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Larval morphology of striped bonito, *Sarda orientalis*, with comments on distinction from kawakawa, *Euthynnus affinis*

Yasuo NISHIKAWA*

Abstract

The morphologies of a developmental series of larval and juvenile specimens of striped bonito, *Sarda orientalis* are described and compared with kawakawa, *Euthynnus affinis*. Larval specimens of *S. orientalis* are characterized by present of a supraoccipital protrusion, spines on the supraorbital ridges, forebrain pigments, isthmus pigments, pelvic fin pigments, a large pigment patch on caudal fin base, and well-developed jaws and teeth. Striped bonito and kawakawa larvae closely resemble each other morphologically but can be distinguished by combinations of various external characteristics.

Introduction

Genus, *Sarda*, is represented by four species throughout the world oceans : Atlantic bonito, *S. sarda* ; eastern Pacific bonito, *S. chiliensis* ; striped bonito *S. orientalis* ; and Australian bonito, *S. australis* (COLLETTE and CHAO, 1975). Among them, only *S. orientalis* is known to occur in Japan, centering the waters around and adjacent to Kyushu. It is frequently caught there by various coastal fisheries such as set net, trolling, and small purse seine (KIKAWA *et al.*, 1963).

However, information is scarce on their early ontogeny. HARADA *et al.* (1974) artificially fertilized eggs of *S. orientalis* and reared the larvae in an aqualium. Description of the cultured larvae is too brief to provide sufficient details for comparison with other species. As for sea-caught larvae of *S. orientalis*, there are no detailed descriptions of the development, comparable descriptions exist on *S. chiliensis* (KLAWE, 1961 ; PINKAS, 1961), and *S. sarda* (DEMIR, 1961 ; COLLETTE *et al.*, 1984).

The purpose of this study is to describe and illustrate a developmental series of the larval and juvenile stages of *S. orientalis* and to define the characters useful for distinguishing them from a closely related species of *Euthynnus affinis*.

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* Far Seas Fisheries Research Laboratory, 7-1, 5-chome Orido, Shimizu 424 Japan.

Materials and methods

With the object of the enhancement of coastal high-quality fishes, such as bluefin tuna, a study project titled "Marine Ranching Program" has started in 1980 by the Agriculture, Forestry and Fisheries Research Council Secretariat. Under this program, the surveys for the distribution and abundance of larvae of the bluefin tuna were carried out in the northwestern Pacific Ocean including the Japan Sea as a pre-survey at 1979 by R/V Shoyo Maru and R/V Wakashio Maru. Larvae of tunas, billfishes, and their ralatives were collected abundantly on these surveys (FISHERIES AGENCY of JAPAN, 1979, 1980, 1981, 1982, 1983, 1985).

Larval specimen of *S. orientalis* were taken on the surveys of Marine Ranching Program from 1979 to 1984 in the said geographical areas (Fig. 1). On the other hand, Juvenile specimen of *S. orientalis* was taken from the eastern Indian Ocean by fisheries high school training vessel, Seiwa Maru.

A total of 64 specimens of *E. affinis* larvae were used for comparison with *S. orientalis*. Among them, 29 larvae ranging from 3.25 mm to 9.75 mm in standard length, were obtained from the northwestern Pacific Ocean, and 35 larvae (2.90-7.30 mm SL) were taken from the eastern Indian Ocean by R/V Shoyo Maru. Both larval and juvenile specimens of *S. orientalis* and *E. affinis* were obtained by horizontal ichthyoplankton net tows at the surface or subsurface (about 20-50 meters deep) with the 2 m or 1.4 m diameter, 0.5 mm mesh conical net.

All the samples were fixed in 10% buffered seawater formalin immediately after collection. The fish eggs and larvae were transferred into 70% ethyl alcohol after sorting in the laboratory. A total of 24 larvae and one juvenile of *S. orientalis* were examined. Methods used for counts, measurements, and division of dorsal and ventral parts of caudal fin followed Nishikawa (1985). Pigments were examined on the left side of the body. The juvenile specimen of *S. orientalis* was X-rayed to count vertebrae. Standard length (SL) was

