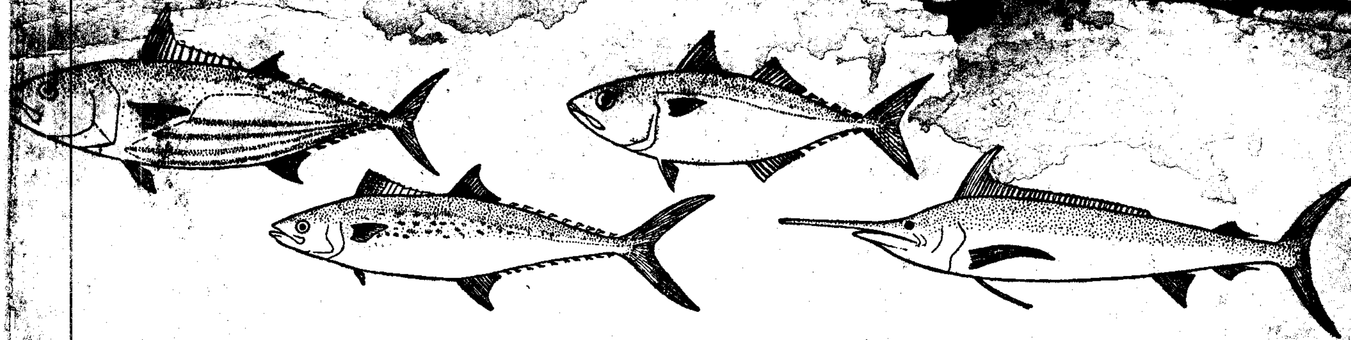


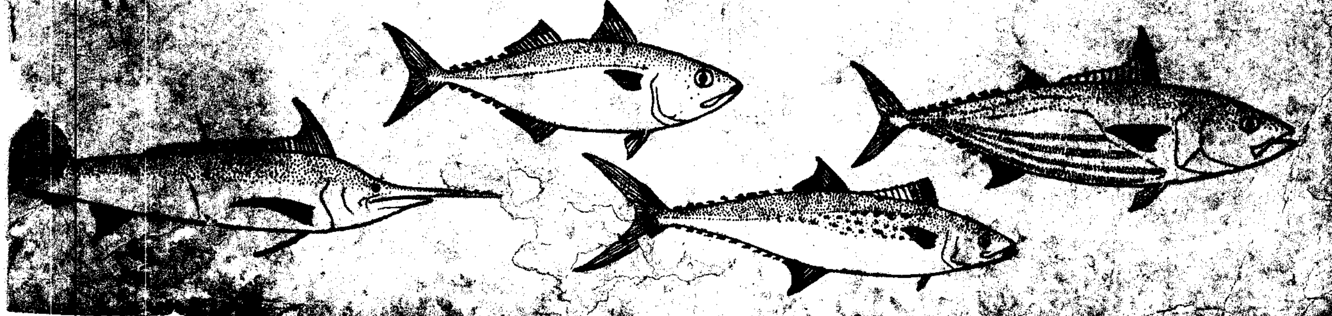
SYMPOSIUM ON SCOMBROID FISHES

PART I

MARINE BIOLOGICAL ASSOCIATION OF INDIA

MANDAPAM CAMP

S. INDIA



PROCEEDINGS OF THE

SYMPOSIUM ON SCOMBROID FISHES

HELD AT MANDAPAM CAMP FROM JAN. 12—15, 1962

PART I

SYMPOSIUM SERIES 1
MARINE BIOLOGICAL ASSOCIATION OF INDIA
MANDAPAM CAMP
S. INDIA

ASPECTS OF THE TAXONOMY AND BIOLOGY OF THE ORIENTAL BONITO *SARDA ORIENTALIS* (TEMMINCK AND SCHLEGEL)*

BY

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INTRODUCTION

Three species of *Sarda* Cuvier (1829), namely *S. sarda* (Bloch), *S. chilensis* Cuvier, and *S. orientalis* (Temminck and Schlegel) are at present recognised from the tropical and temperate waters of the world. However, as the position of the genus itself in the system is not yet well defined and as various views have been held by authors regarding the higher categories under which the genus has to be placed among the scombroids, a brief résumè is called for.

HISTORICAL RESUME

Günther (1860) did not recognise the genus *Sarda* Cuvier, but included certain species referable to it under the composite genus *Pelamys* Cuvier, which in turn was placed under Group Scombrina of family Scombridae. Jordan and Evermann (1896), Fowler (1936) and others recognised *Sarda* as a distinct genus under the family Scombridae, and Fraser-Brunner (1950) placed it under the subfamily Scombrinae of family Scombridae. Kishinouye's (1923) treatment of *Sarda* as a distinct genus under the family Cybiidae along with the genera *Acanthocybium*, *Grammatorcynus*, *Cybium*, and *Gymnosarda* has not found acceptance amongst other workers. Godsil's excellent anatomical studies of the species of *Sarda* (Godsil, 1954, 1955) shows the closer affinities of the genus to *Thunnus* than to *Katsuwonus*, but his scheme of classification placing the latter two genera under the families Thunnidae and Katsuwonidae respectively does not provide for the accommodaticn of *Sarda* under either. The question remains whether *Sarda* should be given a separate family status (Sardidae) as given by Munro (1958) or should it be placed under a subfamily Sardinae, of the family Thunnidae (Fowler, 1949) or merely as a genus of the family Thunnidae ? According to de Sylva (1955) "In view of the compact group represented by the genus *Thunnus* in relation to its closest relatives............*Euthynnus*, *Katsuwonus*, and *Sarda* the designation of the genus *Thunnus* as a separate family by certain authors seem to be osteologically untenable. The members of the family Scombridae are more closely related to each other than to any other group. *Euthynnus* and *Katsuwonus* form a natural group on one side of and close to *Thunnus* while *Sarda* forms a natural group on the other side. Examination of the skeletons of the aforementioned genera (Godsil and Byers, 1944; Kishinouye, 1923; Starks, 1910; Clothier, 1950) shows that while *Auxis*, *Euthynnus* and *Katsuwonus* stand as a compact group, above generic rank, they are closely related osteologically to *Thunnus* and to a lesser extent to *Sarda*." This would imply that it may be desirable to consider these groups of genera under the family Scombridae perhaps under different subfamilies. Excessive splitting and upgrading of different groups of scombroids to ordinal or subordinal ranks (Kishinouye, 1923; Berg, 1947) is not a desirable course and unnecessary.

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SPECIES OF *SARDA* CUVIER

The species of *Sarda* are distributed as follows: *S. sarda* in the Atlantic, Mediterranean, and Black Sea; *S. chilensis* in the Pacific (*S. c. chilensis* in E. Pacific and *S. c. australis* in east Australasian waters); and *S. orientalis* in the Indo-Pacific. While, *S. sarda* has been well studied resulting in the recognition of a single species with not much variations and the suppression of the following names to its synonymy (*Scomber pelamys* Brunnich, 1786; *Pelamis Belonii* Willugby, 1789; *Scomber sarda* Bloch, 1793; *S. mediterraneus* Bloch and Schneider, 1801; *S. pelamis* Asso, 1810; *S.ponticus* Pallas, 1811; *Thynnus sardus* Risso, 1826; *Pelamys sarda* Cuvier, 1831; *Sarda pelamys* Gill, 1862; *S.mediterranea* Jordan and Gilbert, 1883; *Pelamis sarda* Graells, 1885 ; *Sarda sarda* Dresslar and Fesler, 1889 and *Sarda pelamis* Lozano, 1919), the works of Kishinouye (1923), Godsil (1954, 1955), and others, clearly draw attention to the need for more detailed investigations on the species problem concerning the Indo-Pacific species. Briefly stated, Godsil (1954, 1955) has shown that *Sarda lineolata* (Girard, 1858) is conspecific with *S. chilensis*, and the latter along with *S.sarda* forms a group or complex—the *sarda-chilensis* complex. He has also discussed the conspecificity of *S. velox* Meek and Hildebrand (1923) to *S. orientalis*, denoting them as the *orientalis-velox* complex. The record of *S.velox* by Breder (1932) from Block Island, R. I., U.S.A., and of *S. orientalis* based on a single specimen from the Gold Coast, Africa, by Fraser-Brunner (1950) extends the distribution of the *orientalis-velox* complex to the Atlantic. However, the last said two records are subject to confirmation by the collection of fresh material from the Atlantic.

Godsil (1955) differentiated the *orientalis-velox* complex from the *sarda-chilensis* complex by four diagnostic characters, namely, the non-development of gill teeth or posterior rakers on the first arch (*versus* developed) ; the posterior U-shaped portion of the maxillary plus the auxiliary maxillary about half as wide as long (*versus* as wide as long); 2-4 gill rakers on upper limb of first arch excluding raker at angle and 8-13 total rakers (*versus* 7-10 and 20-27 respectively); and the lower jaw with about 10-15 teeth on each side (*versus* 20-25).

