

Studies on the Larvae and Juveniles of the Sinistral Flounders—IV. *Arnoglossus japonicus*

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Abstract Specimens, including all stages of metamorphosis or thereabout, as well as juveniles, were collected from southern Japan and the southwestern waters of Japan. On the basis of the meristic characters they were identified as *Arnoglossus japonicus* Hubbs. The postlarvae at the early metamorphic stage have a very remarkable second dorsal spine, which is stringlike in shape, with seven branches on its posterior end. Metamorphosis in the present species occurs at rather large size, about 46 mm in standard length. Examining the developmental process of the nostril and the olfactory lamella, it is found that these organs begin to form at a considerably late developmental stage, and they are useful characters for examination of the detailed developmental stage of the postlarvae.

Introduction

Fifteen specimens of larvae and juveniles (20.0–58.9 mm in standard length) collected off southern Japan and the southwestern waters of Japan during 1954 to 1967, are at hand. They are a series of developmental stages of metamorphosis or thereabout, and also juvenile.

The postlarvae are characterized by having a remarkably elongate second dorsal spine and a short first spine, and especially by having seven branches regularly produced from the posterior membrane of the second spine. Such a larva has already been reported by Schmidt (1932) from the Indian Ocean, northeast of Madagascar, and by Uchida (1936) from the western area of Kyushu. The present postlarva is similar to Schmidt's unidentified postlarva in the number of branches and body shape, and to Uchida's postlarva, provisionally identified by him as *Psettina iijimae* (Jordan and Starks) in meristic characters and in general appearance. The present postlarvae and juveniles also seem to be closely allied to the Mediterranean species of the genus *Arnoglossus* in having an elliptical body, the posterior process of the pelvic bone not serrate, the moderate size, and the elongate second dorsal spine (Kyle, 1913). On the basis of those characters including the meristic ones, the present specimens may be identified as *Arnoglossus japonicus* Hubbs, 1915, of which the adult form is widely distributed in the southern waters of Japan. A metamorphosing

larva, briefly reported by Ochiai and Amaoka (1963) as *A. japonicus*, from off Owase, Mie Prefecture, agrees well with the present postlarvae in meristic characters and the elongate dorsal spine, and represents one stage in a developmental series of the present species.

In the present paper, the feature of metamorphosis is revealed through full descriptions and figures, and discussed on the basis of the identification to species. The function of the elongate dorsal spine and the development of the nostrils and the olfactory lamellae are also discussed herein.

Material and method

Specimens examined here are of 15 in number and collected off Owase, Mie Pref., or else in the southwestern waters of Japan ranging 24°40'~30°06'N and 126°10'~131°22'E by means of a trawl and larva net, and preserved in 10% formalin. Detailed data on the collection of the specimens are given in Table 1. They are deposited in the Department of Fisheries, Faculty of Agriculture, Kyoto University (FAKU) Kyoto, or in the Department of Aquiculture and Biology, Shimonoseki University of Fisheries (SUF) Shimonoseki.

The present specimens fall naturally into four sharply divided stages, from the early metamorphic to juvenile stages as shown by Amaoka (1970). Counts and measurements were made in accordance with the method used by Norman

Table 1. The data of collection of the larvae and juveniles of *Arnoglossus japonicus*. In column specimen registered number (No.); number of individuals in parentheses; —, unknown.

	Date	Time	Locality	Collecting depth	Device
FAKU 54-10 (1)	October, 1954	night	off Owase, Mie Pref.	—	trawl
FAKU 60-3-1 (1)	March 1, 1960	night	off Owase, Mie Pref.	—	trawl
SUF 61-6-25 (1)	June 6, 1961	—	25°47'N, 129°15'E	—	larva net
SUF 61-8-A, 61-8-D (2)	August 19, 1961	8.10~8.40	24°40'N, 126°10'E	surface	larva net
FAKU 34605~34611 (7)	December 12~14, 1961	night	off Owase, Mie Pref.	100~200m	trawl
SUF 63-7-A (1)	July 27, 1963	23.40~23.55	30°06'N, 131°01'E	surface	larva net
SUF 66-7-A (1)	July 16, 1966	20.35~21.05	28°58'N, 130°59'E	0~30m	larva net
SUF 67-8-A (1)	August 25, 1967	5.45~6.00	29°26'N, 131°22'E	—	larva net

(1934); in vertebral counts, the urostyle is counted as one.

Description

1. Early metamorphic stage (Fig. 1; 6, A~D; 7, A, B)

Six specimens, SUF No. 61-8-A, No. 61-8-D, No. 61-6-A, No. 63-7-A, No. 66-7-I, No. 67-8-A, 23.4~40.2 mm in total length, 19.8~35.9 mm in standard length. Dorsal II, 100~102; anal 78~80; pelvic 6; caudal 17; vertebrae 10+32~34=42~44.

In standard length: head 4.0~4.7; depth 2.56~3.08. In head length: snout 2.75~3.46; left eye 3.79~5.0; right eye 3.79~5.0; maxillary 3.4~4.17 on each side; lower jaw 2.5~2.88 on each side; depth of caudal peduncle 2.12~2.55; longest dorsal ray 1.36~1.71; longest anal ray 1.39~1.61; pectoral fin 2.25~3.24 on each side; pelvic fin 3.16~5.0 on left side, 3.6~7.14 on right side; base of pelvic fin 3.13~5.56 on left side, 6.55~9.17 on right side.