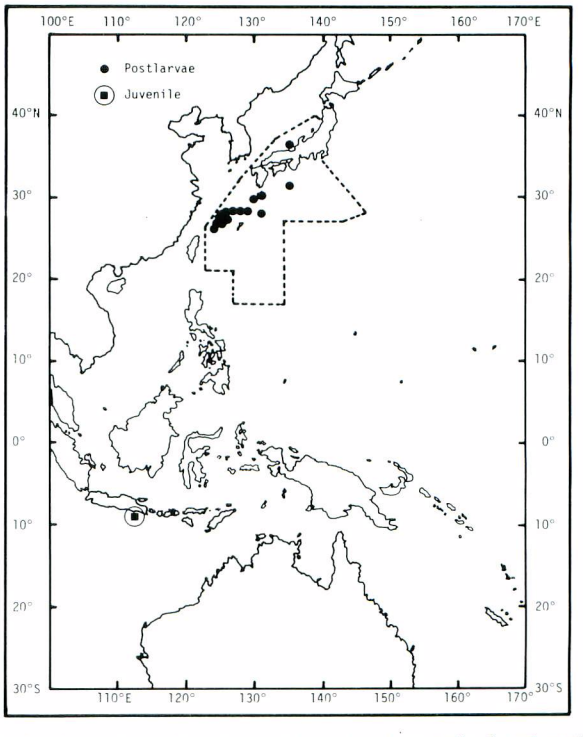

Fig. 1. Locations of capture of larval and juvenile *S. orientalis* taken by ichthyoplankton net tows. The survey area for bluefin tuna larvae under the Marine Ranching Program is surrounded by a dotted line.

used for the body length measurement.

Description of early stages

Descriptions of larval and juvenile stages are based on seven specimens selected to represent developmental stages. The morphologies of these stages are illustrated in Figs. 2 and 3. Appendix 1 gives data on capture, meristic counts, and measurements of the specimens. Morphometric data for 24 larval specimens examined are given in Appendix 2.

Morphology. The larvae of *S. orientalis* have a large head, large eyes, and large mouth. The body is somewhat deep and laterally compressed. The snout is moderately long. The abdominal cavity is compact and approximately equilaterally triangular in shape. The anus is located near the mid-point of body length in early stages, but shifts posteriorly to 2/3 of body length in the late larval and juvenile stages. The head occupies about 28% of body length in a specimen of 3.16 mm SL, and head length increases gradually to 40-50% in late larval stage (Appendix 2). The profile of head is concave anterior to eyes, and there is a slight protrusion in supraoccipital region in larval stages. This supraoccipital protrusion, however, disappears in the juvenile of 22 mm SL (Fig. 3D). Two small spines are present on posttemporal region in larvae larger than about 5 mm SL. There are two series of spines on the posterior margin of the preopercle : 1-3 on the anterior series and 1-8 on posterior one. The surface of all preopercular spines is smooth. Two small spines on the supraorbital ridges are first observed in larva of 4.7 mm SL, and increase in number to 4 with growth. The spination of head is most developed in larvae between 5 mm and 7 mm SL, and supraorbital, posttemporal, and preopercular spines remain even in the juvenile of 22 mm SL. The posterior end of maxillary reaches the posterior edge of eyes throughout larval and juvenile stages. Both upper and lower jaws are furnished with conical teeth even in a very small specimen of 3.16 mm SL (Fig. 2A). Teeth on both jaws become well developed with growth, and their number increases to 12 on upper and 11 on lower jaw in the juvenile of 22 mm SL ; those on lower jaw are slightly larger than those on upper jaw.

Rays first differentiate in anal, pectoral, and caudal fins of the 4.76 mm SL larva. The rays in the dorsal, anal, and pelvic fins increase in number with growth. The number of fin rays and spines of all fins have attained the full number of the adults in the larva of 7.50 mm SL, and both dorsal and anal finlets are clearly differentiated at this stage from caudal fin. However, the finlets in dorsal and anal fins are still connected each other by basal membrane. The juvenile of 22 mm SL has a rather deep and fusiform body and narrow caudal peduncle. The body shape is similar to that of adult fish. The number of vertebrae of juvenile of 22 mm SL is 23+21 (including urostyle).

Pigmentation. Even early larva have developed pigmentation on the body and head. Black pigments present on eyes, tip of both jaws, forebrain, midbrain, isthmus, dorsal wall of peritoneum, and ventral edge of tail including caudal fin in specimens as small as 3.16 mm SL (Fig. 2A). Conspicuous pigment spots appear on the ventral edge of tail from just behind anus to caudal peduncle. The number of pigment spots on the ventral edge of tail varies from 3 to 13. These spots

are more numerous in early stage larvae than in late stages. These pigment stots become larger in size as their number decreases. The anterior spots seem to be embeded under the skin (Table 4). The black pigments on the caudal fin may appear on dorsal and/or ventral sides : 0 or 1 on dorsal side

Table 1. Comparison of number of melanophores on ventral edge of tail and caudal fin in larvae of *S. orientalis* and *E. affinis*.

