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Development of the Eggs and Larvae of the Pike Eel, *Muraenesox cinereus*

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Abstract Embryonic and larval development of the pike eel, *Muraenesox cinereus*, are described following natural fertilization in the laboratory. Eggs are pelagic and spherical with diameters from 1.8 to 2.1 mm and have a colorless, transparent chorion and numerous oil globules. Hatching occurs 36 hours after spawning at a water temperature of 25℃. Newly-hatched larvae are 5.8 mm in mean TL, and the number of myomeres averages 86. Absorption of the yolk is completed 8 days after hatching, at 9–10 mm TL. Larvae survive for 10 days without food supply. At this time they are 11.2 mm in mean TL and have 97+55=152 myomeres, which is a diagnostic character of this species. They have large eyes and well-developed jaws with sharp teeth.

The pike eel *Muraenesox cinereus* is a very common muraenesocidid fish in Japan southward from Aomori Prefecture (Asano, 1984). Early life histories of anguilliform fishes including muraenesocidids are poorly known. Artificially matured and fertilized eggs of anguilliform fishes are reported in the Japanese eel, *Anguilla japonica* (Yamamoto and Yamauchi, 1974; Yamauchi et al., 1976) and the pike eel (Takai, 1979), but no observation is available for larval development following natural spawning.

In this paper, we describe the egg and larval development of the pike eel derived from natural fertilization and discuss the ecological significance of larval morphology.

Materials and methods

Eggs and larvae were obtained through natural spawning at the Kamiura Branch of the Japan Sea-Farming Association, Ohita Prefecture, on July 30 to August 11, 1987. Fifty-seven females and 78 males caught at Hyuganada during the early summer of 1986/87 were used as parental stock. They matured with increasing water temperature from 20℃ to 25℃ in a 50-ton tank. After about one month, the fish spawned and eggs were naturally fertilized on July 29, 1987. Eggs spawned were transferred to a 500-*l* tank at 25℃ and their development was observed every 2 hours. Hatched larvae were sequentially sampled every 12 hours and preserved in 10% v/v formalin. Their development was observed under a dissecting microscope. The influence of rearing temperature on incubation time and larval development was examined at temperatures of 18℃, 22℃ and 30℃.

Results

Eggs. The eggs are free, pelagic and almost spherical in shape, measuring 1.8–2.1 mm in diameter (Fig. 1A). The chorion is colorless and transparent. The yolk is yellow. There are numerous oil globules with a diameter of 0.03–0.10 mm, just after fertilization. Embryonic development at 25℃ is shown in Table 1 and Fig. 1. Hatching occurred 62, 47, 36 and 29 hours after fertilization at 18℃, 22℃, 25℃ and 30℃, respectively. Water temperature influenced the incubation period, but not larval features at hatching. Size at hatching was almost the same (5.8 ± 0.18 mm in mean$\pm$SD), except for larvae incubated at 18℃, which were a little smaller than the others.

Larvae. The newly-hatched larvae, averaging 5.0 mm TL, were slightly bent and had 86 myomeres