Body elongate, elliptical, highest near anterior 1/3 of body, its depth about as long as or more than 1/3 its length. Dorsal contour with a large projection in front of upper margin of eye, rising strongly and almost vertically from tip of snout to the projection, and then evenly and gently arching; ventral contour except for the slightly projecting pelvic bone, similar to dorsal contour. Caudal peduncle very narrow, a little narrower than 1/3 depth of body.

Head blunt, rather small, as long as or less than 1/4 length of body. Snout short, slightly longer than eye diameter. A projection supporting first short spine and second elongate spine, very large, overhanging snout, and pro-

jecting beyond tip of snout as specimen becomes smaller, its length about as long as eye diameter. Circular eye situated on each side of head, almost symmetrical, a little popped-out. Olfactory organ on each side situated in front of upper margin of eye, almost symmetrical in position and shape, varying in shape according to size of specimen. In smaller specimens (19.8~20 mm in standard length) nostrils not divided into two openings, but with an elliptical opening surrounded by a thin membrane rising from the dorsal, ventral, and anterior margins of the hollow, and without olfactory lamellae (Fig. 3 A, B); in middle-sized specimens (26.1 mm) lamellae absent, anterior nostril small, more or less tubular, posterior nostril large, not tubular (Fig. 3C); in larger specimens (30.5~35.9 mm) lamellae arranged longitudinally or somewhat radiately, increasing in number with progressing developmental stages (Fig. 3 D~F).

Mouth moderate in size, oblique and subequal on both sides, maxillary extending to below or slightly beyond anterior margin of eye; pedicel of premaxillary large, triangular, its tip extending to nearly below projection above snout. Small conical teeth on both jaws, arranged in a row; those on the upper slightly feebler than teeth of the lower, about 8 in upper and 5 in lower. Scales and lateral line not yet discernible.

Dorsal fin originating on anterior margin of projection above snout; first spine slender, tapering and very short, about half (smaller specimen) or as long as (larger specimen) eye diameter; second spine string-like, tapering, and greatly elongate, much longer than body length and about 4~6 times of head length, with a broad membrane on its posterior margin

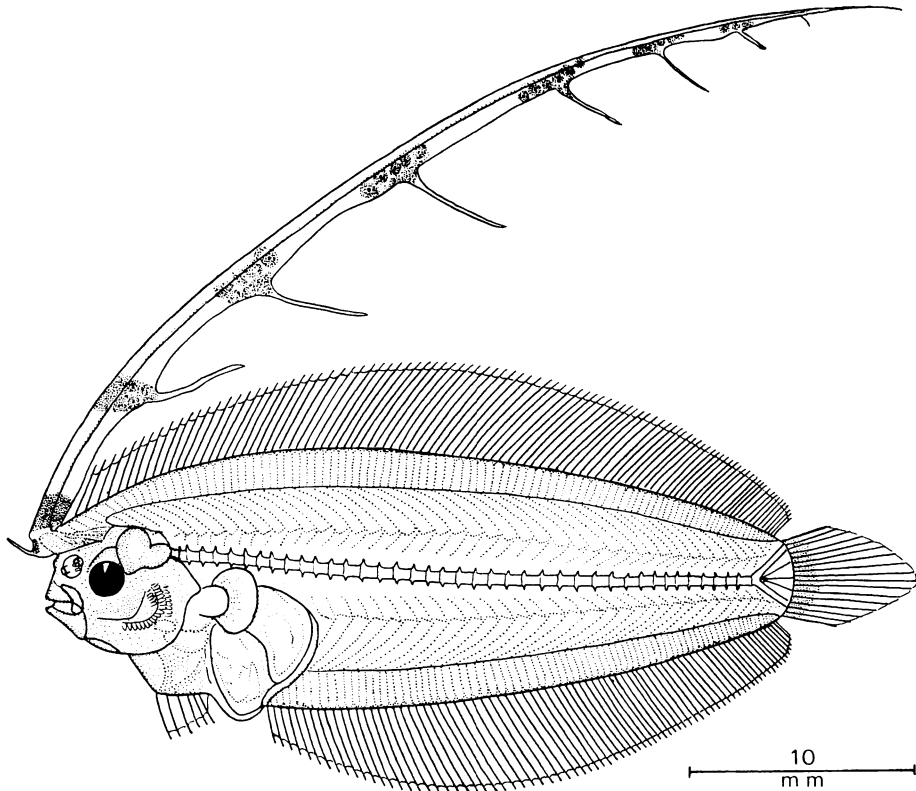


Fig. 1. Postlarva of *Arnoglossus japonicus* in early metamorphic stage, 30.5 mm in standard length, collected at 30°06'N, 131°01'E.

supporting seven membrane-like branches regularly arranged from near base to tip, the longest branch of which is about 3 times eye diameter; rays starting somewhat behind second dorsal spine, becoming highest near posterior 1/3 of body, and then shortening evenly. Anal fin originating immediately behind of anus, similar in shape and structure to rayed part of dorsal fin; origin of this fin migrating forward with growth. Pectoral fins symmetrical, fanlike, each with a heavy base surrounded by thin transparent membrane, but rays undeveloped. Pelvic fins well developed on both sides of body, asymmetrical in shape and in position, first ray on right side opposite fourth ray on left side. Pelvic fin well separated from first ray of anal fin by a protrusion of posterior process of pelvic bone surrounding liver and intestinal coil, this interspace becoming narrower as specimen grows. Caudal fin slender, rounded posteriorly, a little longer than head; some middle rays branched in larger specimens, all rays simple in

small specimens. Urohyal situated in front of anterior part of pelvic bone, bending in hook-like posteriorly, entirely smooth ventrally; this bone covered by branchiostegal membrane anteriorly, connected with upper margin of anterior part of pelvic bone by a strong membrane. Pelvic bone well developed, asymmetrical in shape, bifurcate below, its anterior process supporting six pelvic fin rays; left bone in advance of right; posterior process slender and tapering, surrounding ventral margin of liver and intestinal coil, and extending to above origin of anal fin; ventral margin of process not serrate. Liver and intestinal coil not greatly produced beyond body. Brain and digestive organ visible externally.

