The Postlarvae of Spotted Mackerel *Scomber australasicus* CUVIER (Pisces, Scombridae)

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(Accepted December 15, 1983)

The postlarvae of *S. australasicus* were collected by larva net during 2 cruises in the seas off southern Japan and northern South China Sea (Feb.-Mar. 1973), and East China Sea (Mar. 1982). It was found that they possess distinctive dorsal melanophores just below the origin of body muscle in shoulder throughout the postlarval stage, not seen in the larvae of related species of the western North Pacific, *S. japonicus* and *R. neglectus*. The larvae from the East China Sea showed later occurrence of melanophores and smaller body proportions than those from the South China Sea.

Japanese waters comprise 2 species of the genus *Scomber*: a temperate water inhabitant *S. japonicus* HOUTTUYN (Masaba in Japanese) and a subtropical inhabitant *S. australasicus* CUVIER (Gomasaba in Japanese). Both are commercially important pelagic fishes in Japan, the catch of *S. japonicus* being much more abundant than that of the other.

Recently, *S. australasicus* showed a remarkable increase in catch and a northward extension of distribution along the coasts of Honshu.¹⁻⁷⁾ TZENG *et al.*⁸⁾ considered a relation of this change with an increase of population size in and around the East China Sea where is the main fishing ground and a spawning area of this species.

Information about the early life history will contribute to the further studies of this change. YABE⁹⁾ reported preliminarily the larvae presumably identified as *S. australasicus* for the first time. His identification was based on the variable characters such as body shape, position of anus, etc., and not on distinctive structural characters. Subsequent authors^{9,10)} could not also find decisive characters of the larvae assigned to this species.

During the cruise of R. V. Hakuho Maru (Feb.-Mar., 1973), Ocean Research Institute, University of Tokyo, many *Scomber*-like larvae were collected from the northern part of South China Sea and the Pacific Ocean off Ryūkyū Is. Since these larvae are readily discriminated by a character from *S. japonicus*, they are identified as *S. australasicus* and their development is reported.

Materials and Methods

The cruise of R. V. Hakuho Maru (KH-73-2)

was made from Feb. 20 to Mar. 27, 1973 in the Pacific Ocean off southern Japan and the northern part of South China Sea (Fig. 1). The larvae of *S. australasicus* were collected from 5 stations: one station off Ryūkyū Is. with 3 specimens (3.4-3.6 mm standard length), 4 in the South China Sea with 99 specimens (2.3-9.2 mm SL). Gear and methods of collections were not constant in this cruise (for details see Ocean Research Institute¹¹⁾). In addition, 22 specimens (3.0-8.9 mm SL; the largest being broken) were collected from 3 localities in the East China Sea during the cruise of T. S. Kagoshima Maru (KG-82-1: 15-29, March 1982), Faculty of Fisheries, Kagoshima University (Fig. 1). During this cruise, a 1.6 m diameter larval net was towed in the surface at a speed of about 2 kt for 20 min in day.

The specimens were preserved in 70% ethanol after initial preservation in 10% formalin aboard vessels. Measurements were made under a binocular microscope. Morphometric measurements (Fig. 2) are defined as follows: Standard length (SL), distance from tip of snout to tip of notochord or to posterior margin of hypural elements before or after the completion of caudal fin; Head length (HL), distance from tip of snout to posterior margin of operculum; Body height (BH), vertical distance of body at base of pectoral fin; Pre-anus length (PAL), distance along midline of body from tip of snout to a vertical from tip of anus. Larvae develop many melanophores distributing mainly in a series or an aggregated pattern. As seen in Fig. 2, symbols are used to denote them. Two larvae among the largest were cleared and stained for the count of meristics after TAYLER¹²⁾

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Fig. 1. Cruise tracks and sampling stations (circles) of the cruises of R. V. Hakuho Maru (KH-73-2) and T. S. Kagoshima Maru (KG-82-1). Closed and open circles are positive and negative stations of *Scomber australasicus*, respectively.