Six additional superficial corroboratory characters given separating the two species complexes are:

sarda-chilensis	*orientalis-velox*
Head length/maxillary length =1.86—1.93	Head length / maxillary length =2.05—2.18
Glossohyal has a short longitudinal depression on ventral face of proximal portion.	Glossohyal lacks this groove and face of bone is convex outwards.
Greatest length of auxiliary maxillary / greatest width = 3.00—3.83	Same = 4.01—4.50
Clavicle: posteriorly projecting plate expanded near midlength, and tapered distally.	*Clavicle*: posteriorly projecting plate of approximately uniform width.
Hyomandibular: spine projecting posteriorly from centre condyle slopes upwards.	*Hyomandibular*: spine projecting posteriorly from centre condyle slopes down, or at most is perpendicular to shaft of bone.
"*Vertebral column*: can be positively identified by direct comparison of ventral processes".	"*Vertebral column*: can be positively identified by direct comparison of ventral processes, but probably not without other type of comparison"

The last said character needs further elaboration which would be clear from Godsil's earlier work (Godsil, 1954) wherein he remarks about *S. lineolata* (= *S. chilensis*), and *S. velox* (= *S. orientalis*) as follows: "A subtle though constant and diagnostically valuable difference distinguishes the vertebral column of *velox* from that of *lineolata*. It concerns the minor ventral processes of the central vertebrae. In *lineolata* the inferior zygopophyses projecting ventrally at the posterior end of each vertebra are broad and blunt and point ventrally. Between them and the small spur that projects from the contiguous proximal portion of the next haemapophysis there is rarely any connection and the two are separated by an appreciable space. In *velox* these inferior zygopophyses are fine, distally pointed and they arch posteriorly so that they approximate or abut against the adjacent spur on the haemapophysis, which incidentally is more developed. While there is considerable variation in individual vertebrae, the aggregate appearance is sufficiently great to identify any and every specimen. Hence this can be considered a positive diagnostic character and a specific difference."

Undue emphasis has been given by previous workers on characters such as colour markings, and varying proportional measurements and meristic counts in describing new species of *Sarda*. Godsil (1955) has rightly drawn attention to the considerable variation in the colour pattern in the different species and its non-utility as a specific character. This we are in full agreement with, since we find variations in the colour pattern with age as well in specimens of about the same size in *S. orientalis* from Indian seas. Likewise, proportions also change with body length and can be used only when treated as regressions on body length, otherwise the proportions being valid indices only for fish of the same size. Concluding his observations on species of *Sarda*, Godsil (1955) remarks that " Superficially it appears that *chilensis* is nothing more than a geographic variation of *sarda* while *australis* (to judge by a photograph) belongs to the *orientalis-velox* complex. " Available information indicates that there is no overlap in the number of spines in the first dorsal fin in *S. sarda* and *S. chilensis*, the counts being 20–24 and 18–19 respectively. If future investigations are to show overlap in this character, then as suggested by Godsil, it will be desirable to consider *chilensis* as a geographical subspecies of *S. sarda*, but at present it is best to consider both as specifically distinct. Regarding Godsil's observation on *australis*, the gill raker counts of it given by Munro (1958), namely 6–8 + 12–14, clearly indicates that its affinities are more towards *chilensis* (gill rakers 7–10 + 1 + 11–18 = 20–27) than to the typical *orientalis* (gill rakers 2–3 + 1 + 8–10 = 11–14), and we agree with Munro in designating it as *S. chilensis australis* (Macleay).

Whitley (1945) described a subspecies, *Sarda orientalis serventyi* from S. W. Australia (type locality:Albany, Western Australia), on the grounds that *S. orientalis* has a restricted distribution along that coast and is separated from its congeners by a wide distance. In the absence of sufficient morphometric or meristic detail to support this separation, *S. o. serventyi* is considered here as an absolute synonymy of *S. orientalis*. No doubt, a disjunct pattern of distribution is seen for *S. orientalis* in the Indian Ocean (Silas, 1962) (Fig. 5) but whether this represents the real state of affairs or what amount of it is due to our inadequate knowledge of the fauna in the areas inbetween, such as British East African Coast, North East Coast of India, Laccadive-Maldive Archipelagos; Andaman Sea and Sunda Sea south of Java is to be seen. In the event that *S. orientalis* is found to exhibit slight morphometric and meristic differences, the question is whether these should be recognised as different subspecies or considered as clinal differences from area to area as would appear to be the case for some of the tunas.

On the basis of the above discussion, the following synonymies of *Sarda orientalis* (Temminck and Schlegel), 1842 are recognised. Pertinent references are also mentioned alongside.

Sarda orientalis (Temminck and Schlegel), 1842

Pelamis orientalis Temminck and Schlegel, 1842.

Pelamis orientalis Günther, 1860.

Scarda chiliensis* var. *orientalis* Steindachner and Döderlein, 1885 (**Scarda* typographic error for *Sarda*)

Pelamys chiliensis (*nec* Cuvier) Day, 1878 ; 1889.

Sarda chilensis (*partim*) Meek and Hildebrand, 1923 ;
Barnard, 1925.

Sarda velox Meek and Hildebrand, 1923 ;
Breder, 1929 ; 1932 ;
Jordan, Evermann and Clark, 1930 ;
Walford, 1937 ;
LaMonte, 1945, 1950 ;
Hildebrand, 1946 ;
Linder, 1947 ;
Schweigger, 1947 ;
Godsil, 1954, 1955 ;
Pinkas, 1961.

Sarda chiliensis (*partim*) Chabanaud, 1944.

Sarda orientalis serventyi Whitley, 1945 ; 1947.

Sarda chilensis (*nec* Cuvier) Smith, 1949.

Sarda orientalis Kishinouye, 1915 ; 1919 ; 1923 ;
Soldatov and Lindberg, 1930 ;
Fraser-Brunner, 1950 ;
Rosa, 1950 ;
Mac Innes, 1950 ;
Warfel, 1950 ;
Wheeler and Ommanney, 1953 ;
Herre, 1953 ;
Yabe *et al.*, 1953 ;
Godsil, 1954, 1955 ;
Berdegue, 1956 ;
Munro, 1958 ;
Jones, 1960 ;
Jones and Silas, 1960 ; 1962 ;
Klawe, 1961 ;
Smith, 1961 ;
Yokota *et al.*, 1961.
Silas, 1962.

TABLE I

Common and Vernacular names of *Sarda orientalis*

Country	Standard common name(s)	Vernacular name(s)
Australia (Western) ...	Oriental bonito	
India ...	Oriental bonito	Vari choora (Malayalam)
Japan ...	Hagatsu	Hagatsuwo
	Sujigatuwo	Hohzan
		Kitsunegatsuwo
		Sabagatsuwo
		Shimagatsuwo
		Sujigatsuwo
		Tohzan
Mauritius–Seychelles		Brasse-a-dents (Creole name)
Philippines	Bonito	Oriental bonito
		Skipjack (also for *Katsuwonus pelamis*)
		Gantaan
Somalia		Sinufa
Union of South Africa	Bonito	
United States of America	Bonito	

Rosa (1950) lists the following names for *S. orientalis* from Japan, these being variations of the spelling of those given in the above table : Kitsunekatsuo, Shimakatsuo, Hosan, Sabakatsuo and Sujikatsuo.

DESCRIPTION OF *S. ORIENTALIS* (TEMMINCK AND SCHLEGEL) FROM INDIAN SEAS

Body proportions :

Body proportions expressed as thousandths of total length (measured as suggested by Marr and Schaefer, 1949) for 45 specimens, 80 mm. to 497 mm. collected from Vizhingam from the Kerala Coast are given in Table II.

Fin ray counts :