Species	Ventral edge of caudal region													Caudal fin					
	Number of melanophores													No. of melanophores					
														Ventral				Dorsal	
	1	2	3	4	5	6	7	8	9	10	11	12	13	0	1	2	3	0	1
Sarda orientalis	—	—	1	3	2	4	4	2	2	2	2	1	1	—	7	15	2	21	3
Euthynnus affinis	16	17	12	13	5	1	—	—	—	—	—	—	—	15	47	2	—	64	—

and 1-3 on ventral side (Table 1). The presence of two melanophores on the ventral side in caudal fin is typical. The larvae larger than 5.5 mm SL, pigments appear on the pelvic fins. Pigments on dorsal fin and caudal fin base first appear at 6.5 and 6.8 mm SL, respectively. The black pigments on caudal fin base increase in number with growth, forming a conspicuous patch. With further growth, black pigments form on infraorbital and postorbital regions and lateral part of lower jaw, and pigmentation spreads over the surface of peritoneum and top of head. In the juvenile of 22 mm SL, four transverse pigment bands appear on the body from nape to caudal peduncle, and the mid-lateral part of caudal peduncle is densely pigmented, forming a longitudinal pigment stripe. A conspicuous pigment patch is present on caudal fin base, and melanophores are dotted along the posterior edge of the hypurals. Black pigments are scattered on caudal fin. The anterior half or more of the first dorsal fin is heavily pigmented.

Identification

The larval and postlarval specimens examined are morphologically similar to reared larvae of *S. orientalis* described by HARADA *et al.* (1974) and characters such as melanophore patterns on the head and body are the same. These specimens are also similar to *S. chiliensis* larvae (KLAWE, 1961 ; PINKAS, 1961 ; COLLETTE *et al.*, 1984) and *S. sarda* (DEMIR, 1963 ; COLLETTE *et al.*, 1984) in the following external characteristics : the forebrain and isthmus pigments, large pigment patch on caudal fin base, dense pigments on pelvic and dorsal fins, and spines on the supraorbital ridge. The only diferrence is that the larva of 3.5 mm in total length of *Sarda* sp. described by KLAWE (1961) has black pigments just anterior to the anus, while the present larval specimens lack pigment on this part. The presence of a supraoccipital protrusion appears to be characteristic of *Sarda*, even though previous workers have not referred to it, except for COLLETTE *et al.* (1984).

All larval specimens were obtained in the Nansei Islands waters of southern Japan (Fig. 1). According to KIKAWA *et al.* (1963) and COLLETTE and CHAO (1975), only *Sarda* species that occurs in waters around Japan is *S. orientalis*.