Color in formalin. General ground color yellowish white, with blackish eye; small dark brown spots at anterior part of produced process above snout, and dark brown rectangular blotches with small more or less inconspicuous ocelli at stem and membrane of basal region of

each of the seven branches and at base of second elongate spine.

2. Middle metamorphic stage (Figs. 2; 7, C)

One specimen, FAKU No. 60-3-1, 56 mm in total length, 46 mm in standard length. Dorsal I, 100; anal 79; pelvic 6; caudal 17; vertebrae 10+33=43.

In standard length: head 4.2; depth 2.7. In head length: snout 4.1; upper eye 4.24; lower eye 4.26; maxillary 3.42 on each side; lower jaw 2.65 on left side, 2.46 on right side; depth of caudal peduncle 2.6; longest dorsal fin ray 1.6; longest anal fin ray 1.6; pectoral fin 3.41 on each side; pelvic fin 3.8 on left side, 3.43 on right side; base of pelvic fin 3.42 on left side, 5.89 on right side.

Body elongate, elliptical, highest near middle part of body, its depth about as long as 1/3 its length. Dorsal contour with a slight notch in front of lower margin of upper eye, gently and evenly rising to middle part of body and then slowly descending to caudal base on a curve similar to that of anterior half; ventral contour nearly similar to dorsal contour. Caudal peduncle very narrow, slightly narrower than 1/4 depth of body.

Head blunt, rather small, about 1/4 length of body. Snout round and short, about as long as eye diameter. A rostral beak supporting dorsal spine becoming detached ethmoid at its base, thus forming a slit surrounding upper margin of

upper eye. Eyes rather large and ovoid in shape, left eye situated lower than in early metamorphic stage, its lower margin extending to level of snout; right eye migrating through slit above ethmoid region to a position slightly above and a little in advance of left eye. Nostrils on left side in front of interorbital space, anterior nostril tubular, posterior not tubular; olfactory lamellae well developed, radiating from a central rachis of some length, 13 in total number (Fig. 3G); those on right side almost symmetrical in position without olfactory lamellae.

Mouth oblique, maxillary extending backwards to slightly beyond anterior margin of lower eye. Teeth all small, conical and arranged in a row, about 10 in number on each side of both jaws. Scale sheath present; lateral line not yet discernible.

Dorsal fin originating on tip of rostral beak, second spine greatly elongate, tapering and bifurcate at tip, a little shorter than half body length and about 2 times head length; its posterior margin with broad membrane only at its basal region; the seven branches seen in former stage have disappeared entirely, though they may be mutilated; first short spine, located in front of elongate second spine in former stage, has disappeared in this stage. Dorsal rays originating somewhat behind dorsal spine, becoming higher near middle part of body, and

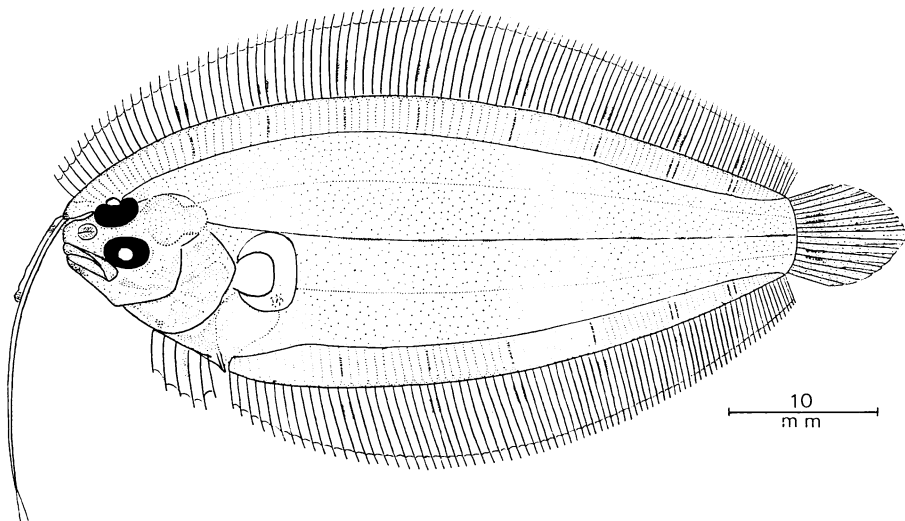


Fig. 2. Postlarva of *Arnoglossus japonicus* in middle metamorphic stage, 46.0 mm in standard length, collected off Owase.

shortening evenly in height posteriorly. Anal fin originating below base of pectoral fin, similar in shape and structure to rayed part of dorsal fin. Pectoral fins symmetrical, fanlike, similar in structure to that in early metamorphic stage, rays not yet visible. Pelvic fins well developed, closer to origin of anal fin, similar in shape and in structure to that in former stage. Caudal fin rounded posteriorly, slender, about as long as head; upper and lower three rays simple, other rays branched. Urohyal fishhook-like but covered by opercle, not visible externally. Pelvic bone bifurcate in lower region, anterior process long, supporting pelvic fin; posterior process very short, triangular, its tip extending to origin of anal fin. Liver and intestinal coil not produced beyond body.