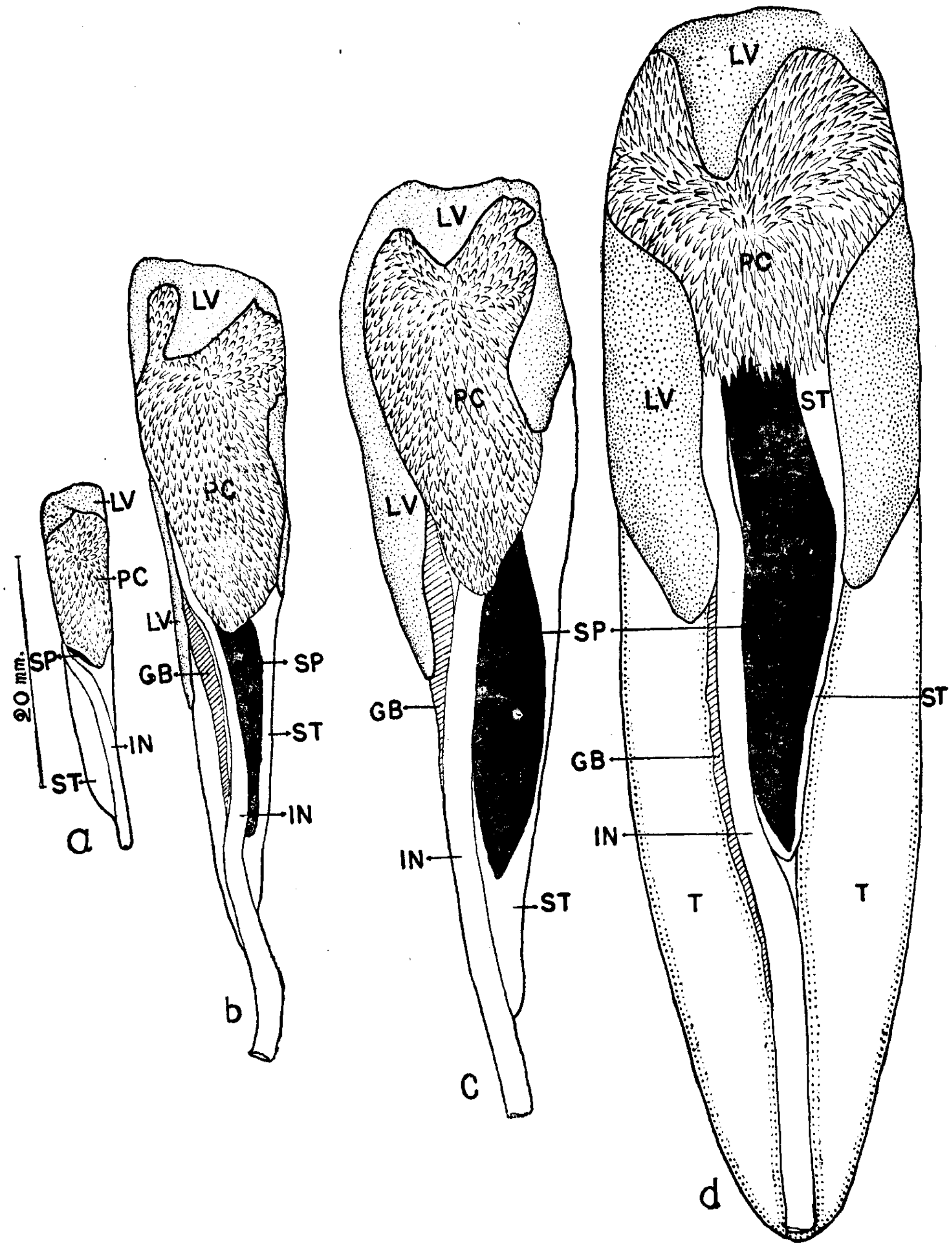
Table III gives details of fin ray counts in specimens collected at Cape Comorin, Vizhingam and Calicut.

Gill raker counts :

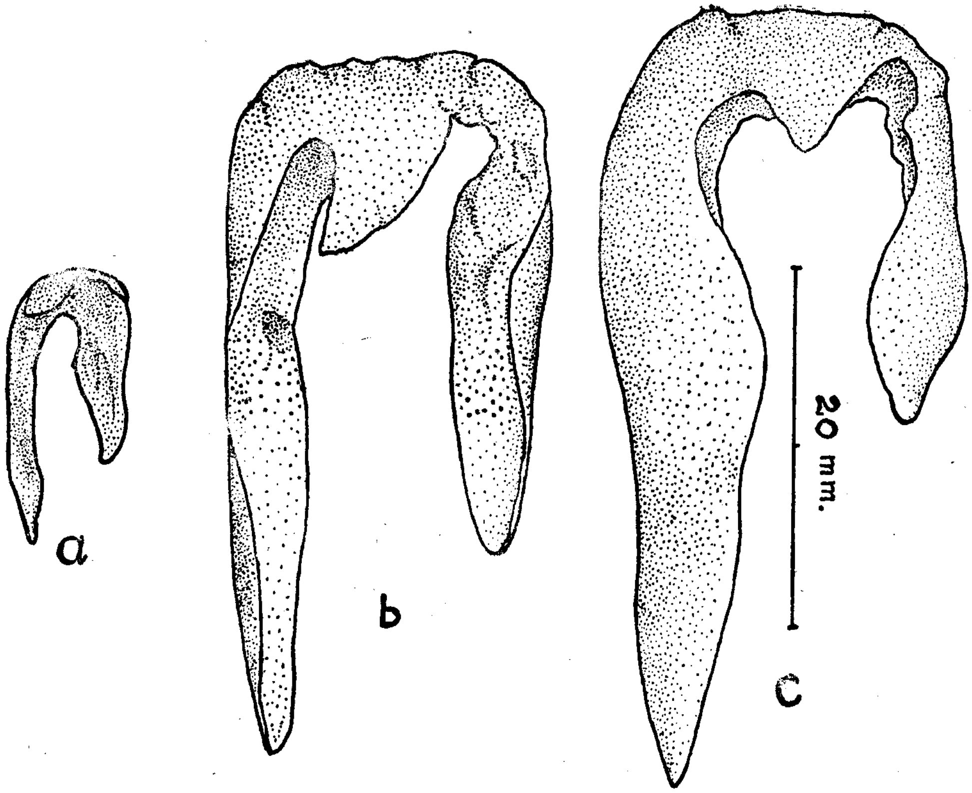
Variations in gill raker counts are indicated in Tables IV, V and VI, for specimens from Cape Comorin, Vizhingam and Calicut.

Visceral organs :

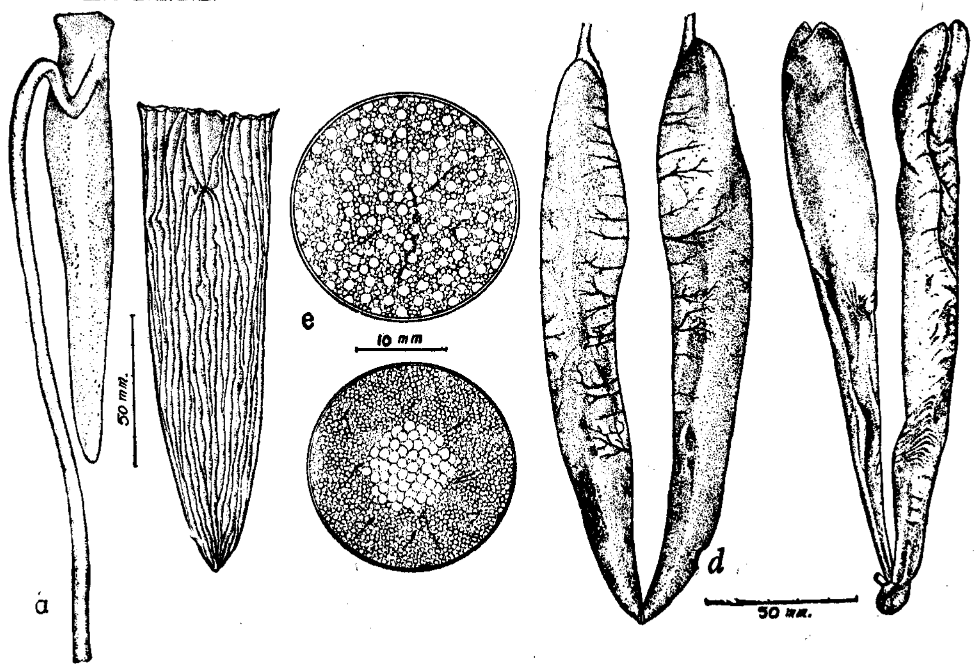
Various authors (Kishinouye, 1923 ; Godsil and Byers, 1944 ; Godsil, 1954, 1955 ; Serventy, 1941) have drawn attention to the nature and disposition of visceral organs as useful tools in taxonomic differentiation of species of scombroid fishes. In *S. orientalis*, slight differences with size may be seen as shown in the ventral views of the viscera of three specimens (Fig. 1). In an adult male 497 mm. long, but for the gall-bladder which could be clearly seen lying alongside the intestine, there is hardly any difference in the disposition of the other organs than what has been shown for an adult specimen of the typical *S. orientalis* from Japanese waters by Godsil (1955). As could be seen from figure 2, the right lobe of the liver is slightly longer than the left. In the larger specimens, with the development of the gonads, the stomach is hidden from the ventral view of the viscera *in situ*. The stomach is elongate, reaching backwards to about three-fourths the length of the straight part of the intestine, when partly filled. The wall of the stomach is thick and sufficiently distensible and internally shows about ten to twelve longitudinal ridges which converge posteriorly at the sac-portion (Fig. 3b). The intestine is long, with a single upward loop soon after descending from the stomach (Fig. 3a), the condition being totally different from that seen in the yellowfin tuna, the bluefin tuna, etc., where the intestine is more or less N-shaped.



Text Fig. 1. *Sarda orientalis* (T. & S.). Ventral view of viscera in specimens—(*a*) 80 mm.; (*b*) 176 mm.; (*c*) 202 mm. and (*d*) 368 mm. respectively, collected at Vizhingam. (GB—gall bladder ; IN—intestine ; LV—liver ; PC—caecal mass ; SP—spleen ; ST—stomach ; T—testes).



Text Fig. 2. *Sarda orientalis* (T. & S.). Ventral view of liver in specimens : (*a*) 80 mm.; (*b*) 202 mm. and [illegible] (*c*) 368 mm. respectively, showing nature of the three lobes.



