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Juvenile Stages and Effect of Salinity on the Survival of Larvae and Juveniles in the Striped Fingerfish, *Monodactylus sebae*

Yoshimitsu Ogasawara, Sumito Akatsu, and Yasuhiko Taki

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Abstract Laboratory-raised juveniles of *Monodactylus sebae* began to develop scales at about 10.0 mm TL. The pelvic fins were disproportionally large, but the growth of the first (longest) soft ray was completed at about 15.0 mm TL. The adult color pattern was established at about 30.0 mm TL. *Monodactylus sebae* was stenohaline during the postlarval stage, being able to adjust well to only around 25~50% sea water. The fish became euryhaline on or shortly after it reached the juvenile stage at about 9.0 mm TL about 30 days after hatching. This stage will be one of the most important turning points in the life of *M. sebae* both morphologically and physiologically.

An account of the spawning behavior and the embryonic and larval stages of *Monodactylus sebae* (Cuvier), the West African monodactylid commonly known as the striped fingerfish, has lately been published by Akatsu *et al.* (1977). They showed that neither normal sea water nor pure fresh water was favorable for the embryonic and early larval life of this species. Further to their study, we traced in the present work the course of growth of juvenile *M. sebae* and investigated the effect of salinity on the survival of the fish during the postlarval and juvenile stages.

Material and methods

The rearing experiment was carried out from November 1967 to June 1977 at the Research Laboratory of Fisheries Resources, Tokyo University of Fisheries. The breeding pairs which provided material for this study were the same fish that were used in Akatsu et al. (1977). Larvae and juveniles were kept in 8~100 *l* aquaria with 25% sea water (Cl: 4.21~5.10‰) at 24.8~27.9°C, fed with *Brachionus plicatilis*, nauplii of *Artemia salina*, *Tigriopus japonicus*, minced tubifex worm, or chopped clam meat dependent on their body size. Samples reared under these conditions were used for the description of juvenile growth and the analysis of relative growth. Measurements of body parts were made on fresh-preserved, alizarin-stained specimens with an ocular micrometer attached to a dissecting microscope for all measurements under 10.0 mm. Above that, a scale graduated to 0.5 mm and placed under the dissecting microscope was used.

Larvae and juveniles of four different stages of growth, i.e., 3-day larva (three days after hatching), 10-day larva, 30-day juvenile, and 90-day juvenile, were used for the experiment of their salinity tolerance. Examples of each stage were placed in a set of five acrylic or glass containers with the water they had lived in. The number of fish in each container and the capacity of the containers were: 100 fish, 1 *l* (3-day larva, 2.5~2.7 mm, mean 2.6 mm in total length); 50, 1 *l* (10-day larva, 2.7~3.7 mm, mean 3.0 mm in total length); 30, 30 *l* (30-day juvenile, 9.2~13.6 mm, mean 10.9 mm in total length); 10, 100 *l* (90-day juvenile, 17.5~21.0 mm, mean 19.4 mm in total length). Then examples of each stage were acclimated to five different salinities, 0, 25, 50, 75 and 100% sea water, by permitting fresh or saline water to drip gradually into the aquaria for three days. No death occurred during the period of acclimation. During the experiment the chlorinity of the water in the four sections other than 0% sea water were 4.36~5.02‰, 9.84~10.94‰, 14.60~15.79‰, and 18.34~19.87‰, respectively. The larvae and juveniles except for those used for survivorship under starvation were fed the same food as stated above. Uneaten food and waste were removed daily.

Results

Growth of juvenile. The growth of *M. sebae* during the pre- and postlarval stages was a little