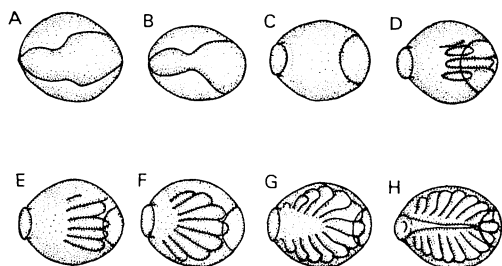


Fig. 3. Outer view of nostrils and olfactory lamellae of postlarvae and juvenile in *Arnoglossus japonicus*. A, 19.8 mm in standard length; B, 20.0 mm; C, 26.1 mm; D, 30.5 mm; E, 32.1 mm; F, 35.9 mm; G, 46.0 mm; H, 52.1 mm. A~F, early metamorphic stage; G, middle metamorphic stage; H, juvenile stage.

Color in formalin. General ground color yellowish white, with blackish eye; prominent streaks of dark dots well developed on both sides of body, 7 regularly arranged along myoseptum on midaxis of body, 8 similar streaks on dorsal margin and 6 on ventral margin, the posterior two on both margins double; other dark spots as long as or a little shorter than eye irregularly scattered on both jaws, opercular and abdominal regions; numerous reddish dots arranged along each myotome; some dark double streaks near bases of dorsal, anal, and caudal fins; a single streak on pelvic fin of left side.

3. Late metamorphic stage (Figs. 4; 7, D)

One specimen, FAKU No. 54-10-1, 55.9 mm in total length, 46.9 mm in standard length.

Dorsal I, 104 (?); anal 80; pelvic 6; caudal 17; vertebrae 10+33=43.

In standard length: head 4.75; depth 2.74. In head length: snout 4.71; upper eye 4.12; lower eye 4.2; maxillary 3.38 on each side; lower jaw 2.55 on left side, 2.5 on right side; depth of caudal peduncle 2.35; longest dorsal ray 1.67; longest anal ray 1.59; pectoral fin 3.41 on left side, 3.59 on right side; pelvic fin 3.75 on left side, 4.2 on right side; base of pelvic fin 2.63 on left side, 3.25 on right side.

Body elongate, elliptical, its depth a little more than 1/3 its length. Dorsal contour with a small projection in front of middle part of upper eye, gently and evenly arched; ventral contour similar to dorsal except for projection.

Head very small, much shorter than 1/4 length of body. Snout short, about as long as eye diameter. Anterior part of dorsal fin entirely fused to ethmoid region, and slit in front of upper eye lacking. Right eye, having finished migration, located above left eye, and separated by a narrow bony ridge; upper eye slightly in advance of lower eye. Nostrils on each side similar in shape and in structure to those in middle metamorphic stage. Olfactory lamellae radiating from a central rachis, about 15 in number.

Mouth oblique, maxillary extending to below anterior 1/3 of lower eye. Teeth small, conical, and arranged in a row, those on lower jaw a little stronger than those on upper jaw. Scale sheath present, scales and lateral line not yet discernible.

Dorsal fin originating on tip of projection in front of upper eye, spine moderately elongate, about 2/3 of head length, though it may be mutilated at tip. Dorsal rays starting somewhat behind dorsal spine. Anal fin originating immediately behind anus, similar in shape and in structure to rayed part of dorsal fin. Pectoral, pelvic, and caudal fins similar in shape and structure to those in middle metamorphic stage. Urohyal not entirely visible externally, only posterior process of pelvic bone visible externally, triangular, its tip extending to near anus. Liver and intestinal coil not visible externally.

Color in formalin. General ground color yellowish white; many prominent brownish streaks arranged on both sides of body, along three myosepta on midaxis, between epaxial

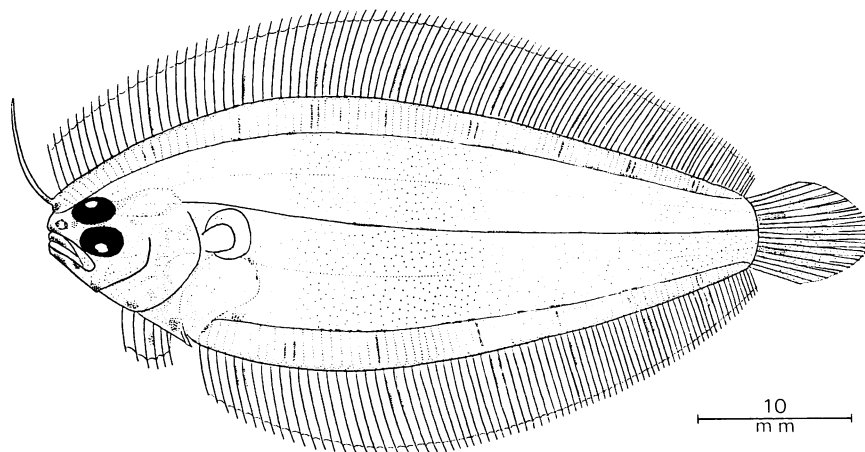


Fig. 4. Postlarva of *Arnoglossus japonicus* in late metamorphic stage, 46.9 mm in standard length, collected off Owase.

portion and dorsal interspinous region and between hypaxial portion and anal interspinous region; 8 other single and double vertical streaks on dorsal margin and 6 on ventral margin of body; other dark spots, smaller than eye, irregularly scattered on both jaws, opercular and abdominal region; dark streaks on dorsal and anal fins, these regularly arranged on basal portions of both fins above streaks on body; a pair of wide dark streaks on caudal base.