Text Fig. 3. *Sarda orientalis* (T. & S.). (*a*) stomach and intestine ; (*b*) inner surface of stomach showing nature of mucous folds ; (*c*) fully mature testis of a specimen 497 mm. from Vizhingam (the left testis is slightly turned over to show ventral groove accommodating blood vessel) ; (*d*) ripe ovary from specimen 490 mm.; (*e*) cross section of same (schematic) at middle to show distribution of transparent large ova among undeveloped ova from centre to periphery ; (*f*) cross section of ovary (schematic) in ripe running condition in specimen 605 mm. (spawning—see table XII) showing accumulation of ripe transparent ova in central lumen of ovary.

Dentition :

The posterior teeth on each side of the lower jaw are more prominent than those towards the symphysis as well as those on each side of the upper jaw. However, more teeth are present in the upper jaw (10—14 on each side) than in the lower jaw (7—12 on each side), a specimen 386 mm. showing 13 + 14 (= 27) in the upper jaw and 10 + 12 (= 22) in the lower jaw.

TABLE II

Body measurements expressed in thousandths of total length in different size groups of *Sarda orientalis* (Temminck and Schlegel)

Characters		Size groups					
		50-100 mm.	150-200 mm.	201-250 mm.	251-300 mm.	351-400 mm.	451-500 mm.
Head length	...	1 : 319	24 : 275-319 (299)	3 : 291-307 (299)	13 : 288-306 (302)	2 : 295-312 (303)	2 : 294-299 (296)
Snout to origin of D_1	...	1 : 310	23 : 271-315 (297)	3 : 291-311 (300)	13 : 300-311 (306)	2 : 298-312 (305)	2 : 294-310 (302)
Snout to origin of D_2	...	1 : 610	24 : 532-619 (586)	3 : 569-599 (587)	13 : 593-626 (604)	2 : 588-604 (596)	2 : 590-608 (599)
Snout to origin of A	...	1 : 709	24 : 623-721 (684)	3 : 688-698 (692)	13 : 686-710 (699)	2 : 688-710 (699)	2 : 688-694 (691)
Snout to origin of P_2	...	1 : 341	23 : 302-350 (330)	3 : 318-354 (334)	13 : 311-339 (328)	2 : 311-337 (324)	2 : 322-336 (329)
Greatest depth of body	...	1 : 225	24 : 204-233 (218)	3 : 213-240 (226)	13 : 214-234 (224)	1 : 215 ...	2 : 204-209 (206.5)
Length of P_1	...	1 : 101	24 : 67-121 (107)	3 : 103-124 (112)	13 : 115-126 (129)	2 : 127-131 (129)	2 : 124-137 (130.5)
Height of D_2	...	1 : 73	24 : 51-80 (64)	3 : 64-80 (73)	13 : 54-86 (70)	2 : 82-84 (83)	2 : 86-87 (86.5)
Height of A	...	1 : 78	23 : 58-81 (64)	3 : 60-71 (66)	13 : 64-79 (71)	2 : 80-87 (83.5)	2 : 86-91 (88.5)
Diameter of iris	...	1 : 56	24 : 39-56 (43)	3 : 43-50 (46)	13 : 43-49 (46)	2 : 49-51 (50)	2 : 41-42 (41.5)

In each column the number of specimens is given followed by range and the mean is indicated in parenthesis.

TABLE III

Meristic counts for specimens from Indian seas*

Characters		Dorsal spines	Second dorsal rays	Dorsal finlets	Pectoral rays	Anal rays	Anal finlets
Range	...	17 18 19	14 15 16	7 7 + 1 8 8 + 1	23 24 25	13 14 15 16	5 5 + 1 6 6 + 7
Number of specimens	...	2 37 7	20 7 3	7 5 31 1	3 28 13	4 18 6 1	2 3 36 2 1
		N = 46 M = 18.1	N = 30 M = 14.43	N = 44 M = 7.86	N = 44 M = 24.2	N = 29 M = 14.13	N = 44 M = 6.02

*For calculating mean, when dorsal and anal finlet counts are given as 5 + 1, 6 + 1, 7 + 1 and 8 + 1, these are treated as 6, 7, 8 and 9 respectively.

TABLE IV

Gill raker count for *S. orientalis* from three centres along the South West Coast of India

Locality	Gill rakers on upper and lower limbs of outer gill arch												No. of specimens
	1+8	2+8	3+8	4+8	1+9	2+9	3+9	4+9	1+10	2+10	3+10	4+10	
Cape Comorin	...	...	...	...	...	...	2	1	...	...	...	...	3
Vizhingam ...	1	2	3	...	3	6	14	2	...	1	4	1	37
Calicut ...	...	...	...	...	...	...	2	...	...	...	...	...	2
No. of specimens	1	2	3	..	3	6	18	3	...	1	4	1	42

TABLE V

Locality	Gill rakers						
	Upper limb				Lower limb		
	1	2	3	4	8	9	10
Cape Comorin ...	...	...	2	1	...	3	...
Vizhingam	4	9	21	3	6	25	6
Calicut	...	...	2	...	...	2	...
No. of specimens	4	9	25	4	6	30	6
	N = 42		M = 2.7		N = 42		M = 9

TABLE VI

Locality	Total No. of gill rakers					
	9	10	11	12	13	14
Cape Comorin ...	...	...	...	2	...	...
Vizhingam ...	1	5	9	15	6	1
Calicut ...	...	...	...	2	1	..
No. of specimens ..	1	5	9	19	7	1
	N = 42		M = 11.7			

Scales :

Scales are minute. The corselet is not conspicuous as in *Auxis* or *Euthynnus*, but is well formed, its posterior extension reaching to below tip of pectorals. The lateral line takes an upward loop above level of mid-pectoral from whence it gently slopes to the caudal keel, slightly undulating.

Osteology :

No work has been carried out on *S. orientalis* from Indian seas. However, the works of Kishinouye (1923), and Godsil (1954, 1955) give ample information about the skeletal features of this species from Japanese Sea as well as Eastern Pacific.

Colouration

There are marked differences between juvenile and adult body colourations. According to Jones (1960) in a small juvenile 80 mm. long " The body bears twelve transverse bands which are broad at the dorsal aspect and taper laterally to become imperceptible on reaching the sides of the abdomen and above the anal." In " One of the larger juvenile specimens measuring 158 mm. in standard length and 174 mm. in total length collected from Vizhingam... the transverse bands referred to the previous stage have subdivided into more or less horizontal streaks, which ultimately unite to give rise to the lines so characteristic in the adult. In a specimen 262 mm. in total length all the lines immediately above the pectoral fins have already been formed as in the adult." (Jones, 1960). In specimens between 250 mm. and 300 mm. examined by me from Vizhingam the sides of the body are characterised with 5 to 7 longitudinal stripes along the upper half running horizontally. Below the stripes in the lower half of the body the interrupted bars are still evident. The tips of the second dorsal, dorsal finlets, anal and anal finlets are whitish. The interspinous membrane of D_1 is blackish throughout except for the narrow basal area between the first eight spines which is light dusky. The outer margin of the pectoral is also whitish while the pelvics are colourless. In formalin preserved specimens, dorsally the body is blackish while laterally it is dusky and ventrally yellowish brown, the last appearing in life more or less silvery. In adults according to Day (1878) " The upper half of the body with about eight broad, straight, blue lines passing backwards and a little upwards, silvery below the lateral line where, however, there are similar lines but very faint."

GENERAL VARIABILITY

The meristic counts for *S. orientalis* as recorded by various authors from different parts of the Indo-Pacific are given in Table VII. This shows the following meristic formula for the species :

D_1 XVII—XIX ; D_2 12—16 ; D_2 finlets 6—9 ; P_1 22—27 ; A. 12—16 ; A. finlets 5—9 ; gill-rakers 1 - 4+5—10.

The data are not comprehensive enough to draw attention to differences from area to area, except for material from Japan and Indian seas which shall be dealt with presently. Other differences of interest noticeable from the data given in the table are :

(1) Yabe *et al.* have given the second dorsal fin ray counts as 12—14 for juvenile specimens from Japan. The count of 12 is definitely on the lower side, and 14—16 appears to be the more frequent counts for this character for the species. However, 15—16 spines have also been recorded for adult specimens of *S.orientalis* from Japanese Sea.

(2) South African specimens of *S. orientalis* have been reported as having 6-9 dorsal finlets, the count of 6 being low when compared to the range of 7-9 for this character for the species.

(3) Likewise, in the case of the anal finlet counts, it is 5-7 for all areas except South Africa where a range of 6-9 has been reported. More data regarding the number of dorsal and anal finlets and their frequency of occurrence in samples from South African waters will be desirable.

(4) A range of 8—14 may be expected for the total gill raker counts. For the Indian specimens the counts include only those structures that can be elevated from the arch and not mere basal plates and protruberances which cannot be elevated from the arch. Differences in the methods of counting may account for some of the differences seen in the counts from the different areas. As seen for samples from Japanese and Indian seas, slight

differences in modal values may be expected. The counts given by Yabe *et al.* indicate the modal formula for juvenile specimens from Japan to be 4+8, as compared to specimens I have examined from Indian waters, the latter being 3+9. However, data for adult specimens from Japanese Sea given by Kishinouye (1923), namely 4+9, and by Godsil (1955), namely 2—3+1+8—9 show considerable overlapping in this character. For the Indian specimens examined, no difficulty was experienced in making separate counts of the upper and lower limbs of the outer gill arch, while some authors have used +1+ for a raker at the angle of the arch. Lack of uniformity in recording gill raker counts precludes any detailed comparisons at this stage.