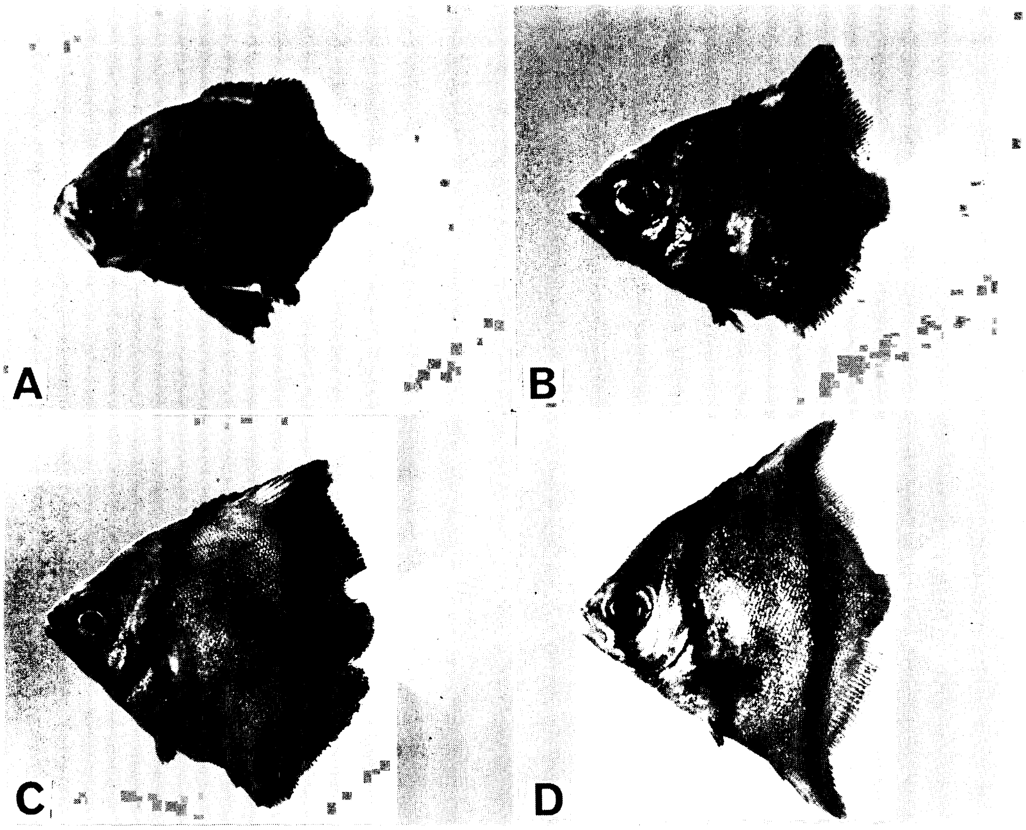

Fig. 1. Juvenile growth of *M. sebae*. A, 9.8 mm TL (ca. 30-day juvenile); B, 14.5 mm TL (ca. 50-day juvenile); C, 24.5 mm TL (ca. 90-day juvenile); D, 29.0 mm TL (ca. 120-day juvenile)

faster than in the previous study by Akatsu et al. (1977). However, individuals of the same stage of growth in the present and previous studies were not significantly different in total length (TL), and the larvae attained the juvenile stage at about 9.0 mm TL as they did in the previous study, with fully developed adult compelements of fin rays (D. VIII*, 33; A. III, 35; P. I, 5). The juveniles are described and illustrated according to size groups that exhibited major changes in morphological characters.

About 10.0 mm (TL) juveniles (30~50 days after hatching) (Fig. 1, A). The pelvic fins were disproportionally large, their length being 18.7~21.4% of TL (N=5). The length of the pelvic spine was less than half that of the first (usually longest) soft ray (Fig. 2). Ctenoid scales with a few teeth appeared in the center of the side of the body and in front of the pelvic insertion. The whole body surface and dorsal, anal and pelvic fins were densely covered with black melanophores.

About 15.0 mm juveniles (50~70 days after hatching) (Fig. 1, B). The first pelvic soft ray reached its maximum length at this stage, and then began to reduce in length. While the pelvic spine continued growing at least up to 15.0 mm TL at a growth rate much lower than in the soft ray (Fig. 2). Scales with an increased number of teeth developed all over the body save for the head and a small area around the vent. Pigmentation faded on the head remaining a dark band across the eye. The anterior portion of the dorsal fin between the sixth and eighth spines became whitish.

About 25.0 mm juveniles (80~110 days after hatching) (Fig. 1, C). The middle portion of the dorsal and anal fins began to elongate. The spine and the first soft ray in the pelvic fins were almost equal in length. The reduction in size

* Erratum for Akatsu et al. (1977): p. 212, right, 26th line; read VIII for XIII.

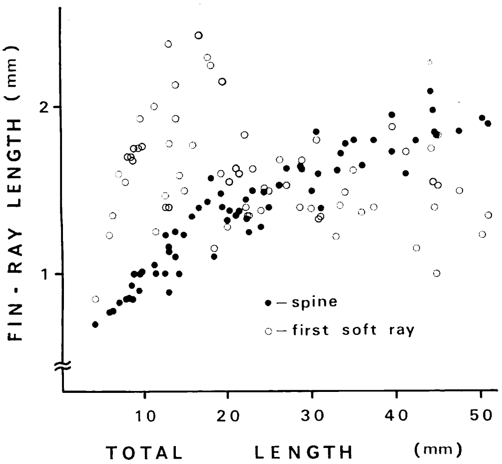

Fig. 2. Relationship between total length and the length of pelvic spine and of the first (usually longest) pelvic soft ray in larval and juvenile *M. sebae*.

of the first pelvic soft ray was completed at this stage, and the ray appeared to remain in the same length hereafter (Fig. 2). Scales covered the whole surface of the body except the head and appeared also on the basal portions of the dorsal and anal fins. The dark color of the body began to fade and a cross band on the side running from the tip of the dorsal fin to that of the anal fin became more or less distinct.

