

Development of Eggs and Larvae in the Angelfish, *Centropyge ferrugatus*

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Abstract Reproduction of *Centropyge ferrugatus* was observed in the aquarium. Reproduction between the same parent fish was observed on at least 16 occasions during the period from April 26 to May 16, 1987. The fertilized eggs were spherical, pelagic and measured 0.67–0.70 mm in diameter. Hatching took place from 16 hours 10 minutes after fertilization at 25.0–26.0°C. Newly hatched larvae, measuring 1.28–1.30 mm in total length, had a large ellipsoid yolk sac whose front tip clearly protruded beyond the snout of the larva. The larvae were maintained for five days after hatching and about ten of them reached the post-larval stage, measuring 2.43–2.50 mm in total length. Larval characteristics are reviewed and a brief comparison is made with other studies of angelfish.

Centropyge ferrugatus Randall et Burgess, the rusty pygmy angelfish belonging to the family Pomacanthidae, is distributed from Miyake-jima Island and Tanabe Bay in central Japan to the Philippines and Hawaii. It reaches about 10 cm in total length, making it one of the smallest species among this fish family.

The early developmental stages of the angelfishes have hitherto been studied in detail for five Japanese species, *Chaetodontoplus septentrionalis* (Temminck et Schlegel), *Genicanthus lamarck* (Lacepède), *G. semifasciatus* (Kamohara), *G. melanospilos* (Bleeker) and *Centropyge interruptus* (Tanaka) (Fujita and Mito, 1960; Suzuki et al., 1979; Hioki et al., 1982; Hioki and Suzuki, 1987), and briefly reported for one Indian species, *Centropyge argi* Woods et Kanazawa (Bauer and Bauer, 1981). The present study is thought to be the seventh report on larval characteristics among the angelfish family (Thresher, 1984; Leis and Rennis, 1982; Okiyama, 1988).

Materials and methods

Two adult fish (78.0 mm male and 66.0 mm female, both in total length), which were collected from the coast of Okinawa Island for the present experiment, were reared for 56 days in the same aquarium tank of the Marine Science Museum of Tokai University from March 2, 1987.

The acrylic aquarium tank used for rearing and spawning of the fish was 1.3×2.0×0.75 (H) m in size, and 1.95 m³ in capacity. Water was circulated through a sand filter and the water temperature was kept at 25.0–27.0°C. The fish were fed once daily

with chopped or sliced fresh meat of fishes, clams, and prawns. No special conditions were provided for their reproduction.

Continual observations were made, and immediately after each spawning was confirmed the released eggs were scooped up in a glass beaker and transferred into a plastic receptacle (30 l) in which the fertilized eggs and hatched larvae were maintained in still water with weak aeration. The rearing water for eggs and larvae was renewed several times each day. The water temperature was kept at 25.0–26.0°C during the experiment.

Results

Spawning. Reproduction of the present species took place after several repetitions of the courtship behavior which seemed to be common to all species among the angelfishes (Lobel, 1978; Moyer and Nakazono, 1978; Bauer and Bauer, 1981). Successful reproduction was first observed on April 26, and then continued intermittently up to May 16. During those 21 days, fertilized eggs were confirmed 16 times. Following a lengthy period of courtship behavior which started in the early afternoon, spawning occurred at 18:00–19:00, that is, 60–90 minutes after sunset (Fig. 1).

Fertilized eggs. The characteristics of the fertilized eggs of *C. ferrugatus* were mostly identical to those of the other angelfishes studied. The fertilized eggs of *C. ferrugatus* were buoyant, transparent, colorless, spherical, and non-adhesive with a narrow perivitelline space. They measured 0.67–0.70 mm in diameter and contained a single oil globule which

measured 0.16–0.17 mm in diameter. No structures or appendages were found on the surface of the yolk and egg membrane.

Development of egg. Forty-five minutes after fertilization, the egg reached the two-cell stage (Fig. 2A); at 2 hours and 20 minutes, it reached the morula stage (Fig. 2B); at 7 hours and 45 minutes, the blastoderm covered two-thirds of the yolk and the embryonal body appeared (Fig. 2C); at 9 hours and 55 minutes, six myotomes were seen and Kupffer's and optic vesicles appeared (Fig. 2D). Immediately before hatching, 19 myotomes were seen distinctly, a lens was formed in each of the optic vesicles, the oil globule was fixed in the caudal part of the embryonal body, numerous branched melanophores were seen along the dorsal axis of the embryonal body, and a few of these were present on the frontal part of the yolk sac with about ten on the surface of the oil globule (Fig. 2E). Hatching took place at 16 hours 10 minutes after fertilization. Almost all the larvae hatched out within 40 minutes after the first hatching (Table 1).