TABLE VII

Meristic counts in *Sarda orientalis* from various parts of the Indo-Pacific

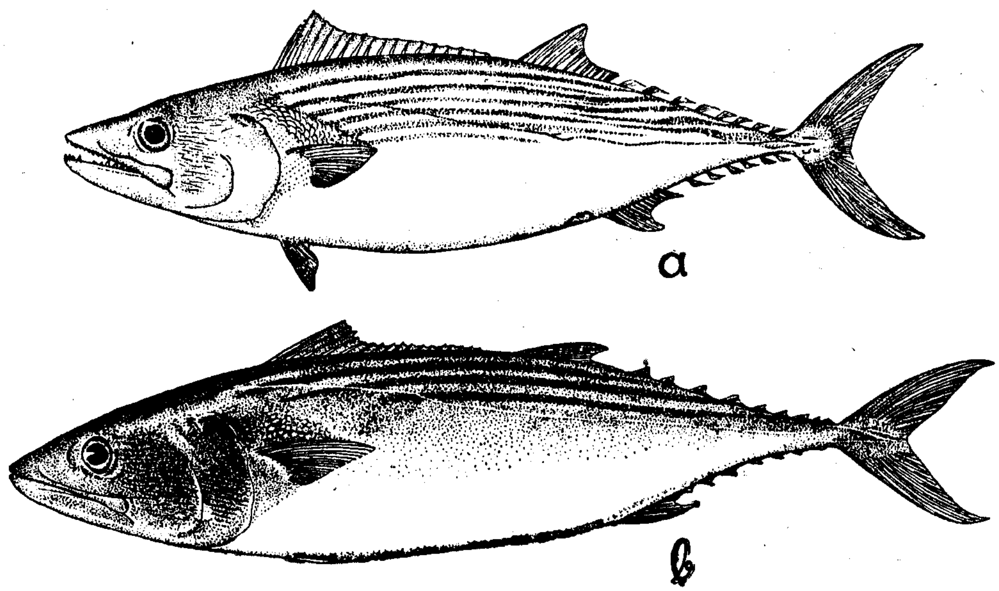
Author and area	D_1	D_2	D_2 finlets	P_1	A	A finlets	Gill rakers
A—Western Indian Ocean							
East coast of S. Africa :							
Barnard (1927) (*S. chilensis*) ...	XVIII	14–16	(6) 7–9	...	2, 10–12	6–9	...
Smith (1949 ; 1961) ...	XVII–XIX	14–16	6–9	...	2–3, 10–12	6–9	— + 8
Seychelles Plateau :							
Wheeler and Ommanney (1953) ...	...	...	8	...	...	7	...
B—Northern Indian Ocean							
Coast of India :							
Day (1878) ...	XVIII	3, 13	8	24	3, 12	6	...
S. W. coast of India :							
Silas (in this paper) ...	XVII–XIX	14–16	7–8 (exceptionally 9)	23–25	13–16	5–7	1—4+8—10 (= 9—14)
C—Eastern Indian Ocean							
W. Australia :							
Munro (1958) ...	XVII–XIX	15	7–8	22–27	15	5–6	2—4+7—9
D—Western Pacific							
Philippines :							
Warfel (1950) ...	XVIII–XIX	14–15	7–9	...	14–15	5–6	3+1+7—10 (= 11—14) Mode 4+9
E—North Western Pacific							
Japan :							
Kishinouye (1923) ...	XIX	15	7–8	...	15	5–6	4+9 (=13)
Yabe *et al.* (1953) ...	XVII–XIX	12–14	7–8	...	12–15	...	2—4+7—9 (=10—12)
Godsil (1955) ...	XVIII	15–16	8	...	15	6–7	2—3+1+8—9 (=11—13)
F—Eastern Pacific							
Meek and Hildebrand (1923) (*S. velox*) ...	XVIII	16	8	...	2, 12	7	— + 9
Godsil (1954) (*S. velox*) ...	XVII–XIX	15–16	7–9	...	14–16	6	2—3+1+5—8 (=8—11)
G—General							
Fraser-Brunner (1950) ...	XVIII (fig.)	...	7–8	...	...	5–6	3—4+7—9
Klawe (1961) ...	...	...	...	...	...	...	2—3+6—10

TABLE VIII

Range in gill raker counts in *S. orientalis* from Japanese and Indian seas

Area and author	Gill rakers													
	Upper limb				Lower limb				Total gill rakers					
	1	2	3	4	7	8	9	10	9	10	11	12	13	14
Japan :														
Yabe *et al.* (1953)	...	1	7	10	6	11	1	...	...	4	6	8	...	...
Godsil (1955) (+ 1 + raker at angle added to lower limb) ...	...	1	4	...	...	...	3	2	...	...	1	2	2	...
Total for Japanese Seas	...	2	11	10	6	11	4	2	...	4	7	10	2	...
India :														
Silas (in this paper)	4	9	25	4	...	6	30	6	1	5	9	19	7	1

(5) As in the case of *S. velox* (Figure 4b), available information on *S. o. serventyi* (Figure 4a) shows the very close relationship of the latter with the typical *S. orientalis*. Since our views regarding subspecies, races, populations, etc., of tunas and tuna-like fishes are still



Text Fig. 4. (*a*) *Sarda orientalis serventyi* Whitley (after Whitley 1947) ; (*b*) *Sarda velox* Meek and Hildebrand (after Meek and Hildebrand, 1923)

in a nebulous state, it may be desirable to refrain from recognising subspecies of *S. orientalis* at this stage. As could be seen from figure 6 showing the distribution of the genus *Sarda*, the known occurrences of *S. orientalis* does not show a continuous pattern. Observations on spawning areas as well as corroborative evidence based on the occurrence of larvae and juveniles from three areas (S. W. coast of India; Japanese Sea ; and Eastern Pacific) tend to indicate the likelihood of independent populations occurring in the different areas. More information is needed about the occurrence of *S. orientalis* in the Atlantic as its records from the east coast of United States, (Block Is. Rhode Is. : Breder, 1932) and the West Coast of Africa (Gold Coast: Fraser-Brunner, 1950) are based on single specimens.

VARIATIONS IN GILL RAKER COUNTS WITH SIZE

Since gill raker counts in the genus *Sarda* appear to be a dependable character for use in species identification, it will be interesting to establish at what length they develop and at what length the final complement is attained. Out of 41 early and late juveniles from S. W. coast of India, the size and gill rakers of 18 are given along with data for 18 specimens from Japanese Sea given by Yabe *et al.* (1953). To indicate specific importance of this character as well as the fact that the final complement of the gill rakers is attained even at an early stage, comparable data for 14 specimens of *S. chilensis* given by Klawe (1961) are also included in Table IX.

ABNORMALITIES

Only two types of abnormalities, namely, the occasional absence of a finlet indicated by a wide gap between two successive finlets and the marked shortening of the pectoral fin were noticeable in over 45 specimens of *S. orientalis* examined from the S. W. coast of India.

TABLE IX

Size of specimens and No. of gill rakers in *S. orientalis* and *S. chilensis*

S. orientalis				*S. chilensis*	
S.W. coast, India		Japan (after Yabe *et. al.*, 1953)		Peru, Chile (after Klawe, 1961)	
Size mm.	No. of gill rakers	Size mm.	No. of gill rakers	Size mm.	No. of gill rakers
80	3 + 9	76	4 + 8	34	7 + 1 + 15
156	3 + 9	144	4 + 7	36	7 + 1 + 15
165	4 + 9	147	3 + 9	37	4 + 1 + 16
175	3 + 9	147	3 + 8	39	5 + 1 + 14
178	3 + 9	156	4 + 7	41	7 + 1 + 15
183	3 + 10	185	4 + 7	44	7 + 1 + 16
184	3 + 9	200	3 + 8	70	7 + 1 + 18
188	3 + 9	215	4 + 8	89	7 + 1 + 17
194	2 + 9	216	4 + 8	94	9 + 1 + 16
198	1 + 9	219	4 + 8	106	7 + 1 + 15
199	2 + 9	220	4 + 8	111	8 + 1 + 17
212	3 + 9	235	3 + 7	128	9 + 1 + 17
242	3 + 9	240	2 + 8	129	7 + 1 + 15
257	3 + 9	243	3 + 8	135	7 + 1 + 15
266	2 + 8	245	3 + 7		
276	2 + 10	252	4 + 8		
285	2 + 9	252	3 + 7		
293	2 + 9	260	4 + 8		

KEY FOR THE IDENTIFICATION OF THE SPECIES OF THE GENUS *SARDA*

1*a*. XX-XXIV spines in the first dorsal; vertebrae 26-28+26-27 (=ca 53-54) (Atlantic). ... *Sarda sarda* (Bloch)

1*b*. XII-XIX spines in the first dorsal; vertebrae 22-25+20-22 (=ca 44-46)............2

2*a*. 12 or more gill rakers on lower limb of outer gill arch, gill raker formula being 6-10+12-19; length of maxillary less than 50% of head length......................3

2*b*. Less than 12 gill rakers on lower limb of outer gill arch, gill raker formula being 1-4+5-10; length of maxillary distinctly more than 50% of head length (Indo-Pacific; Atlantic?).