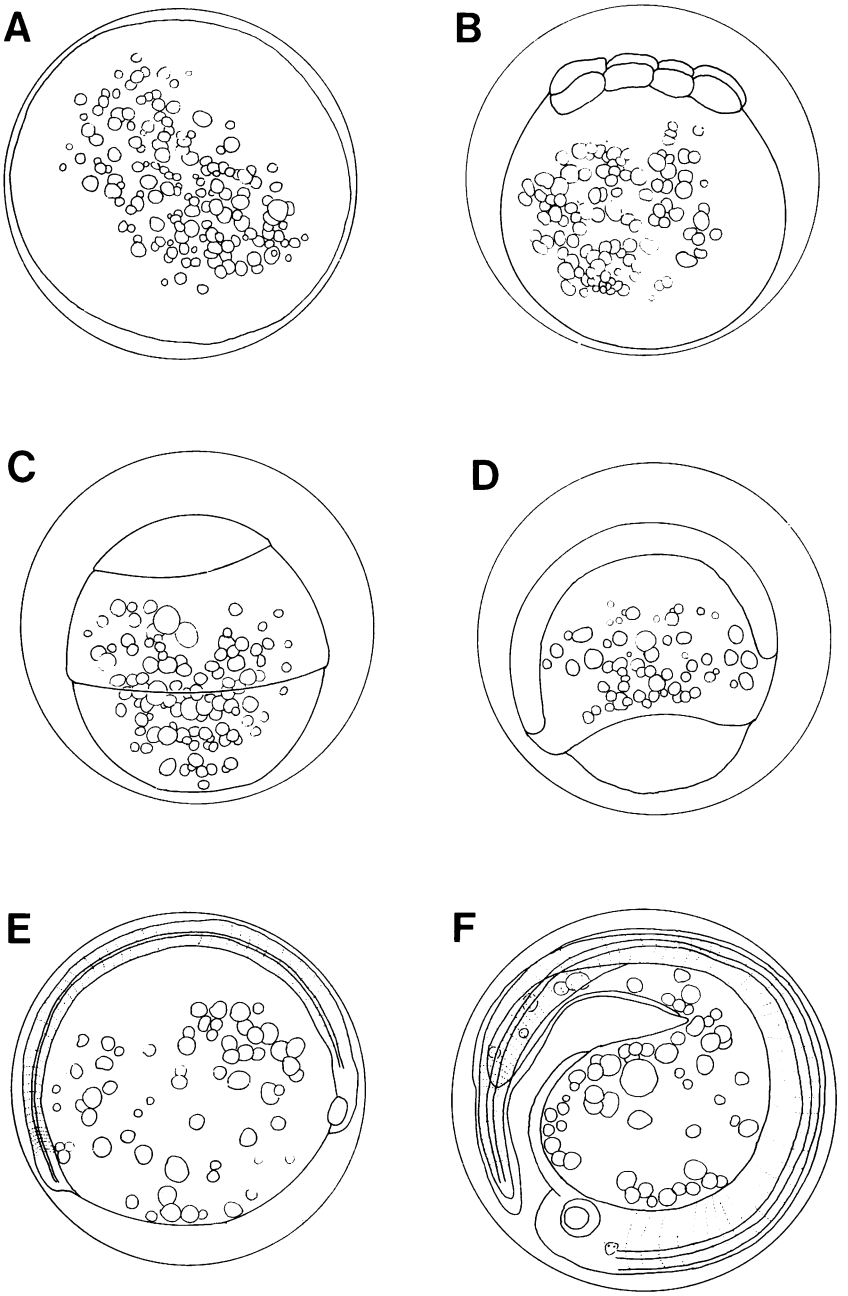

Fig. 1. Development of eggs of *Muraenesox cinereus*. A, fertilized egg newly spawned; B, 8-cell stage; C, middle stage of gastrula; D, early stage of embryonic body formation; E, stage of vesicle formation; F, tail free stage (after pulsation commencement).

(Fig. 2A). A large yolk containing numerous oil globules was observed. The mouth was undeveloped. The eye lens were completely formed without melanophore deposition. The pectoral fins were undeveloped. The gut was only recognized along the dorso-anterior one-third of the yolk sac. The larvae swam sporadically in a horizontal position and rested suspended in a head-up posture.

Larvae 1 day after hatching were 6.5 mm TL with 94 myomeres. The yolk sac decreased in height but oil globules of various sizes were still numerous (Fig. 2B). The head had increased in size as the brain differentiated. The anterior part of the yolk was positioned over the posterior of the mouth. The gut became longer. Small gills were clearly recognized. The larvae swam against physical irritation such as a weak water flow.

Two-day-old larvae were 8.5 mm TL, with 80+62=142 myomeres (Fig. 2C). The pectoral fins were still not observed. The yolk was further absorbed and became elongate, lying below the gut. Oil globules had decreased in size and number. The mouth was open and teeth anlagen had appeared in the lower jaw. Black pigments were recognized for the first time at seven sites, five along the gut, and two along the tail including one at the tip.

Three-day-old larvae were 9.1 mm TL, with 78+69=147 myomeres (Fig. 2D). The yolk was divided into three parts and oil globules had drastically decreased in number. Both the upper and lower jaws were further developed, and the teeth anlagen had differentiated into sharp teeth on the upper jaw, which were gradually elongate. Eye pigment was completely deposited. Seven pigmental spots were clearly recognized along the gut. Hepatic anlagen were observed for the first time in the anterior one-fourth of the intestine, 3–4 days after hatching.

Five-day-old larvae were 9.8 mm TL, with 87+66=153 myomeres (Fig. 2E). The yolk was barely recognizable, occurring as three minute blocks. A single oil globule was recognized below the pectoral fin. Four pairs of sharp teeth protruded obliquely from the upper jaw. The teeth anlagen in the lower jaw were differentiated into sharp teeth. Larvae began to swim actively.

Eight days after hatching, 9.0–10.0 mm TL, the anus was open, the yolk had been completely absorbed and the oil globules disappeared. The hepatic structure appeared in the anterior one-third of the intestine. The intestine posterior to the hepatic structure was about 3 times higher than the anterior part. On the ninth day, TL and myomeres were 10.4 mm and 88+65=153, respectively (Fig. 2E). The upper jaw had three pairs of teeth in addition to the pair of longest and sharp teeth at the snout tip, while the lower jaw had four pairs of teeth.