Early larval stage. The newly hatched larvae measured 1.28–1.30 mm in total length and had a large ellipsoid yolk sac (0.90–0.97 mm in largest diameter). The front tip of the yolk sac extended beyond the snout of the larva. A single oil globule was situated at the rear end of the yolk sac with its rear half protruding out of the rear margin of the yolk. The numbers of the myotomes were $13+9=22$; the anus was located at an anterior point three-fourths of the total length, close to the rear margin of the yolk sac. Numerous branched melanophores were seen along the dorsal axis of the body; six or seven of these were on the surface of the oil globule, and one or two were on the frontal part of the yolk (Fig. 2F). A great number of small flat tubercles thickly covered the whole surface of the larval body.

Three hours after hatching, the larvae measured

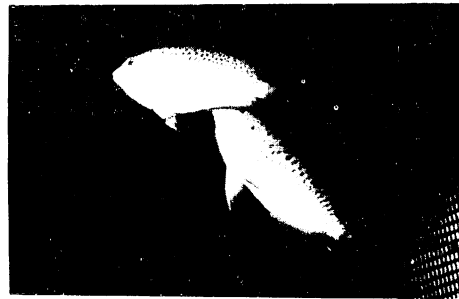


Fig. 1. Courtship behavior of *Centropyge ferrugatus* in the aquarium. The male (below) nuzzles his snout against the belly of the female (above).

1.60–1.62 mm in total length and had $13+14=27$ myotomes. Numerous branched melanophores were seen consecutively along the dorsal axis and extending into the dorsal finfold (Fig. 2G). Six hours after hatching, the larvae measured 1.89–1.92 mm in total length and had $13+15=28$ myotomes. No melanophore was seen on the frontal part of the yolk sac (Fig. 2H). Twelve hours after hatching, the larvae measured 2.16–2.18 mm in total length and had $10+15=25$ myotomes. The yolk sac was somewhat decreased in size. The front tip of the yolk sac was level with the snout. Most of the branched melanophores had disappeared along the dorsal axis of the larval body, except for a large one which spanned the 13th and 19th myotomes. One large melanophore was found extending from the 9th to the 11th myotomes. About ten branched melanophores were present on the yolk and six were seen at the frontal dorsal part of the head of the larvae (Fig. 3A).

One day after hatching, the larvae measured 2.48–2.52 mm in total length and had $10+16=26$ myotomes. A mass of melanophores was seen on the dorsal part of the 17th myotome, and another close to the rear-dorsal part of the digestive organ. The eyes became slightly darkish with an increase in the

Table 1. Developmental process in embryonal stage of *Centropyge ferrugatus*. *At water temperature of 25.0–26.0°C

Stage	Time after spawning		Code in Fig. 2.
	h	min*	
2-cell stage	00	45	A
4-cell stage	01	00	
8-cell stage	01	15	
Morula stage	02	20	B
Formation of embryo	07	45	C
6-myotome stage: appearance of Kupffer's and optic vesicles	09	55	D
19-myotome stage: immediately before hatching	16	10	E