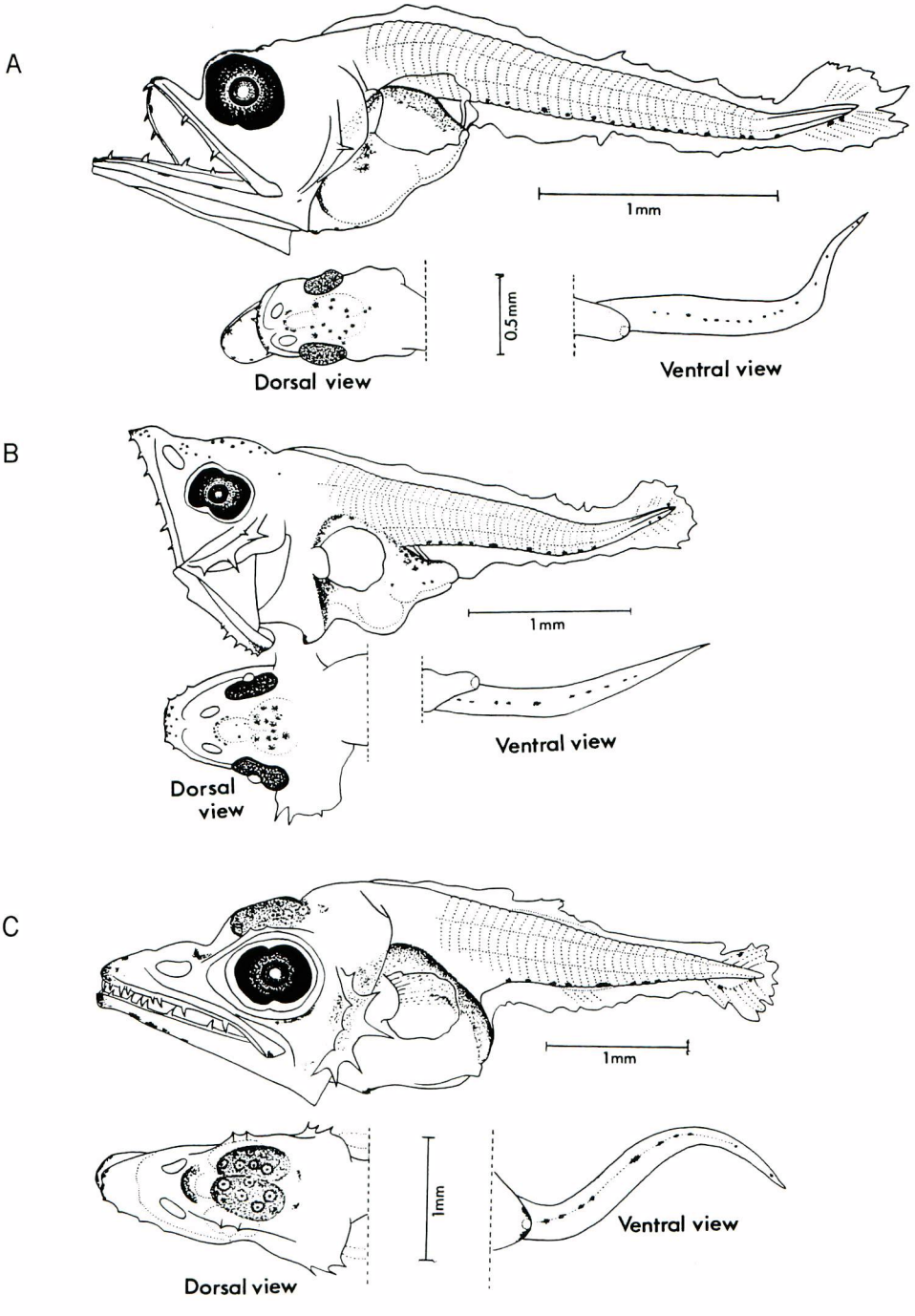

Fig. 2. Development of *S. orientalis*. A : 3.16 mm SL ; B : 3.60 mm SL ; C : 4.76 mm SL.

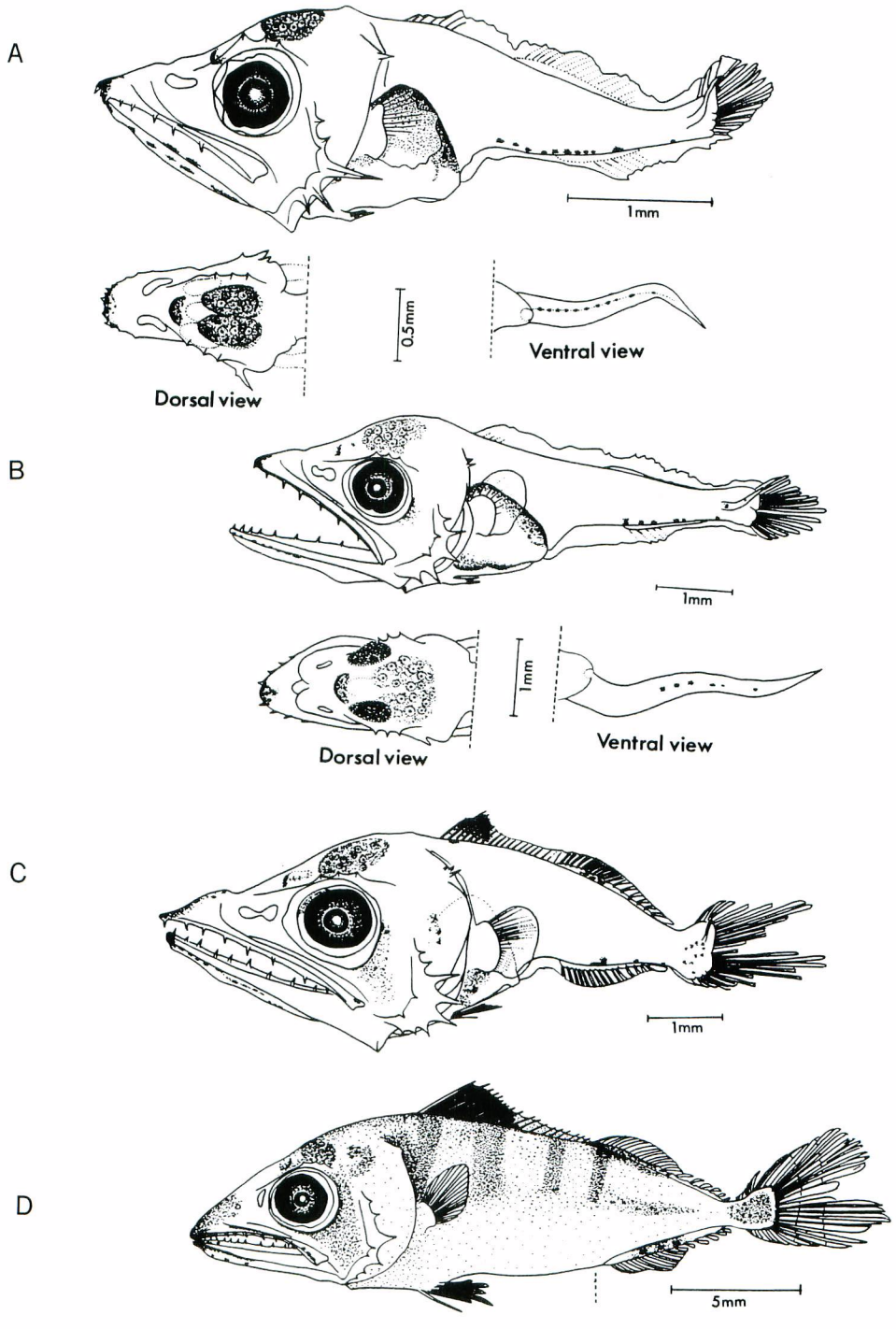

Fig. 3. Development of *S. orientalis*. A : 5.42 mm SL ; B : 6.80 mm SL ; C : 7.50 mm SL ; D : 22.17 mm SL.