Larvae survived for 10 days at 25℃, reaching 11.2 mm TL with 97+55=152 in myomeres. At 22℃,

Table 1. Egg and larval development of *Muraenesox cinereus*.

Time after fertilization (h)	Stage	External features (Figure number)
0.3	Fertilized egg	Perivitelline space and blastodisc are formed. (Fig. 1A)
1.2	Early cleavage	Typical discoidal cleavage. First cleavage.
1.8		Third cleavage (Fig. 1B)
3.0	Late cleavage of the blastodisc	Blastodisc consists of approximately blastomeres.
6.0	Blastula	Each blastomere becomes undiscernible to the naked eye, and blastocoel becomes larger.
11.8	Gastrula	Invagination occurs at one end of the blastoderm. (Fig. 1C)
14.0	Embryonic body formation	Blastoderm covers 1/3 of yolk.
15.0		Embryonic body becomes clear. (Fig. 1D) Three or four somites are recognized.
16.0	Blastopore-closing stage	Blastopore begins to close. About 14 somites are visible. Head becomes differentiated.
28.0	Eye vesicle and ear vesicle formation	Eye vesicle and ear vesicle become recognizable. 50–57 somites are discernible. (Fig. 1E) Tail begins to be elevated from yolk. Eye balls are formed.
30.0	Heart pulsation commencement	Body covers whole yolk circumference. Heart commences pulsation. About 65 somites are visible.
35.0		Embryo begins to move. Membranous fin is well developed. 76–77 somites are recognized. (Fig. 1F)
36.0	Hatching	Hatching is initiated. About 86 somites are counted. Larvae just after hatching have a large yolk sac containing numerous oil globules. Total length is about 5.8 mm. (Fig. 2A)