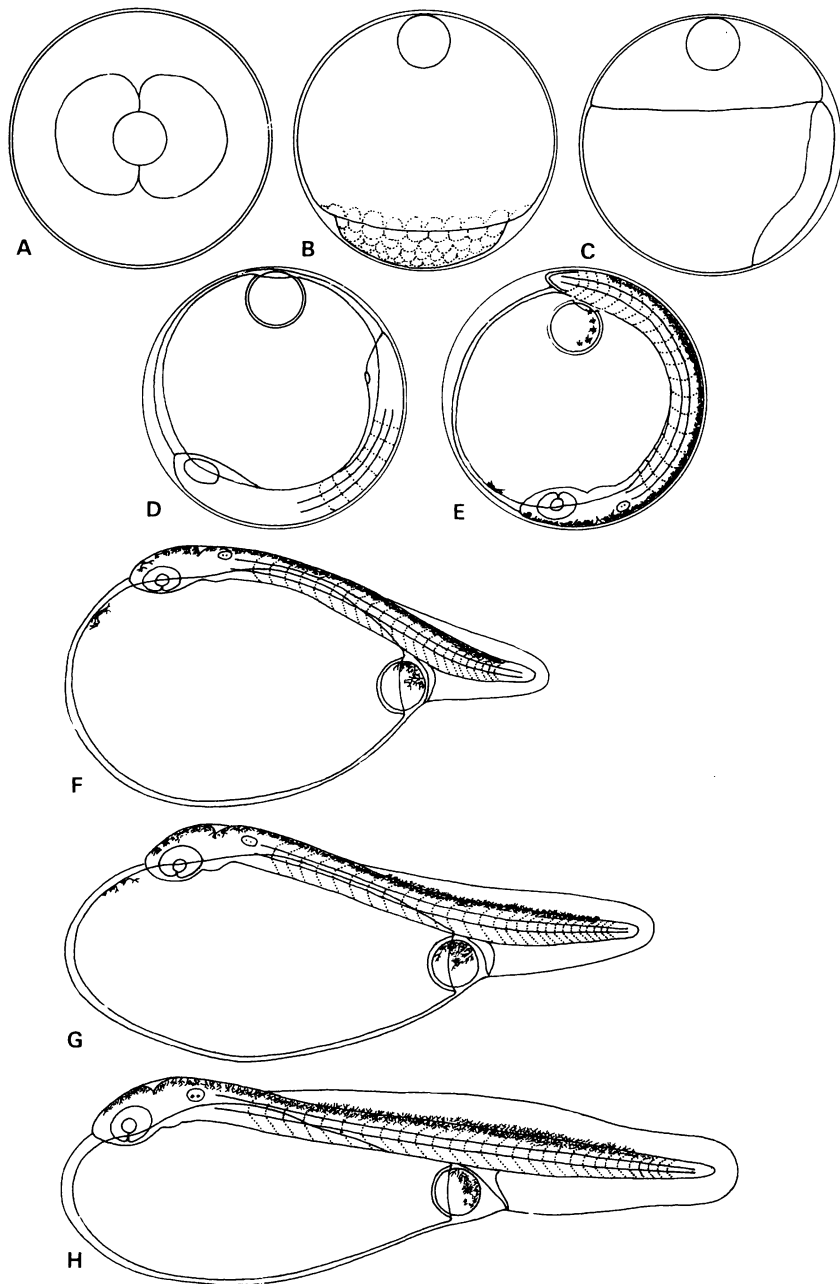


Fig. 2. Developing eggs and larvae of *Centropyge ferrugatus*. A, 2-cell stage, 45 min after fertilization; B, morula stage, 2 h 20 min; C, formation of the embryo, 7 h 45 min; D, 6-myotome stage, 9 h 55 min; E, 19-myotome stage, immediately before hatching, 16 h 10 min; F, newly hatched larva, 1.28 mm in total length; G, early larva, 3 h after hatching, 1.60 mm; H, early larva, 6 h, 1.89 mm