The juvenile specimen has 19 dorsal spines and 15 dorsal rays, 14 anal rays, 7 dorsal and 6 anal finlets and 44 vertebrae (Appendix 1). These meristics and external features agree with those of the adults of *S. orientalis* (COLLETTE and CHAO, 1975). In waters northwest of Australia where the present juvenile specimen was obtained, only other species : leaping bonito, *Cybiosarda elegans*, is known to occur (COLLETTE and NAUEN, 1983). Although this species has almost same number of fin spines with *S. orientalis*, the number of vertebrae of *C. elegans* (47 or 48) differs from present juvenile specimen. From this evidence and locations of capture of specimens, larvae and juvenile examined were identified as *S. orientalis*.

Comparison with *Euthynnus* larvae

Larvae of *S. orientalis* resemble other scombrid larvae for their large head, large mouth, large eyes, and head spination. They resemble *Scomberomorus* larvae in the presence of a supraoccipital crest or spines and supraorbital spines (WOLLAM, 1970 ; JENKINS *et al.*, 1984). The presence of a supraoccipital crest and pigments in forebrain, isthmus and ventral edge of tail is similar to that of *Euthynnus* (MATSUMOTO, 1959 ; COLLETTE *et al.*, 1984). The presence of pigments in the forebrain and isthmus is also similar to that of *Katsuwonus* and *Auxis* (UEYANAGI and WATANABE, 1964). Larvae larger than 5-6 mm SL can be easily distinguished from all other scombrid larvae by spines on the supraorbital ridge, distinct black pigments on pelvic fins and large black pigment patch on caudal fin base. However, in very early stages, the larvae of *S. orientalis* and *E. affinis* are liable to be confused, because these larvae closely resemble each other in the presence of a protruding supraoccipital crest and black pigments on forebrain, isthmus, and ventral edge of tail. However, differences in pigmentation were found between larvae of *S. orientalis* and *E. affinis* (Tables 1 and 3). *E. affinis* larvae usually have melanophores just anterior to the anus, but *S. orientalis* larvae are completely lacking melanophores on this location. There are substantial differences between larvae of the two species in pigmentation on the ventral edge of the tail, including caudal fin (Table 1). The number of black pigment spots on the ventral edge of tail varies from 3 to 13 in *S. orientalis* and 1 to 6 in *E. affinis* larvae. However, most of *S. orientalis* (83%) have 5 or more spots on ventral edge of tail, whereas *E. affinis* larvae have 4 or less (91%) on this location. In addition, the distribution of the pigment spots on the ventral edge of the tail in *E. affinis* larvae is limited to posterior to the mid-point of anal fin base, whereas in *S. orientalis* these pigment spots extend along the entire ventral edge of tail from just posterior to the anus to caudal peduncle. Melanophore patterns on caudal fin also differ in these two species. *S. orientalis* larvae possess 2 or 3 pigments on the ventral side of the caudal fin (71%), but most of *E. affinis* larvae (73%) have one pigment on this part (Table 4). Appearance of pigments on both upper and lower jaws is earlier in *S. orientalis* (appear at 3.00-3.49 mm SL) than in *E. affinis* (appear at 4.50-4.99 mm SL). On the other hand, appearance of the dorsal fin pigments is earlier in *E. affinis* (5.00-5.49 mm SL) than in *S. orientalis* (6.50-6.99 mm SL) (Table 2). Supraorbital spines are particularly important in distinguishing *S. orientalis* from *E. affinis* in larvae larger than 4.7 mm SL (Table 3). In larvae larger than about 6 mm SL, the

Table 2. Comparison of frequency in occurrence of melanophores on upper jaw, lower jaw, and first dorsal fin in *S. orientalis* and *E. affinis* larvae. Numerals indicate number of specimens. Dotted lines show initial size at which melanophores appear in each part.