Fig. 2. Measurement of body proportions and distribution of melanophores.

and DINGERKUS and ULER.¹³⁾

Distinctive Character and Identification of the Larvae

Larvae of the genera *Scomber* and *Rastrelliger* show similar appearance with each other among scombrids.¹⁴⁾ Among the Indo-West Pacific species of these genera, postlarvae of *S. japonicus*^{15,16)} and *R. neglectus*¹⁷⁾ were described in detail. The present larvae are very similar in appearance to those larvae but possess distinctive dorsal

melanophores just below the origin of body muscle in shoulder throughout the postlarval stage examined (Fig. 3). In contrast, these melanophores were not described either in the larvae of *R. neglectus* or *S. japonicus*, and the present author confirmed the lack of these melanophores with many larvae of *S. japonicus* collected off Sendai, Kagoshima Prefecture, at May 1971 with larval net.

Specific identification of the present larvae followed MURAKAMI and HAYANO¹⁸⁾, MATSUI¹⁹⁾ and CHANG and LEE.²⁰⁾ The genera *Scomber* and *Rastrelliger* differ in combination of vertebrae: 14+17=31 in the western Pacific *Scomber* and 13+18=31 in *Rastrelliger*. Two western Pacific species of the genus *Scomber* have difference in numbers of first dorsal spines and of interneural bones under first dorsal: 9-10 dorsal spines and 13-15 interneural bones in *S. japonicus*, and 10-12 and 18-20 in *S. australasicus*, respectively.

The staining of bones with 2 large larvae (8.1 and 9.2 mm SL) revealed that both had 14+17 verte-

brae and the largest of them had 11 dorsal spines and 19 interneural bones (Fig. 3E'), although almost all of the bones were yet cartilaginous. Therefore, the present larvae can be identified as *S. australasicus*.

Description of Larval Development

The descriptions below are based on the specimens from the South China Sea as they are abundant in number and cover wide body length.

Before inflection of notochord (Fig. 3A), the larvae have remarkably expanded abdomen and short gut. Head and snout are short. Eyes are large, round but somewhat irregular in shape. Relatively large dorsal and ventral finfolds retreat progressively in later development. The larvae develop the following melanophores which are persistent during larval stages: about 10 and 4 stellate melanophores in groups H_2 and H_3 of occiput, respectively; many internal melanophores over peritoneum; one melanophore after isthmus and before anus (the former disappears in later stages); many punctate melanophores arranged in a line along ventral contour, over 10 in groups $A_2 + A_3$ and about 5 in groups $C_1 + C_2$. A punctate melanophore D_3 at the dorsal midline of caudal peduncle occurs only in some larvae less than 4 mm SL.

Remarkable development occurs during notochord inflection from 4 to 7 mm SL (Figs. 3B and 3C). Head becomes larger, anus moves posteriorly and dilated abdomen becomes less conspicuous. Bases of 2nd dorsal, anal and ventral fins appear. Hypurals develop under the tip of notochord and principal caudal fin rays (8+7) is completed until the end of notochord flection. The following melanophores appear during this stage, and some larvae of 5 mm size show definite larval melanophores (Table 1): groups H_1 on head, and OP_1 and OP_2 on operculum (these groups are composed of a few melanophores even in large larvae); D_1 and D_2 groups on dorsal contour (a few D_2 melanophores first and a few ones in D_1 next in appearance; through development these increase in number and distribute densely in a line). The persistent melanophore groups show the following change: A_2 melanophores on ventral contour less in number and a few foremost ones deep in muscle; C_1 and C_2 groups separate (C_1 comprises only one stellate melanophore and occurs usually either of the side of body).

Larvae after the completion of notochord flection

Fig. 3. Postlarvae of *Scomber australasicus*. A, 3.8 mm SL (KH-73-2); A', dorsal view of head of A; B, 5.1 mm SL (KG-82-1); C, 5.5 mm SL (KH-73-2); D, 7.1 mm SL (KH-73-2); E, 9.2 mm SL (KH-73-2); E', body skeletons and internal melanophores of cleared and stained E.