4. Juvenile stage (Figs. 5; 7, E)

Seven specimens, FAKU Nos. 34605~34611, 58.5~69.0 mm in total length, 49.9~58.9 mm in standard length. Dorsal 101~105; anal 80~83; pectoral 11~13 on left side, 10~11 on right side; pelvic 6 on each side; caudal 17; vertebrae 10+33~34=43~44.

In standard length: head 3.63~3.94; depth 2.9~3.32. In head length: snout 3.96~4.55; upper eye 3.08~3.66; lower eye 3.18~3.7; maxillary 2.35~2.73 on left side, 2.31~2.53 on right side; lower jaw 1.97~2.06 on left side, 1.76~1.86 on right side; depth of caudal peduncle 2.85~3.06; longest dorsal ray 2.04~2.22; longest anal ray 1.88~2.17; pectoral fin 1.56~1.78 on left side, 3.44~4.0 on right side; pelvic fin 2.78~3.2 on left side, 2.64~3.02 on right side; base of pelvic fin 2.64~3.2 on left side, 5.84~7.43 on right side.

· Body elliptical, highest near anterior 1/3 of body, its depth slightly more or less than 1/3 its length; dorsal contour with a deep notch in front of lower margin of upper eye, rather

gently and evenly arched; ventral contour pointed at posterior tip of lower jaw, and then gently rising to caudal base. Caudal peduncle narrow, about 1/4 depth of body.

Head blunt, heavy, and rather large, longer than 1/4 length of body. Snout strong, short, as long as eye diameter. Eyes ovoid, very large, much more than 1/4 length of head, separated by a high bony ridge, lower eye slightly in advance of upper eye or on same vertical line. Nostrils on left side closely set in front of interorbital ridge, anterior nostril tubular with a long posterior flap extending to anterior margin of posterior nostril when depressed backward; posterior nostril not tubular, without flap. Olfactory lamellae well developed, about 16~18 in number (Fig. 3H).

Mouth oblique, arched and very large, maxillary extending to below middle of lower eye. Teeth uniserial on both jaws, upper jaw armed with four to five enlarged canine-like teeth anteriorly, gradually becoming smaller and shorter backward; lower jaw with about 20 enlarged teeth, much longer than any teeth of upper jaw. Scale and lateral line developed on left side, but lateral line absent on right side.

Dorsal fin originating on right side, on a level with lower margin of upper eye; spine entirely absent. Anal fin starting below base of pectoral fin, similar in shape to dorsal fin. Pectoral fins long, asymmetrical, that on left side a little longer than 2 times that on right side; second or third ray longest, and lower rays

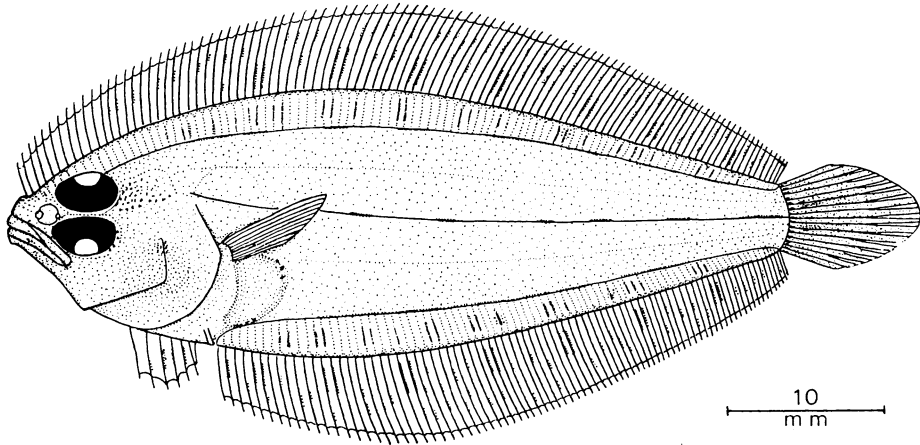


Fig. 5. Juvenile stage of *Arnoglossus japonicus*, 52.1 mm in standard length, collected off Owase.

becoming shorter downward; all rays simple. Pelvic fin on left side originating slightly behind a vertical line through posterior margin of lower eye, first ray on right side opposite fourth ray on left side; base of fin on left side wide much wider than 2 times that on right side. Caudal fin somewhat rounded, uppermost and lowermost 3 rays simple, others branched. Posterior process of pelvic bone very short, projecting nearly to origin of anal fin. Posterior half of brain, gill-lamella, and a part of digestive organ visible externally.

Color in formalin. General ground color yellowish white, numerous dark and pale brownish streaks on body arranged along horizontal myoseptum of midaxis and along myosepta on dorsal and anal interspinous regions; a series of dark brownish dots along myosepta between epaxial portion and dorsal interspinous region, and between hypaxial portion and anal interspinous region; small spots irregularly scattered on posterior half of brain, opercle, abdominal portion, and both jaws. Median fins paler than body; dorsal and anal fins with a series of somewhat regular dark spots; a pair of dark spots on base of caudal fin.