... *Sarda orientalis* (Temminck and Schlegel)

3*a*. Gill rakers in adults 7-10+15-19 (Eastern Pacific: California, Baja California, Peru, Chile).

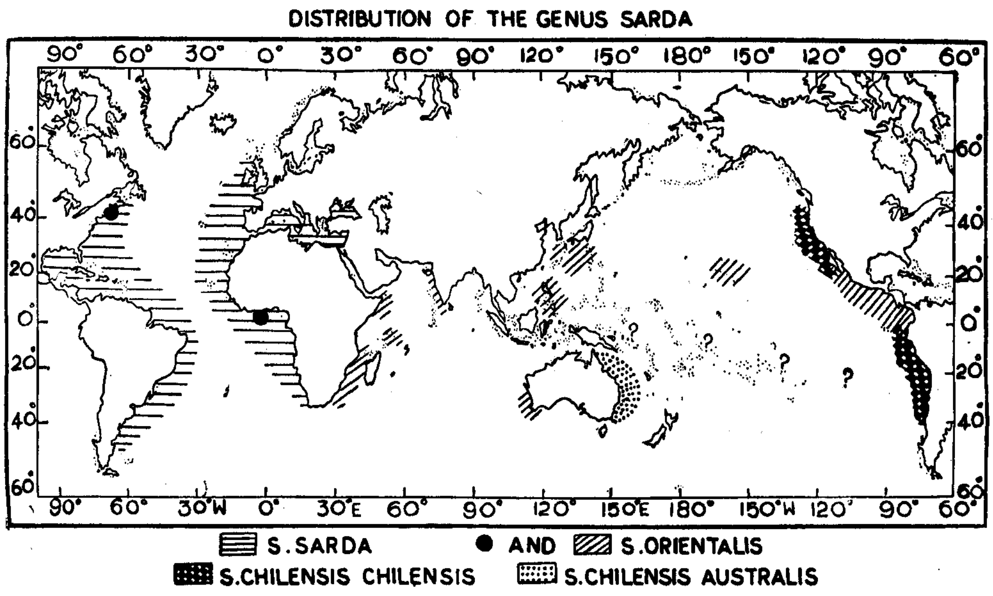
... *Sarda chilensis chilensis* (Cuvier)

3*b*. Gill rakers in adults 6-8+12-14 (Eastern Australia: Queensland, New South Wales, and Victoria).

... *Sarda chilensis australis* (Macleay)

DISTRIBUTION OF *S.ORIENTALIS* IN RELATION TO ERVIRONMENT

As shown in figure 5, the spatial distribution of *S. orientalis* covers: the east coast of South Africa; Seychelles; Somalia and Gulf of Aden; West Coast of India; South West coast



Text Fig. 5. Map showing the geographical distribution of *Sarda orientalis* and related species and sub-species of the genus *Sarda* Cuvier.

of Australia; Philippines; Japan; Hawaii; Pacific coast of Central America and Galapagos Islands, besides two records from the Atlantic. It is interesting that in the Indian Ocean itself the species has not been reported from the British East African Coast, the Laccadive Sea, the Andaman Sea, Sunda Sea south of Java, etc. Eggs of *S. orientalis* have not been identified from the plankton from any area, neither is information available about the distribution of larvae from the Indian Ocean. Larvae suspected to be those of either *S.orientalis* or *S.chilensis* have been obtained from Baja California coast (Klawe, 1961). The collections of juveniles are also from areas of known distribution of adults of the species.

In this connection it may be mentioned that the temperature spectra for bonitos are given by Rosa and Leavastu (1961) as ranging between 12°C and 25°C, and by Kishinouye (1923) for *S. orientalis* as being between 13.5°C and 23°C. Available information also indicates that in the Indian Ocean the species is found in the northern hemisphere between 0°N and ca 20°N and in the southern hemisphere between 10°S and ca 37°S which indicates its presence in more temperate waters in the southern hemisphere in the Indian Ocean. In the Pacific, the pattern of distribution of the species is different in that it is conspicuously absent in the southern hemisphere east of the Philippine Archipelago, while in Japanese waters it may be found as far north as ca 40°N- lat. Interestingly enough in the Eastern Pacific it appears to have a restricted distribution along the coasts of Central America and Galapagos Islands, while its congener *S. chilensis chilensis* occurs along the California coast and further southwards from Galapagos to Chile.

No information is available about the vertical distribution of *S. orientalis*, nor is it known whether like some of the tunas (yellowfin, bigeye, etc.) it exhibits daily vertical migrations. In several areas its occurrence in coastal waters is sporadic and along the south west coast of India where there is a minor seasonal fishery for this species, nothing is known about its whereabouts in the offseason. In this area, fully mature adults appear from about May to September followed by the appearance of juveniles in the months of October-November. Slight fluctuations from year to year as to the months of occurrence may be seen. Similar conditions obtain for other areas also.

The temperature range for fishery of bonitos is given as 15°C to 22°C by Rosa and Leavastu (1961), but no optimum temperature range for fishery is known.

FOOD AND FEEDING HABITS

Only very scanty information is avilable about the food and feeding habits of *S. orientalis*. Jones (1960) remarks that the food of juvenile *S. orientalis* from Indian waters consists of larval and juvenile fish and crustaceans. Yabe *et al.* (1953) found the stomachs of 15 of the 18 juvenile specimens (83.3%) caught along the Southern Kyushyu coast (Aburatsu) to be empty. Two specimens were found to contain remains of *Engraulis japonicus*, while one was found to have unidentifiable fish remains.

For 24 specimens caught in set nets, pole and line fishing and trolling from three areas along the Southern Kyushyu coast Yokota *et al.* (1961) have calculated the "stomach contents weight index" (= SCW/BW x 100) as shown in Table X. (SCW=stomach contents weight; BW=body weight). Munro (1958) mentions "Feeds on pilchards, mackerel and mackerel scad."

TABLE X

" Stomach Contents Weight Index " for *S. orientalis* (after Yokota *et al.* 1961)

SCW Index	*Tanegashima* Set nets						*Tosa-Shimizu* Pole and line		*Kushimoto* Trolling
	Date (Year–Month)								
	59–1	59–4	59–5	59–6	60–1	60–2	60–11	60–11	60–12
0.0	...	2	1	...	0	0	2	4	0
—0.5	2	...	...	1	3	1	3	1	1
1.0	...	...	...	...	...	...	...	...	1
1.5	1	...	...	...	...	...	...	...	...
2.0	...	...	...	...	...	...	...	...	...
2.5	...	...	...	...	...	...	...	...	...
3.0	...	...	...	...	...	...	...	...	...
3.5	...	...	...	...	...	...	...	...	...
4.0	...	...	...	...	...	...	...	...	...
4.5	...	1	...	...	...	...	...	...	...
5.0	...	...	...	...	...	...	...	...	...

The above meagre data would suggest that except in two specimens taken in set nets, the food present in the stomach (when present: by weight) was more or less the same for specimens taken in set nets, by pole and line and trolling.

Yokota *et al.* (1961) give the stomach contents of *S. orientalis* caught in pole and line fishing as shown in the following Table XI.

TABLE XI

Stomach Contents of *S. orientalis* caught in Pole and Line Fishing

Date	Fishing grounds	Nos.	Saury	*Sphyraena* sp.	Squid	Carangoid
1959–2	Satsunan	6	5	...	...	...
1960–10	Ashizuri	5	...	1	...	1
1960–11	Ashizuri	5	...	...	1	...

MATURITY AND SIZE

Along the South West Coast of India, between Trivandrum and Cape Comorin, juvenile and immature specimens are known to occur during the months of October-November. Maturing ovaries containing transparent ova were seen in specimens above 386 mm. at Vizhingam. Specimens collected during the months of August-September, 1960 and 1961 at Vizhingam measuring between 480 mm. and 605 mm. were in ripe running condition or had already spawned, some showing signs of recovering. However, the age of the investigated mature specimens is not known.

As regards size, large specimens caught in shore seines, drift nets, and hook and line off South West Coast of India are generally less than 700 mm. in length. However, the fish is said to attain a larger size as Smith (1949, 1961) mentions (under *S. chilensis* = *S. orientalis*) "Attains atleast 40 inches." According to Kishinouye (1923) *S. orientalis* "Grows to a length of about 80 cm. and to a weight of 1.5-3.0 kg." Munro (1958) mentions a weight of 8½ lb. for Western Australian specimens. Two mature specimens 490 mm. (male) and 497 mm. (female) in length caught at Vizhingam weighed 1.446 kg. and 1.716 kg. respectively. It may be exceptional to find specimens weighing over 5 kg. although Migdalski (1958) mentions "Supposedly, they run in weight up to 25 pounds."