Standard length (mm)	*Sarda orientalis*						*Euthynnus affinis*					
	Upper jaw		Lower jaw		Dorsal fin		Upper jaw		Lower jaw		Dorsal fin	
	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent
2.50—2.99	—	—	—	—	—	—	0	1	0	1	0	1
3.00—3.49	1	1	2	0	0	2	0	14	5	9	0	14
3.50—3.99	2	0	2	0	0	2	0	15	9	6	0	15
4.00—4.49	—	—	—	—	—	—	0	5	2	3	0	5
4.50—4.99	3	0	3	0	0	3	1	3	3	1	0	4
5.00—5.49	3	0	3	0	0	3	2	2	4	0	3	1
5.50—5.99	4	0	4	0	0	4	1	7	8	0	7	1
6.00—6.49	4	0	4	0	0	4	3	2	5	0	5	0
6.50—6.99	3	0	3	0	1	2	3	0	3	0	3	0
7.00—7.49	—	—	—	—	—	—	1	0	1	0	1	0
7.50—7.99	—	—	—	—	—	—	1	0	1	0	1	0
8.00—8.49	—	—	—	—	—	—	1	0	1	0	1	0
8.50—8.99	—	—	—	—	—	—	—	—	—	—	—	—
9.00—9.49	—	—	—	—	—	—	—	—	—	—	—	—
9.50—9.99	—	—	—	—	—	—	2	0	2	0	2	0

Table 3. Comparison of presence of melanophores and head spines in larvae of *S. orientalis* and *E. affinis*.

	Presence of melanophores				Supraoccipital ridge	Supraorbital spines
	Forebrain	Isthmus	Pelvic fin	Front of anus		
Sarda orientalis	Present	Present	Present*	Absent	Weak	1—4
Euthynnus affinis	Present	Present	Absent	Present**	Weak	Absent

*Occur in larvae larger than about 6 mm SL

**There are some cases where this melanophore does not occur

separation of *S. orientalis* and *E. affinis* can easily be done by the presence of black pigments on pelvic fins and caudal fin bases. There are no pigments on these locations in *E. affinis* even in the juvenile stage.

Table 4. Development of melanophores on ventral edge of tail and caudal fin, and preopercular spines in larvae of *S. orientalis* and *E. affinis*.

Size class (mm in SL)	*Sarda orientalis*						*Euthynnus affinis*					
	No. of specimen	Number of melanophores			No. preoper. spine		No. of specimen	Number of melanophores			No. preoper. spine	
		Ventral edge of tail	Caudal fin		Anterior edge	Posterior edge		Ventral edge of tail	Caudal fin		Anterior edge	Posterior edge
			ventral	Dorsal					ventral	Dorsal		
2.00—2.99	—	—	—	—	—	—	1	5	1	0	1	3
3.00—3.99	4	4—13	1—3	0—1	0—2	1—3	29	1—5	0—2	0	1—2	3—5
4.00—4.99	3	8—12	2	0—1	2—3	5	9	1—6	0—1	0	2—3	4—5
5.00—5.99	7	6—11	1—3	0—1	2—3	5—6	12	1—3	0—1	0	2—3	5—7
6.00—6.99	7	5—9	1—2	0	2—3	5—8	8	1—2	0—1	0	2	6—7
7.00—7.99	3	3—4	2	0	2—3	6—8	2	1—2	0—1	0	2	7
8.00—8.99	—	—	—	—	—	—	1	2	1	0	2	7
9.00—9.99	—	—	—	—	—	—	2	1	0—1	0	2	7

Occurrence of larvae

All the larvae and juvenile described here were found within the known range of distribution of adult fish (KIKAWA *et al.*, 1963; COLLETTE and NAUEN, 1983). Larvae of *S. orientalis* were collected in May, June, and July in the Nansei Islands waters, southwestern Japan, and in August in the waters off Hyogo Prefecture of the Japan Sea. A Juvenile was caught in August in waters off southern Java. According to KISHINOUYE (1923) and HARADA *et al.* (1974), mature specimens of *S. orientalis* were caught in May and June near Oshima Island, Wakayama Prefecture, southwestern Japan and two juveniles of 17 and 23 cm of total length were caught in coastal waters of Wakayama and Aomori Prefectures (southwestern and northeastern Japan) in April and September, respectively. These findings indicate that *S. orientalis* probably spawn from spring through summer to autumn at least around Japanese waters. Spawning of *S. orientalis* appears to occur in shallow waters near large islands. The larvae were found to be concentrated in continental slope waters of the Eastern China Sea, mostly to the north and west of the Nansei Islands and not in other parts of the survey area which extends pelagic seas much farther to the south and east (Fig. 1).

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References

COLLETTE, B.B. and L.N. CHAO 1975 : Systematics and morphology of the bonito (*Sarda*) and their relatives (Scombridae, Sardini). *Fish. Bull.*, **73** (3) : 516-624.

COLLETTE, B.B. and C.E. NAUEN 1983 : FAO species catalogue, Vol. 2, Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. *FAO Fish. Symp.*, **2** (125) : 1-137.