Discussion

A postlarva (30.5 mm in standard length) at the early metamorphic stage has a peculiar second dorsal spine consisting of seven branches produced from the membrane of the posterior margin of the spine. The present postlarva is quite like a larva figured by Schmidt (1932) from

the Indian Ocean, northeast of Madagascar. On the other hand, it also closely resembles in general features and in meristic characters a larva from off western Kyushu which was identified as *Psettina ijimae* (Jordan and Starks) by Uchida (1936), though he has left some questions of disagreement with the adult form of *P. ijimae* in meristic characters. Therefore, it is necessary to check the identification of the larva.

It is clear from the asymmetrical pelvic fin—the first ray on the right side originating opposite the fourth ray on the left side—that the present postlarvae and juveniles belong to the member of family Bothidae (Amaoka, 1969). In an attempt to search for adults having meristic counts similar to those of the present specimens (dorsal rays 100~105; anal rays 78~83; vertebrae $10+32\sim34=42\sim44$), the species of *Japonolaeops*, *Laeops*, *Neolaeops*, *Kamoharaia* and *Chascanopsetta* with a higher number of meristic characters, and the species of *Taeniopsetta*, *Tosarhombus*, *Crossorhombus*, *Engyprosopon*, *Bothus* and *Asterorhombus* having a lower number of the characters should be eliminated from the discussion. The species of the remaining genera, *Parabothus*, *Psettina*, and *Arnoglossus*, are similar in meristic characters to the present specimens. In the genus *Parabothus*, there are two species, *P. coarctatus* (dorsal 106~107; anal 87~95; vertebrae $10+32\sim33=42\sim43$) and *P. kiensis* (dorsal 104~113; anal 83~90; vertebrae $10+31\sim32=41\sim42$). The present larvae and juveniles agree fairly

with *P. coarctatus* in the vertebral counts, but disagree with it in having a little lower number of dorsal and anal rays; while they clearly disagree with *P. kiensis* in having a little lower number of dorsal and anal rays and a little higher number of vertebrae. In three species of the genus *Psettina*, *P. iijimae* (dorsal 81~93; anal 62~71; vertebrae 10+26~28=36~38), *P. tosana* (dorsal 89~99; anal 67~79; vertebrae 10+28~30=38~40), and *P. gigantea* (dorsal 90~103; anal 69~80; vertebrae 10+28~30=38~40), the first two species have a lower number of dorsal and anal rays and vertebrae, while the last species has a similar number of dorsal and anal rays but a lower number of vertebrae. These counts will readily eliminate the genus *Psettina* from consideration.

In the genus *Arnoglossus*, there are four species, *A. tenuis*, *A. polyspilus*, *A. japonicus*, and *A. oxyrhinchus*. Among these species, *A. tenuis* has a lower number of fin rays (dorsal 90~95; anal 70~74) and vertebrae (10+30=40), and *A. oxyrhinchus* has a higher number of fin rays (dorsal 108~113; anal 84~89) and vertebrae (11+35=46); *A. polyspilus* is similar to the present specimens in having counts of dorsal rays 100~114 and anal rays 78~91, but it has a slightly lower number of vertebrae 10+30~32=40~42. Thus, there is no difficulty in distinguishing the present larvae and juveniles from these species. The characters of

the adults of the only remaining species, *A. japonicus*, agree well with those of the present specimens (Table 2). Therefore, it is concluded clearly that the present larvae and juveniles represent *A. japonicus*. The metamorphosis of the present species begins to occur at about 46 mm in standard length, which is a rather large size among members of the family Bothidae.

The present postlarva agrees well with Schmidt's larva in body shape, shape of the second dorsal spine and of its branches, and number of branches of the second dorsal spine. As the body characters of Schmidt's larva have not been described, it could not be accurately identified. But judging from the shape of the body and the number of fin rays (dorsal 105; anal 81) on the figure, the postlarva may be considered a species of the genus *Arnoglossus*, probably closely related to *A. japonicus*. On the other hand, large one of two larvae reported by Uchida (1936) as *P. iijimae*, falling within the range of the meristic characters of *A. japonicus*, is believed to be the latter rather than the former (Table 2). In the number of branches, however, the present postlarva differs from Uchida's larva with five branches. It can be considered that the number of branches is not stable, varies considerably by the condition, since they are feeble, fine structures and easily broken, especially those on the upper part of the spine. On Uchida's figure, the upper branch and the tip of the stem

Table 2. Meristic characters of larvae, juveniles, and adults of *Arnoglossus japonicus* and of larger one of two larvae described by Uchida (1936) as *Psettina iijimae*. * in total length

Characters	Larvae and juveniles				Sources of adult characters			Uchida 1936 (larger post-larva)
	Present paper				<i>A. japonicus</i>		<i>P. iijimae</i>	
	early meta-morphic stage	middle meta-morphic stage	late meta-morphic stage	juvenile stage	Hubbs 1915	Amaoka 1969	Amaoka 1969	
Number of specimens	6	1	1	7	3	16	52	1
Standard length (mm)	20.0~35.9	45.0	45.9	43.5~59.5	41~106	110.1~144.2	50.9~85.1	32*
Dorsal rays	100~102	100	104	101~105	97~99	99~105	81~93	104
Anal rays	78~80	79	80	80~83	74~79	76~83	62~71	80
Pectoral rays (left)	—	—	—	11~13	13	13~14	11~13	—
Pectoral rays (right)	—	—	—	10~11	—	10~12	8~12	—
Vertebrae	10+32~34 =42~44	10+33 =43	10+33 =43	10+33~34 =43~44	—	10+32~33 =42~43	10+26~28 =36~38	43

of the elongate dorsal spine seem to be mutilated because the stem is dull at its tip.