FECUNDITY

Preliminary data on fecundity are summarised in Table XII. The fish is said to attain about a metre in length and the estimates given here are only for smaller sizes ranging from 386 mm. to 605 mm. A larger number of eggs may be expected in still larger specimens. The number of ova shed per spawning in two specimens in running ripe stage is estimated to be 0.08 and 0.15 million. The total number of ova produced during a spawning season is estimated to vary from 0.24 to 0.64 millions. Since the specimens were collected more towards the end of the spawning season it is felt that slightly higher estimates of ovarian eggs could be expected if estimates from running ripe ovaries at the beginning of the spawning season could be carried out.

The number of ovarian eggs per 1000 gm. of body weight was not found to differ much in two specimens measuring 386 mm. and 490 mm.

Plate II A—E, and text-figure 3d—f illustrate mature and ripe ovaries of *S. orientalis* collected at Vizhingam. The legend given under the figures are self-explanatory.

EGG STRUCTURE

Ripe ovarian egg is large, spherical and transparent, becoming slightly opaque when preserved in formalin. The ripe ova which had burst from the follicles and were lying loose in the lumen of the ovary were found to have a mean diameter of 1.3 mm. Most of the ripe ova taken as such were found to have a cluster of small oil globules at one of the poles, their numbers varying between 3 and 14 with an average of about 8 and ranging in diameter from 0.06 mm. to 0.23 mm. Several eggs had oil globules of same size as shown in Plate II, figs. G & H. Such large numbers of oil globules are indeed a very peculiar feature and quite contrary to the single oil globule present in the known eggs of other scombroids, except perhaps *Sarda sarda* where the fertilized eggs have been reported as having varying number of oil globules of different sizes (Sanzio, 1932; Vodianitski, 1936; Vodianitski and Kazanova, 1954; Padoa, 1956; and Demir and Demir, 1960). In the present case, however, as the eggs showing multiple oil globules are unfertilized, it is suspected that they may even represent a batch of unshed eggs retained over a longer period and probably in the earliest stage of degeneration. If so, the retention and eventual resorption of a large batch of eggs towards the end of the spawning season is interesting. This is all the more so, as only very few degenerate eggs were seen in recovering ovaries, and these eggs also show scattered oil globules of different sizes. An early ripe ovum in which the oil globules are not discernible (diameter 0,9 mm.) is shown in Plate II, fig. F.

TABLE XII

Counts of Ovarian Eggs in five mature specimens of *S. orientalis* from Vizhingam, S.W. Coast, India

Date of collection	13–9–1961	20–8–1960	8–9–1960	1–8–1960	25–8–1960
Total length (mm.) ...	386	490	...	545	605
Body weight (grams) ...	899	1446	...	...	...
Weight of ovaries (grams) ...	53.650	85.720	89.140	72.750	84.400
No. of countable ovarian eggs in gram of roe ...	4533	4525	5750	8900	4890
No. of eggs in ovaries (in thousands) (to be spawned in a season) ...	2432	3879	5126	6475	3980
No. of eggs per 1000 gms of body weight (in thousands)	2705	2682	..	..	...
No. of eggs of the most advanced mode in grams of roe	...	...	990	2131	160
No. of eggs of the most advanced mode in ovaries ...	...	...	88248	155030	13024
Remarks	Spent-recovering?	Maturing	Ripe running?	Ripe running?	Spawning (partially spent?)

SPAWNING SEASON AND SPAWNING FREQUENCY

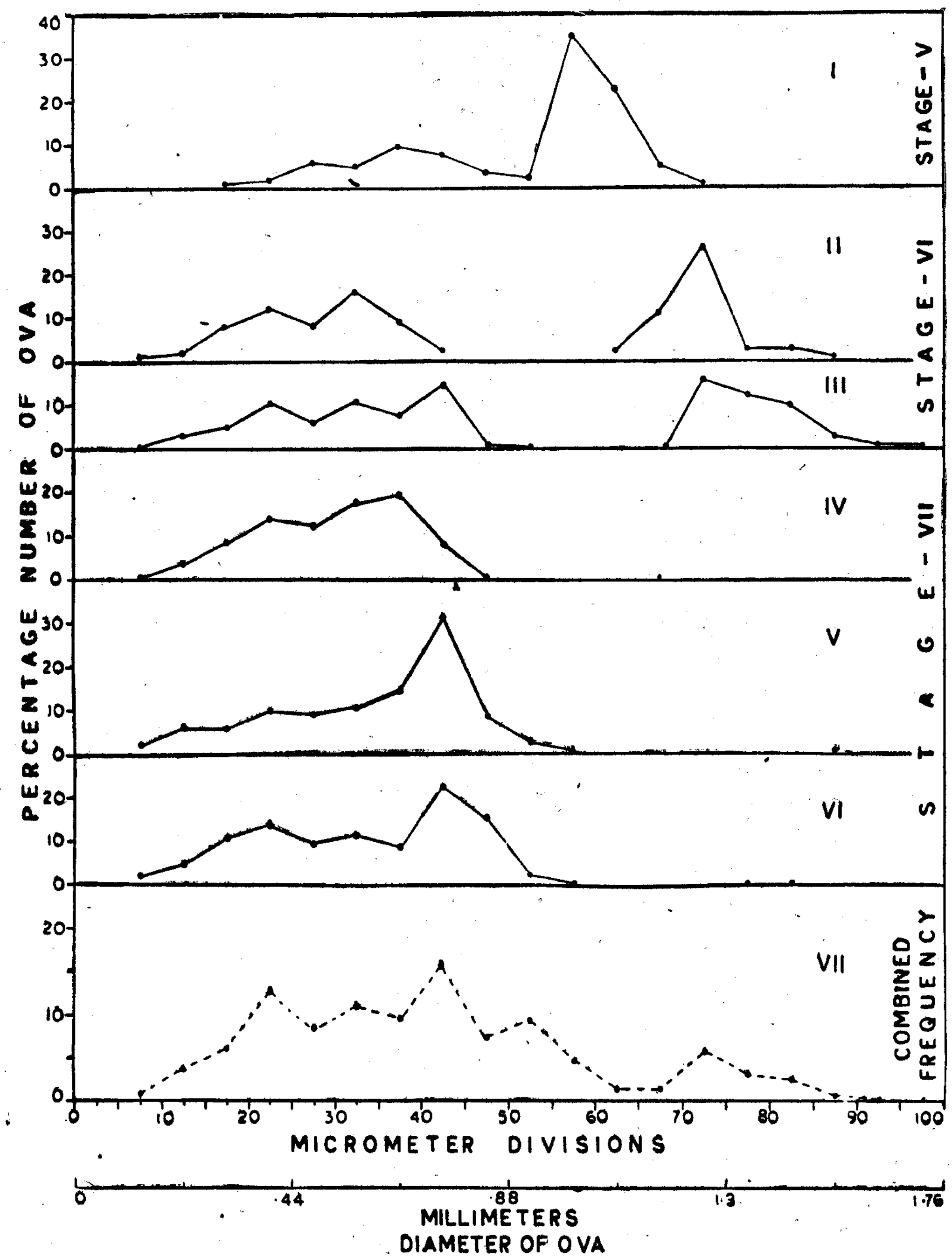
The definite duration of the spawning season is not yet fully known. Specimens in stages V and VI (mature and ripe running) conditions have been collected at Vizhingam during the months of July, August and September 1960 and 1961, suggesting that the spawning season could commence even earlier and last till about September. Practically nothing is known about the spawning season of this species in other areas.

The study of the ova diameter frequency polygons of ripe, spawning (or ripe running) and recovering ovaries indicates that in the most advanced stage (ripe—stage V) (figure 6, I) the most advanced mode containing ripe ova is the most prominent, while more than one mode is seen for the maturing ova. In the ripe running condition (Spawning—stage VI) (figure 6, II and III) the most advanced mode is seen to be completely separated from the maturing eggs which in turn show two or more modes. Three recovering ovaries (stage VII) (figure 6, IV, V and VI) in which there were indications of previous spawning by the presence of degenerate large eggs also show the most advanced mode as the most prominent one as seen in stage V (figure 6, I). The combined frequency (figure 6, VII) shows the most advanced mode containing the ripe ova to be well demarcated from the maturing batches, which in turn show several modes. If it were to be presumed that during a spawning season the ova over 5 microdivisions or about 0.11 mm. are to mature and spawn, it is clear that in *S. orientalis* all the ova do not ripen at one time, but as seen by the number of modes, mature in batches. Spawning season may be an extended one and the preliminary data suggest fractional spawning during a season.

The smallest specimen in the sample examined which had in the ovary a few large eggs, probably remnants of an earlier batch of eggs spawned was 386 mm. If subsequent observations were to corroborate this, then it is evident that the species in these waters becomes mature and is ready for spawning even before attaining 386 mm. The ripe running specimens examined were 49 cm, to 60,5 cm,

SPAWNING GROUNDS

The capture of females with ripe, ripe running and recovering ovaries along the South West Coast of India (Trivandrum to Cape Comorin) indicates that the sea off this coast is one



Text Fig. 6. Ova diameter frequency polygons of ripe, ripe running, and recovering ovaries (Stages V, VI and VII respectively) of *S. orientalis* from south west coast of India.

of the spawning grounds of this species. Larval collections are wanting, but the occurrence of early and late juveniles in this area during October-November months is interesting. No information is available for other areas in the Indian Ocean. In the Pacific, juveniles have been collected along the coasts of S. Japan, and larvae suspected to be that of *S. orientalis* have been collected off the Baja California Coast, suggesting the coastal waters of these areas to be likely spawning grounds.