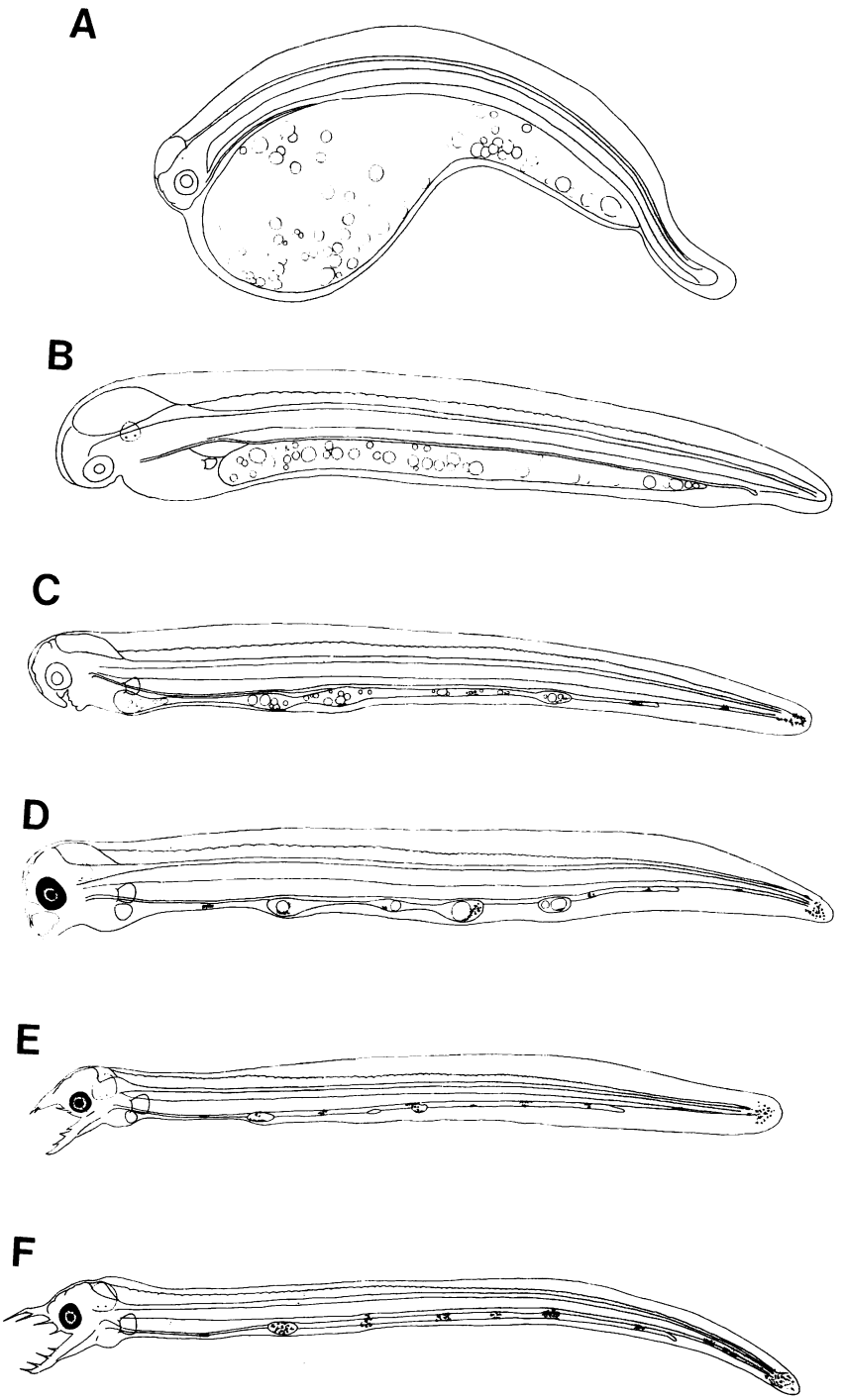

Fig. 2. Development of larvae of *Muraenesox cinereus*. A, larva just after hatching, 5.0 mm TL and 86 myomeres; B, one-day-old larva, 6.5 mm TL and 22+72=94; C, two-day-old larva, 8.5 mm TL and 80+62=142; D, three-day-old larva, 9.1 mm and 78+69=147; E, five-day-old larva, 9.8 mm and 87+66=153; F, nine-day-old larva, 10.4 mm and 88+65=153.

larvae survived for 10 days and larval development was almost the same as that for 25℃. The survival periods for larvae reared at 15℃ and 30℃ were 4 and 2 days after hatching, respectively.

Discussion

In our experiment, the pike eel larvae survived for 10 days and the number of myomeres increased to more than 150, which is a diagnostic character of this species. For anguilliform fishes, no previous experiments have succeeded in obtaining advanced larvae with a full complement of myomeres.

Takai (1979) described artificially hatched pike eel larvae. In his study, hatching occurred 63 hours after fertilization, newly hatched larvae being 3.1–3.3 mm TL at 20℃ to 22℃. This TL is extremely small compared with that observed in this study. His larvae survived for only 42.8 hours after fertilization, by which time the number of myomeres had increased to 127. In a similar study on Japanese eel, *Anguilla japonica*, hatching occurred 38 hours after fertilization, and hatched larvae survived for 14 days (Yamamoto and Yamauchi, 1974; Yamauchi et al., 1976). Early development of the Japanese eel noted above differs from that of the pike eel in that the mouth opens on the third day after hatching and the oil globules remain distinct until the 12th day, near the cranial end of the yolk sac. The most remarkable difference in early stages between the Japanese eel and pike eel is that the number of oil globule is one in the former but numerous in the latter.

Larval pike eel exhibit predation characteristics such as large eyes, well-developed jaws and sharp teeth, as do Japanese eel larvae. These characters suggest that the pike eel is a strike feeder, but no larvae were observed to curl the trunk into an S-shape in this experiment. In addition, we did not notice the larvae striking at food such as rotifers, *Chlorella*, fertilized eggs of sea urchin, Protozoa and phytoplankton (Otake et al., unpublished). No food has ever been found in the gut of any anguilliform leptocephali occurring in natural waters (Moser, 1981). Hulet (1978) reported that the gut is poorly differentiated, and concluded that anguillid leptocephali absorb dissolved organic compounds through the epidermis. In general, fishes quickly learn to avoid spined prey (Dill, 1983; Morgan, 1987). The sharp, well-developed teeth in anguilliforms might be effective as an antipredatory character.

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自然産卵させたハモの卵および仔魚の発生

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ハモの自然受精卵を用いて，実験室内における卵および仔魚の発生を観察した．卵は直径 1.8–2.1 mm のほぼ円形の分離浮遊卵で，卵膜は無色透明，多数の油球を含む．孵化は，水温 25℃ で産卵 36 時間後から始まった．孵化仔魚の平均全長は 5.8 mm で，筋節数は 86 であった．卵黄は孵化後 8 日目で吸収され，その時の全長は 9.0–10.0 mm であった．仔魚は孵化後 10 日目まで生存し，全長は 11.2 mm，筋節数は 97＋55＝152 本で，大きな眼と非常に発達した顎を持ち，鋭い歯が両顎に認められた．

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