A larva just metamorphosing—its right eye migrating through a slit formed above the ethmoid region, to a position just above the left eye—briefly reported by Ochiai and Amaoka (1963) as *Arnoglossus japonicus*, from off Owase, Mie Prefecture, agrees well with the present postlarvae in meristic characters and the elongate second dorsal spine, and it represents the middle metamorphic stage of the present species.

A developmental series and larvae of species in the genus *Arnoglossus* have been reported in detail long ago (Kyle, 1913). The present larvae and juveniles are closely similar to those of the five Mediterranean species described and figured by Kyle, in body shape, shape of the pelvic bone, the first short dorsal spine and the elongate second dorsal spine with broad posterior membrane, but the present larvae differ from the Mediterranean larvae in having branches along the posterior margin of the second dorsal spine. It is obscure that this is a specific

character disappeared immediately after appearing for a short period during the developmental stage, or easily mutilated for its feeble structure. But most of the present larvae retain slight traces of the branches at the lower part of the stem, though only one specimen has the seven branches complete. The branches and their number are assumed to be a specific character of the present species.

The short and elongate dorsal spines become full grown before the metamorphosis. The short spine suddenly disappears when the eye is migrating, and the elongate spine shortens at this stage, but remains after the eye is completely migrated. In the feature of disappearance of the elongate dorsal spine, the present species differs from the Mediterranean species of *Arnoglossus*, in which the spine disappears suddenly when the eye is migrating. It is said that in the Mediterranean species *A. thori* the elongate second dorsal spine of the larval stage may sometimes becomes the characteristic elongate second dorsal ray of the adults (Kyle, 1913), though not as a general rule. In the

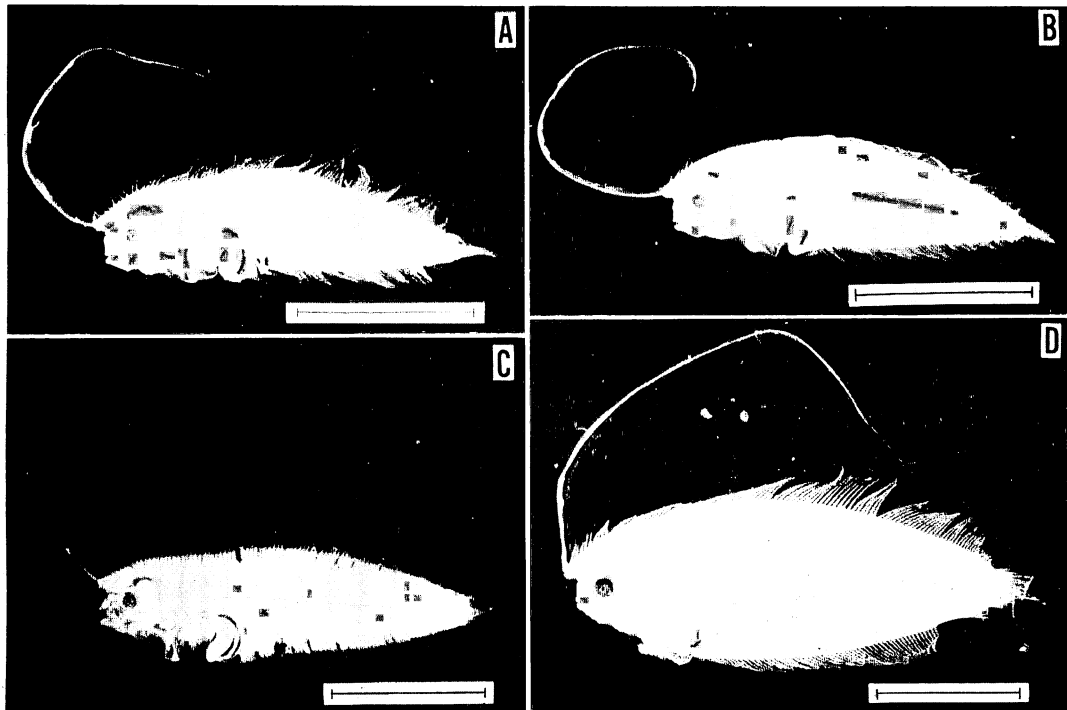


Fig. 6. Photographs of four postlarvae at early metamorphic stage in *Arnoglossus japonicus*. Scales indicate 10 mm. A, SUF 61-8-D, 19.8 mm in standard length; B, SUF 67-8-A, 20 mm in standard length; C, SUF 61-8-A, 26.1 mm, in standard length; D, SUF 63-7-A, 30.5 mm in standard length.