About 30.0 mm juveniles (100∼130 days after hatching) (Fig. 1, D). The dorsal and anal fins became noticeably high. The pelvic spine continued its development and became slightly longer than the first soft ray (Fig. 2). The body color turned silvery as in adult and the characteristic four cross bands became distinct.

In the laboratory the juveniles of *M. sebae* showed marked color change in response to changes in the conditions of the water and the fish themselves, darkened in darkness, in polluted water, or when they were out of health. Juveniles which were fed with *Tigriopus japonicus* had reddish color on the spinous dorsal and anal fins, on the base of the soft dorsal and anal fins, and along the hind margin of the opercle.

Effect of salinity on the survival of postlarvae and juveniles. Survivorship patterns in different salinity and dietetic conditions are described and illustrated according to growth stages.

3-day larvae, without and with feeding (Figs. 3, A, B). Survivorship patterns were essentially similar in the two different feeding conditions. Fresh water (0% sea water) had an immediate lethal effect on the larvae. They also failed to tolerate well the change from 25 to 100% sea water. In 25, 50, and 75% sea water high survival rates were maintained up to the fourth day, wherefrom death occurred abruptly in all these salinity sections when they were kept under starvation. In 75% sea water abrupt death was observed also when they were fed. In the experiment with feeding, the most successful survival pattern was seen in 25% sea water.

10-day larvae, with feeding (Fig. 3, C). In each salinity death occurred in a more or less constant percentage of the original number, and the survival rates showed a gradual reduction in the order 25–50–75–100–0% sea water. The survivorship curves appear to demonstrate that some larvae tolerated the change from 25 to 75 or 100% sea water and finally adapted to hyperosmotic environments.

In 3-day and 10-day larvae their osmoregulatory failure in fresh water was characterized by the swell of the body and eye and that in high salt concentrations (75 and 100% sea water) by the thinning of the tail part.

The larvae of *M. sebae* were observed to absorb their yolks by the third or fourth day after hatching. However, the 3-day larvae were able to live for another three or four days in 25, 50, and 75% sea water regardless of feeding condition, and their survival rates were considerably higher than those of the 10-day larvae in the same salinity levels for the first four days of the experiment. The ability of maintaining life in early postlarvae, presumably sustained by internal energy reserves and/or by some other means, may increase to some extent the ability of maintaining life in rather unfavorable osmotic environments. In the herring, *Clupea pallasi*, larvae can survive with low mortality without feeding for a certain period (Kurata, 1959).

30-day juveniles, with feeding (Fig. 3, D). The juveniles well tolerated all salinity levels here tested. Again in this stage 0% sea water resulted in the lowest survival rate, whereas all of the initial number survived in 100% sea water.

90-day juveniles, with feeding (Fig. 3, E). No death occurred up to the eighth day in all