COLLETTE, B.B., T. POTTHOFF, W.J. RICHARDS, S. UEYANAGI, J.L. RUSSO and Y. NISHIKAWA 1984 : Scombroidei : development and relationship. In Ontogeny and systematics of fishes. *Ame. Soc. Ichthyol. Helpetol., Spe. Pub., Number* 1 : 591-620.

DEMIR, M. 1961 : Synopsis of biological data on bonito *Sarda sarda* (BLOCH) 1973. *FAO Fish. Rep.*, **23** (6) : 102-129.

FISHERIES AGENCY of JAPAN 1979 : Report on 1979 research cruise of the R/V Shoyo Maru. 74pp., Research Division, Fisheries Agency of Japan, Tokyo (in Japanese).

——————— 1980 : Report on 1980 research cruise of the R/V Shoyo Maru. 50pp., Research Division, Fisheries Agency of Japan, Tokyo (in Japanese).

——————— 1981 : Report of the 1981 R/V Shoyo Maru cruise. 37pp., Researh Division, Fisheries Agency of Japan, Tokyo (in Japanese).

——————— 1982 : Report of the 1982 R/V Shoyo Maru cruise. 42pp., Research Division, Fisheries Agency of Japan, Tokyo (in Japanese).

——————— 1983 : Report of the 1983 R/V Shoyo Maru cruise. 55pp., Research Division, Fisheries Agency of Japan, Tokyo (in Japanese).

——————— 1985 : Report on 1984 R/V Shoyo Maru first cruise. 77pp., Research Division, Fisheries Agency of Japan, Tokyo (in Japanese).

HARADA, T., O. MURATA and S. MIYASHITA 1974 : On the artificial fertilization and rearing of larvae in bonito. *Mem. Fac. Agri. Kinki Univ.*, (7) : 1-4. 2 pls (in Japanese).

JENKINS, G.P., N.E. MILWARD and R.F. HARTWICK 1984 : Identification and description of larvae Spanish mackerels, genus *Scomberomorus* (Teleostei : Scombridae), in shelf waters of the Great Barrier Reef. *Aust. J. Mar. Freshw. Res.*, **35** : 341-353.

KIKAWA, S. and Staff 1963 : Synopsis of biological data on bonito *Sarda orientalis* TEMMINCK and SCHELEGEL, 1842. *FAO Fish. Rep.*, **2** (6) : 147-156.

KISHINOUYE, K. 1923 : Contributions to the comparative study of the so-called scombroid fishes. *J. Coll. Agr. Imp. Univ. Tokyo,* 8 : 293-475.

KLAWE, W.L. 1961 : Notes on larvae, juveniles and spawning of bonito (*Sarda*) from the eastern Pacific Ocean. *Pac. Sci.*, **15** (4) : 487-493.

MATSUMOTO, W.M. 1959 : Descriptions of *Euthynnus* and *Auxis* larvae from the Pacific and

Atlantic oceans and adjacent seas. *Dana Rep.*, (50) : 1-34.

NISHIKAWA, Y. 1985 : Identification for larvae of three species of genus *Thunnus* by melanophore patterns. *Bull. Far Seas Fish. Res. Lab.*, (22) : 119-129 (in Japanese).

PINKAS, L. 1961 : Descriptions of postlarval and juveniles bonito from the eastern Pacific Ocean. *Calif. Fish Game, Fish. Bull.*, **47** : 175-188.

UEYANAGI, S. and H. WATANABE 1964 : Identification of tunas and billfishes larvae (11). Materials for tuna fisheries research council, 16pp., Nankai Regional Fisheries Research Laboratory, Kochi (in Japanese).

WOLLAM, M.B. 1970 : Description and distribution of larvae and early juveniles of king mackerel, *Scomberomorus cavalla* (CUVIER) and Spanish mackerel, *Scomberomorus maculatus* (MITCHELL) (Pisces : Scombridae) in the western North Atlantic. *Fla. Dep. Nat. Resour. Mar. Res. Lab. Tech. Ser.*, (61) : 1-35.

ハガツオ *Sarda orientalis* 仔稚魚の形態，特にスマ *Euthynnus affinis* との識別

西　川　康　夫

摘　　要

サバ科の1種であるハガツオの後期仔魚及び稚魚の形態発達について記載するとともに，形態的に酷似するスマ仔稚魚との識別形質の検討を行った。

ハガツオの仔稚魚は上後頭骨が弱く隆起すること，発育の初期から前脳部，峡部，及び上，下顎先端部に黒色素胞が発現すること，両顎歯が良く発達すること，体長約5 mm以上では眼上骨隆起縁に小棘が出現すること，体長6 mm以上では腹鰭，背鰭，及び尾鰭基底部に黒色素胞が発達することによって，サバ科の他種の幼期と識別できる。また，極めて形態の酷似するスマの仔稚魚とは，上に述べた特徴に加えて，尾部の腹縁に発現する黒色素胞の数，眼上骨隆起縁の棘の有無ならびに腹鰭，肛門直前部，及び尾鰭基底部の黒色素胞の出現の有無等の形態的特徴によって，識別が可能である。

Appendix 1. Data on capture, morphometrics and meristic counts of *S. orientalis* larvae described.