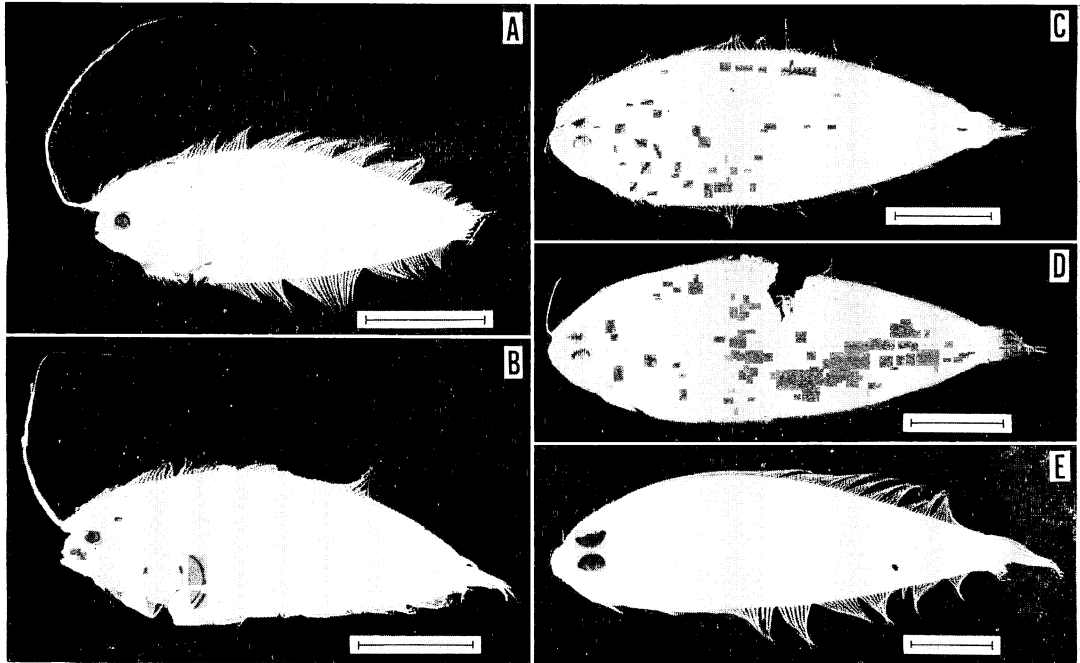


Fig. 7. Photographs of four postlarvae and one juvenile in *Arnoglossus japonicus*. Scales indicate 10 mm. A, SUF 61-6-25, in early metamorphic stage, 32.1 mm in standard length; B, SUF 66-7-A, in early metamorphic stage, 35.9 mm in standard length; C, FAKU 60-3-1, in middle metamorphic stage, 45 mm in standard length; D, FAKU 54-10, in late metamorphic stage, 46.8 mm in standard length; E, FAKU 34610, in juvenile stage, 56.4 mm in standard length.

present species, such a case was not found. The elongate spine is not a permanent organ which becomes a ray in the adult, but a temporary organ seen only in the larval stage.

Kyle has assumed that the function of the elongate second dorsal spine projecting in front of and above the head is to give notice of impending danger, and to guard against damage to the front part of the brain-case. It, however, may be thought that the spine will be more useful as a floating organ than as protection of the front part of the head: the spine is absent in the prelarval stage, and immediately after this stage it appears suddenly (Kyle, 1913); the spine is seen in bothid flounders growing to a large size during the larval stage (Bruun, 1937; Nielsen, 1963; Hubbs and Chu, 1934; Amaoka, 1971 and 1972); and it suddenly shortens or disappears, when metamorphosis is complete.

It is noteworthy to discuss the development of the nostrils and the olfactory lamellae in the present species. Apart from the stages divided by the metamorphosis, these organs also can be

used as an indicator of the developmental stage of the postlarvae and juveniles in bothid flounders. Especially, in the postlarvae at the early metamorphic stage, they are most useful for examination of more detailed developmental stage, since they show remarkable changes in order until migration of eye.

On the other hand, in the present species, the nostrils and the olfactory lamellae are closely similar to those of many other fishes already known in a developmental stage (Kleerekoper, 1969), but the present species may belong to group in which these organs are formed considerably late in the developmental stage, though this varies among fishes. The organ may be closely related to the feeding behavior at the larval stage, though it has various functions. Kleerekoper (1969) reported that while the olfactory groove is being closed, the olfactory nerve begins to make its appearance. But the olfactory organ may not fully function at this stage, at which the olfactory lamella has not sufficiently formed. In the present species, the

larva spends a floating life during a long period before metamorphosis. During this period, the olfactory organ may be unnecessary to the larva as the feeding behavior is rather passive. However, when the juveniles assume a benthic life, a well-developed olfactory organ may be necessary as the feeding behavior becomes active. It is an interesting fact that the olfactory organ develops completely at the juvenile stage, at the time of sudden growth of such organs as the mouth, teeth, and eyes, which are closely related to the feeding behavior.

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ヒラメ類の稚仔魚の研究—IV. ニホンダルマガレイ 尼岡 邦夫

1954年から1967年の間に、南日本および日本の南西海域から稚魚網と底曳網で採集された15個体のニホンダルマガレイ *Arnoglossus japonicus* Hubbsの後期仔魚(体長20.0~45.9 mm)および稚魚(43.5~59.5 mm)を調べ、成育にともなう形態変化を記述した。本種は体長約46 mmのとき眼が移動しますが、この体長はダルマガレイ科の中ではむしろ大きい方である。本種の変態期の仔魚は、吻の上部に短い背鰭第1棘とその直後にある著しく伸長したむち状の第2棘を持ち、さらにその後縁に7本に分枝した膜状物をそなえることで特徴づけられている。第1棘は変態中期に完全に消失するのに対し、第2棘は変態中期直前に最大となり、その後急激に短縮することから、後者は浮遊器官として重要な役割をはたしていると考えられる。鼻孔

と嗅器官の發育程度は変態初期の後期仔魚の發育段階を調べるのに有効な形質である。また、これらの器官は浮遊生活中の後期仔魚期では十分に発達していないが、底生生活に移る稚魚期に入って完成する。この時

期には口・歯などの摂餌器官も急激に成長する。

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