(Figs. 3D and 3E) have the constant body proportions (Fig. 4) and the definite larval pigmentation (Table 1). Head is lengthened to 37–42% of SL, abdominal expansion has decreased to 25–30% of SL, and anus has moved posteriorly to 60–65% of SL, though still apart from anal fin base even in the largest larva (Fig. 3E). Nostrils have 2 pores and jaws are stout. Larvae show some changes in the persistent melanophores: marked increase of H_2 group both in number and space; less conspicuous H_3 due to overlying muscle; simultaneous exchange in A_2 group from internal melanophores (now invisible) to a few external ones at about 7 mm size; only one melanophore just before anus. The larva of Fig. 3D has a light melanophore on tip of snout and a series of melanophores on mediolateral

Table 1. Occurrence (ratio in %) of melanophores during development of *S. australasicus* caught in KH-73-2 and KG-82-1 (in parenthesis). N indicates the number of specimens examined.

SL, mm	N	H ₁	OP ₁	OP ₂	D ₁	D ₂	D ₃	L
~4	7	0	0	0	0	14	28	0
~5	6	0	0	67	0	33	0	0
	8	(0)	(0)	(0)	(0)	(50)	(50)	(0)
~6	7	57	28	100	43	100	0	0
	6	(50)	(0)	(33)	(17)	(83)	(67)	(0)
~7	7	50	28	100	71	100	0	33
~8	2	100	0	100	100	100	0	50
~9	2	100	100	100	100	100	0	0
~10	2	100	100	100	100	100	0	0

Fig. 4. Changes of body proportions through early development of *Scomber australasicus*. Small black circle, samples of KH-73-2; large white circle, samples of KG-82-1.

line of caudal part, but the largest larva (Fig. 3E) lacks both melanophores and has A₂ groups only on right side of body. During this stage fin ray formation is remarkable, and in the largest larva almost all of the fin rays are formed: constant in D. (XI-12+5 fin-lets) and A. (11+5); not completed in P. (13) and V. (5). Low finfolds still remain before anal fin base and between 1st and 2nd dorsal fin bases even in this larva.

The sequence of melanophore development, fin ray formation and change of body proportions including posterior movement of anus of these larvae are fundamentally identical with those in *S. japonicus*^{15,16} and *R. neglectus*.¹⁷

Discussion

Special reference is made on the melanophores and body proportions because of their apparent difference between the larvae of KH-73-2 and KG-82-1. A few larvae caught off Ryukyu Is. in KH-73-2 have no difference from those of the South China Sea in the same cruise. Body length of the larvae of KG-82-1 is limited from 3.0 to 5.8 mm SL (the largest one, 8.9 mm SL, broken).

There is no difference in the persistent larval melanophores of H₂, H₃, A₁-A₃, C₁ and C₂ (Fig. 3B), but those appearing mainly later show difference between the cruises (Table 1). In the larvae of KH-73-2, the groups H₁, OP₁, OP₂, D₁ and D₂ appear progressively with D₂ the earliest and OP₁ the last. All larvae over 8 mm SL have the definite pattern of larval melanophores, although D₃ is peculiar to some earlier larvae and L group may be formed at smaller sizes (6 and 7 mm) than in *S. japonicus*.^{15,16} On the other hand, the larvae of KG-82-1 seem to develop melanophores, especially OP₂ group and D₃, later than those of KH-73-2.

Body proportions are shown in Fig. 4. Only 3 specimens in good condition of KG-82-1 are measured. All of them have smaller proportions of pre-anus length, body height and head length than those of KH-73-2.

The later occurrence of melanophores and smaller body proportions of the larvae of KG-82-1 seem to indicate their slower development.

The difference of early development is said to reflect broad distribution and/or racial difference of species.²¹ *S. australasicus* distributes widely in the western North and South Pacific as well as in Hawaii and off Mexico in the east,¹⁹ and is supposed to have 2 races in the western North Pacific which separate latitudinally in Taiwan.²⁰ Due to

scarcity of the specimens of KG-82-1, it is left to be examined whether the differences in larval development described above have originated from the existence of races suggested by CHANG and LEE²⁰⁾.

Acknowledgements

The author is very grateful to the officers and crew of R. V. Hakuho Maru, Ocean Research Institute, University of Tokyo, and of T. S. Kagoshima Maru, Faculty of Fisheries, Kagoshima University, for help in collection of samples, Miss M. SAITŌ, Japan NUS Co., Ltd., for sorting fish larvae from KG-82-1 samples, and Dr. M. OKIYAMA, Ocean Research Institute, University of Tokyo, for reviewing the manuscript.

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