Specimens	1	2	3	4	5	6	7
Date	4 Aug. 1984	31 May 1983	3 Jun. 1982	28 May 1983	2 Jun. 1981	2 Jun 1981	20 Aug. 1969
Locality	35°55.7′N 135°34.0′E	27°10.5′N 125°38.0′E	27°13.4′N 125°38.1′E	25°32.3′N 123°59.8′E	26°44.4′N 125°11.4′E	27°14.7′N 125°38.0′E	8°44.5′S 112°57.0′E
Measurements (mm)							
Standard length	3.16	3.60	4.76	5.42	6.80	7.50	22.17
Head length	1.02	1.21	1.91	2.35	2.97	4.10	8.49
Body depth	0.84	1.12	1.49	1.75	2.35	2.75	6.50
Eye diameter	0.34	0.35	0.50	0.60	0.74	1.00	2.05
Orbit diameter	0.36	0.45	0.75	0.80	0.95	1.30	2.59
Upper jaw length	0.62	0.75	1.34	1.64	2.03	2.85	4.62
Predorsal length	1.01	1.10	1.90	2.45	2.75	3.75	8.69
Prepelvic length	—	—	—	—	2.87	3.85	8.21
Prepectoral length	1.04	1.25	1.91	2.41	2.93	4.20	8.50
Preanus length	1.40	—	2.50	3.10	4.01	4.76	14.75
Counts							
Dorsal fin	—	—	—	VI, 5	IV,	XIX, 18	XIX, 15+7
Anal fin	—	—	4	3	5	15	14+6
Pectoral fins	—	—	7	9	6	19	22
Pelvic fins	—	—	—	I, 1	I, 2	I, 5	I, 5

Appendix 2. Morphometric data for 24 *S. orientalis* larvae from the Marine Ranching Program survey area. Numerals in parentheses indicate proportion of each measurement to standard length.

Standard length (mm)	Head length (mm)	Eye diameter (mm)	Upper jaw length (mm)	Preanus length (mm)
3.16	0.90 (0.28)	0.35 (0.11)	0.62 (0.19)	1.40 (0.44)
3.30	1.17 (0.35)	0.36 (0.10)	0.75 (0.22)	1.65 (0.50)
3.50	1.20 (0.34)	0.39 (0.11)	0.76 (0.21)	1.81 (0.51)
3.60	1.21 (0.33)	0.35 (0.09)	0.75 (0.20)	—
4.50	1.75 (0.38)	0.51 (0.11)	1.27 (0.28)	2.02 (0.44)
4.71	1.85 (0.39)	0.51 (0.10)	1.26 (0.26)	—
4.76	1.91 (0.40)	0.50 (0.10)	1.34 (0.28)	2.50 (0.52)
5.15	2.26 (0.43)	0.55 (0.10)	1.57 (0.30)	3.01 (0.58)
5.31	2.30 (0.43)	0.56 (0.10)	1.60 (0.30)	2.91 (0.54)
5.42	2.35 (0.43)	0.60 (0.11)	1.64 (0.30)	3.10 (0.57)
5.50	2.41 (0.43)	0.61 (0.11)	1.50 (0.27)	3.00 (0.54)
5.75	2.59 (0.45)	0.55 (0.09)	1.92 (0.33)	—
5.90	2.60 (0.44)	0.66 (0.11)	1.70 (0.28)	3.50 (0.59)
5.90	2.62 (0.44)	0.64 (0.10)	1.73 (0.29)	3.70 (0.62)
6.00	2.76 (0.46)	0.70 (0.11)	1.92 (0.32)	3.56 (0.59)
6.01	2.74 (0.45)	0.71 (0.11)	1.95 (0.32)	3.50 (0.58)
6.05	2.84 (0.46)	0.76 (0.12)	1.97 (0.32)	3.73 (0.61)
6.25	2.91 (0.46)	0.75 (0.12)	2.10 (0.33)	3.93 (0.62)
6.61	3.05 (0.46)	0.80 (0.12)	2.17 (0.32)	4.25 (0.64)
6.80	2.97 (0.43)	0.74 (0.10)	2.03 (0.29)	4.01 (0.58)
6.87	3.48 (0.50)	0.80 (0.11)	2.21 (0.32)	4.32 (0.62)
7.40	3.60 (0.48)	0.89 (0.12)	2.49 (0.33)	4.89 (0.66)
7.50	4.10 (0.54)	1.00 (0.13)	2.85 (0.38)	4.76 (0.63)
7.89	3.95 (0.50)	0.90 (0.11)	2.63 (0.33)	4.91 (0.62)