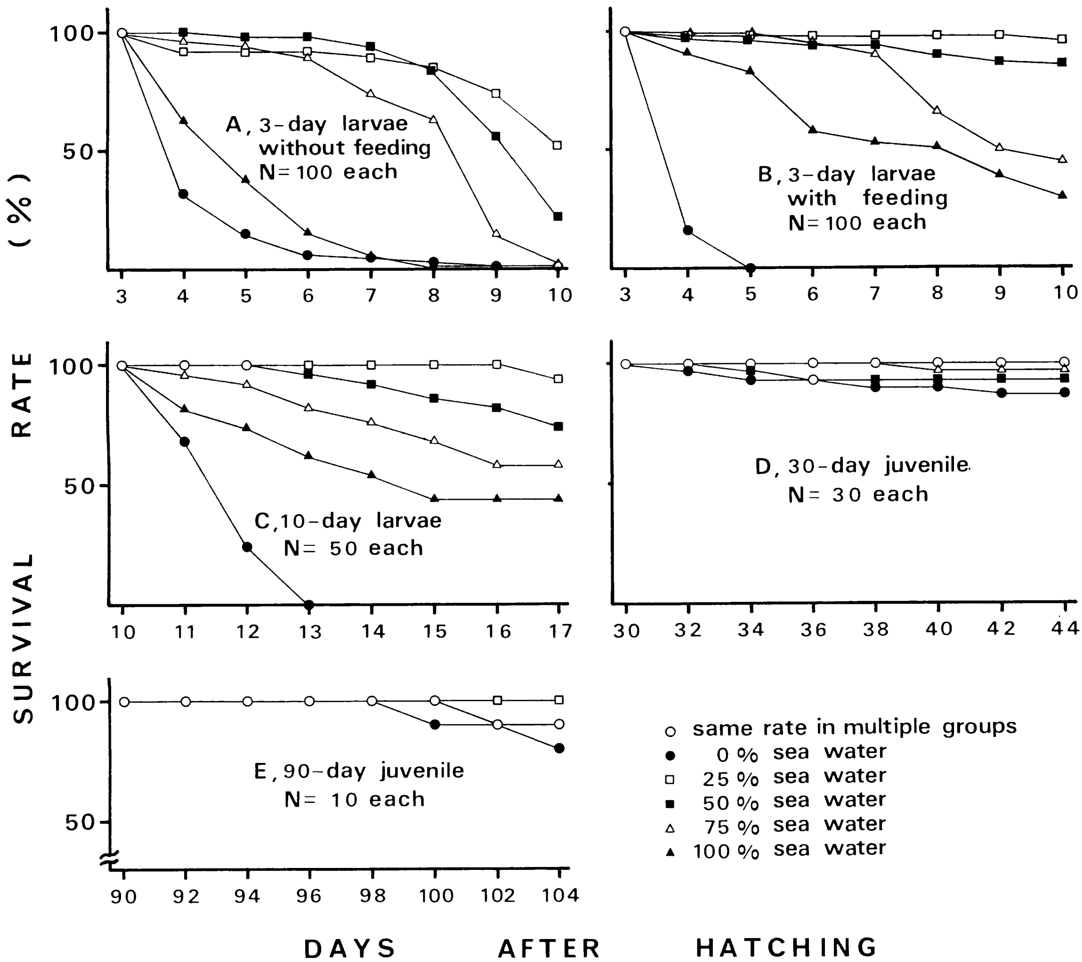

Fig. 3. Survival rates of *M. sebae* postlarvae and juveniles at different salinities. For 3-day larvae survival rates in tow different feeding conditions are shown. Data for other stages of growth are from experiment with feeding. A, 3-day larvae, without feeding; B, 3-day larvae, with feeding; C, 10-day larvae; D, 30-day juvenile; E, 90-day juvenile.

salinity levels. The juveniles appeared to be able to adjust to any salt concentrations between 0 and 100% sea water.

Discussion

On the basis of the results presented above, changes in the ability of osmoregulation in postlarval and juvenile *M. sebae* may be described as follows: 1) early postlarvae are stenohaline, being able to tolerate well a rather narrow range of salinity between about Cl: 5.0‰ (ca. 25% sea water) and about Cl: 11.0‰ (ca. 50% sea water), and are not able to survive in fresh water, 2) as they grow the ability of osmoregulation increases, likely at first toward high salt concentrations and later toward low concentrations, 3) on or shortly after entering the juvenile stage and upon attaining 9.0 to 10.0 mm TL, they become truly euryhaline, being able to adapt to all osmotic environments from pure fresh water to normal sea water.

Holliday (1963) indicates that the change in salinity tolerance in the plaice, *Pleuronectes platessa*, is a gradual process completed just after metamorphosis, when the typical adult pattern is established. Hoshiai (1977) shows that growth inflections found in several body parts of the scorpaenid *Sebastes schlegeli* coincide with the shift period from the larval to juvenile stages, and suggests that the growth inflection may reflect the completion in a way of adult physiological function.

In *M. sebae*, too, the stage (3) above is the time when the development of the adult complements of fin rays is completed and the scales begin to develop. This stage will be one of the most important turning points in the life of *M. sebae* not only morphologically but physiologically and ecologically as well.

Acknowledgments

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(Tokyo University of Fisheries, 4-5-7 Konan, Minato-ku, Tokyo 108, Japan)

西アフリカ産ヒメツバメウオ科 *Monodactylus sebae* の稚魚期と仔稚魚の塩分抵抗

小笠原　義光・赤津　澄人・多紀　保彦

Monodactylus sebae (Cuvier) の稚魚期の形態変化と仔稚魚におよぼす塩分の影響を明らかにした．腹鰭第 1 軟条長は全長約 15 mm で最大になり，その後，短縮するという顕著な変化が見られた．全長約 30 mm では親と同様の体色を呈し，4 本の横縞が明瞭になる．仔魚期は狭塩性であるが，稚魚期になると淡水および海水に対する抵抗性が増し，広塩性になる．今回の実験結果から，稚魚期には形態変化と並行して，生理・生態的な機能が多岐に分化することが伺われた．

(108 東京都港区港南 4-5-7　東京水産大学)