered in their breeding will be eliminated.

Ethical approval

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No ethical approval was required.

Data availability statement

The authors declare that data are available from authors upon reasonable request.

Conflicts of interest

There is no conflict of interests for publishing of this study.

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Contribution of authors

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