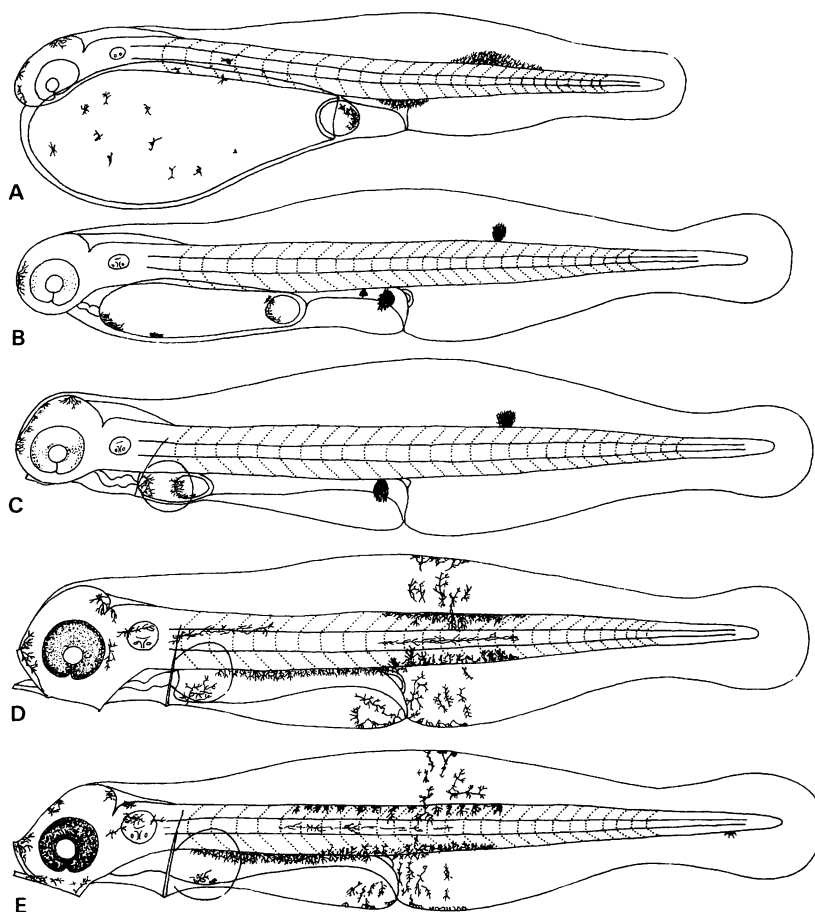


Fig. 3. Early and post-larvae of *Centropyge ferrugatus*. A, early larva, 12 h after hatching, 2.16 mm in total length; B, early larva, 1 day, 2.48 mm; C, early larva, 2 days, 2.56 mm; D, early larva, 3 days, 2.50 mm; E, post-larva, 5 days, 2.50 mm.

number of melanosomes (Fig. 3B). Two days after hatching, the larvae measured 2.56–2.60 mm in total length and had $10 + 16 = 26$ myotomes. The pectoral fins appeared. The pigmentation of the larvae was mostly similar in number and location to that of the preceding stage (Fig. 3C). Three days after hatching, the larvae measured 2.50–2.56 mm in total length and had $10 + 15 = 25$ myotomes. The yolk sac was mostly absorbed. The mouth and anus were opened. The eyes became completely black. Several branched melanophores were concentrated in the central zones of the larval body and of the dorsal finfold, the frontal zone of the ventral finfold, and the rear zone of the preanal finfold. Numerous branched melanophores were seen along the dorsal

surface of the digestive organ (Fig. 3D).

Post-larval stage. Five days after hatching, the larvae measured 2.43–2.50 mm in total length and had $10 + 15 = 25$ myotomes. The locations of the melanophore pigment were mostly identical to those at three days after hatching (Fig. 3E).

Discussion

Hioki and Suzuki (1987) briefly compared the characteristics of newly hatched larvae of five angelfishes belonging to the three genera. They noted the following common larval features in these angelfishes: 1) the existence of a large ellipsoid yolk sac whose front tip extends beyond the larval snout;

2) the presence of a single oil globule situated at the rear end of the yolk sac; 3) the position of the anus is at a little behind or close to the rear margin of the yolk sac; and 4) the appearance of the melanophores on the oil globule.

The present larval characteristics of *C. ferrugatus*, at the newly hatched stage, agreed with these common larval features in the angelfishes studied. The yolk sac of the newly hatched larvae of the present species was rounder in shape than that of the genus *Genicanthus* (see Suzuki et al., 1979; Hioki et al., 1982) and almost equal to that of the genus *Chaetodontoplus* (see Fujita and Mito, 1960; Hioki, pers. obs.).

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アカハラヤッコの卵と仔魚

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水槽飼育されたアカハラヤッコ *Centropyge ferrugatus* に産卵が観察された。親魚は雌雄各1尾（雄全長 78.0 mm；雌全長 66.0 mm）で 1987 年 4 月 26 日-5 月 16 日の間に 16 回（1 日 1 回）の産卵が観察された。繁殖期間中の飼育水温は 25.0-27.0°C であった。受精卵は油球 1 個を有する無色透明の球形分離浮性卵で卵径 0.67-0.70 mm，油球径 0.16-0.17 mm，卵膜腔は狭く卵膜および卵黄表面に特殊な構造はない。水温 25.0-26.0°C で受精 16 時間 10 分後に最初の孵化が認められた。孵化直後の仔魚は全長 1.28-1.30 mm，卵黄が大きくその先端は吻部より前方に突出する。油球は卵黄の後端に位置し，その後半は卵黄囊外に突出する。肛門は卵黄後縁に接して位置する。黒色素胞が頭部から尾部の体背面に多数，油球表面に 6-7 個，卵黄前端上縁部に 1-2 個認められる。孵化 5 日後の後期仔魚まで飼育され記載することができた。本種の孵化直後から 5 日後までの仔魚の形状は同属のレンテンヤッコと良く似る。孵化直後の仔魚について既知のキンチャクダイ科のタテジマヤッコ，キンチャクダイ属属と比べると本種の仔魚では卵黄の形が丸みを帯びている。しかし，その他の形質には，科内各種相互の共通点が少なくなかった。

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