BEHAVIOUR

Schools of adults and juveniles appear along the South West Coast of India from about June to December, the large schools of juveniles appearing especially in October-November when they enter bays and inshore areas and are caught in shore seines.

Kishinouye (1923) mentions that it " lives rather near the surface of the coastal waters, and sometimes makes large shoals." Tominaga's (1945) observations are in general agreement with that of Kishinouye's statement, but he mentions that in southern Japanese waters large and dense schools of *S. orientalis* are not met with and the fish is rarely seen at the surface. " They always swim around the reef or the seas near the cape where the current is strong, and never go out to the high seas ".

Both Kishinouye, as well as Tominaga mention that the fish bites eagerly on dead bait or artificial bait and hence is easily caught with trolling lines as well as occasionally in longlines.

The following observations by Migdalski (1958) may be of interest. He observes that " As in the Atlantic, these fishes make excellent strip bait........, and they also afford great sport to anglers working light tackle. They strike a lure or bait in full stride with such force that it surprises the angler. Often the bonitos will be attracted by a disturbance in the water. When a fish or two are hooked, you can bet that there is a school in the vicinity, and chumming in the area will provide more fish. Continuous chumming may hold the school for quite a while. Then the school may leave and flash back at varying intervals."

Localized south to northward movement in Japanese coastal waters is suspected (Tominaga, 1943). Yabe *et al.* (1953) report the capture of small numbers of juveniles around Aburatsu in the month of March while appreciable numbers of adults are caught in set nets from November onwards.

PARASITES

Juvenile and adult specimens caught at Vizhingam were invariably found to have a species of monogenetic trematode (*Capsala* sp.) on the gills, palate or inner wall of the operculum. Silas and Ummerkutty (1962) have recorded the parasitic copepods *Caligus bonito* Wilson (adults and chalimus stages), and *Parapetalus* sp. from the gills, buccal cavity and branchial arches of juvenile and adult specimens of *S. orientalis* collected at Vizhingam.

Shiino (1955) described a new genus and species of Caligoid copepod, *Alicaligus tripartitus* from *Sarda orientalis*.

Winter (1955) described a new species of monogenetic trematode, *Capsala caballerio* from *S. orientalis* from the pacific coast of Mexico.

RELATION OF POPULATION TO COMMUNITY AND ECOSYSTEM

The term 'neritic pelagic' may be applied to the habitat of *S. orientalis*. Within this relam, it may be said to belong to the surface and midwater community as most other scombroids. The area of occurrence of *S. orientalis* off South West Coast of India is an area of high biological productivity. In this area, the fishery for this species also coincides that for the little tunny *Euthynnus affinis affinis* (Cantor), the northern bluefin tuna or Indian longtailed tunny *Kishinoella tonggol*, and few other scombroids, especially *Auxis* spp., *Scomberomorus commerson* (Lacépède) *S. guttatus guttatus* (Bloch and Schneider) and *S. lineolatus* (Cuvier). Most of these species prey on smaller fishes and as such it is likely that a certain amount of competition for food may exist between these species in this area.

In Japanese waters *S.orientalis* is usually also caught in pole and line fishing while fishing for the skipjack *Katsuwonus pelamis* in coastal waters. Some competition for food between these two species may exist in this area.

Nothing is known as to whether inter-specific or intra-specific competition of any sort exists in the genus *Sarda*. In this context, the distribution of *S. orientalis* and *S.c.chilensis* in the Eastern Pacific along the Coast of America is interesting. It is highly doubtful whether the distributions of these two forms could be considered allopatric as a certain amount of mixing between *S.c.chilensis* from the California and Mexican coasts and peru, and Galapagos Is., could be expected although at present the patterns of distribution of these as well as *S. orientalis* appears exclusive in this area (Fig. 5). No such condition obtains for *S. orientalis* in the rest of the Indo-Pacific. Records of *S. orientalis* from the Atlantic are from areas from where *S. sarda* is also known (Fig. 5), but the data being meagre, no comments are permissible.

FISHERY

Fishing gear

Along the South West Coast of India, adult *S. orientalis* are usually caught in drift nets (gill nets) and rarely in shore seines. Juveniles are generally caught in shore seines and gill nets. The species has also been taken by trolling in Seychelles waters (Wheeler and Ommanney, 1953).

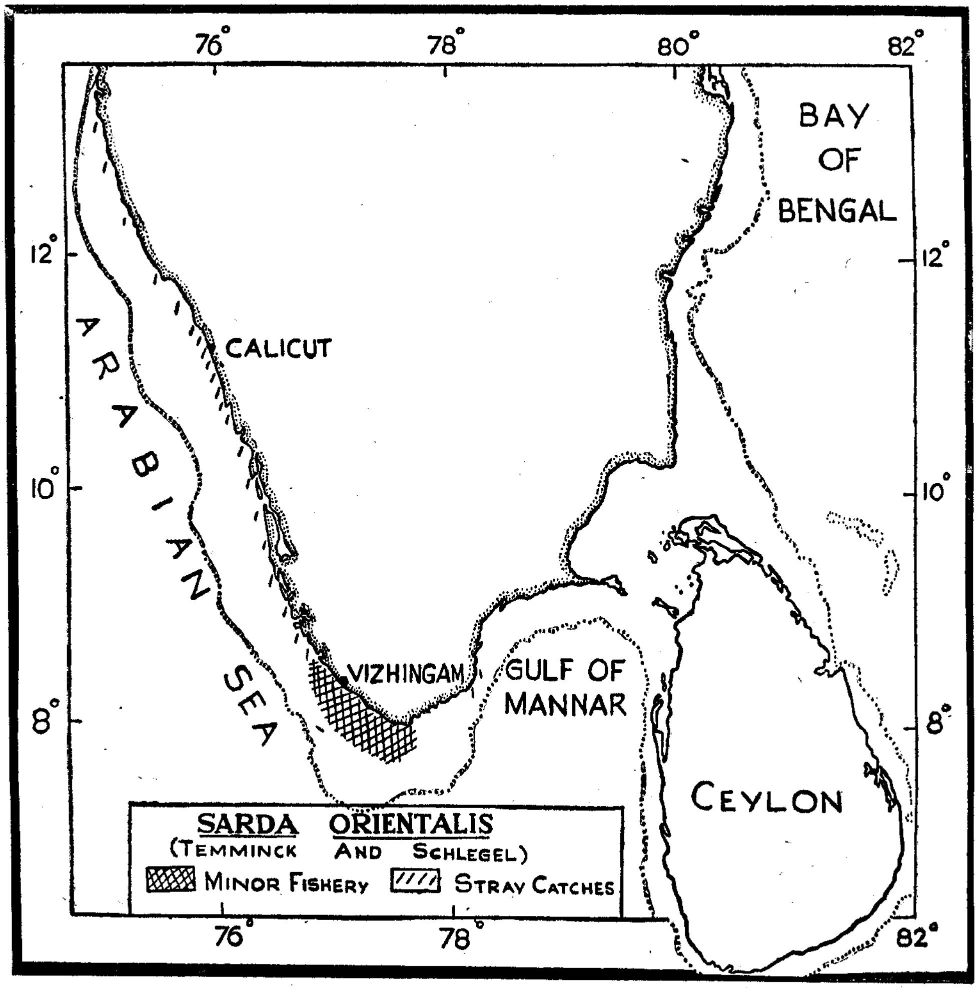
In Japanese waters adults and juveniles are caught in set nets and adults are also caught by trolling, in longlines and also by pole and line.

Warfel's work (1950) on the development of tuna industry in the Philippines indicates that most of the catch of *S. orientalis* at Batangas, Iloilo, and Zamboanga were taken in traps during 1948-'49. Two types of traps used for tuna capture one a shallow trap set in not more than five fathoms and made almost entirely of bamboo and rattan and the second, a deeper trap set in about twenty fathoms and made of pilings of palm trees with bamboo matting are mentioned.

No special boats appear to be in use for fishing for the oriental bonito.

Fishing areas :

Fishing areas for the oriental bonito along the South West Coast of India is shown in figure 7. Rosa and Laevastu (1961) also indicate the regular occurrence of *S. orientalis* along the Somalia coast.



Text Fig. 7. Map showing the occurrence and fishing areas of *Sarda orientalis* along the south west and south east coasts of India.

It forms a minor fishery in certain areas in the Philppines as the data given by Warfel (1950) reproduced here in Table XIII would indicate.

TABLE XIII

Tunas landed at Three Philippine Markets 1948–49

(after Warfel, 1950)

(Most of these were taken by traps)

Scientific name	Number landed at		
	Batangas	Iloilo	Zamboanga
Neothunnus macropterus	3,617	14,056	975
Euthynnus yaito	9,462	48,768	7,490
Kishinoella tonggol	1,570	3,422	231
Katsuwonus pelamis	2,139	2,208	47
Sarda orientalis	269	2,308	6,762
Gymnosarda nuda	27	47	3
Parathunnus mebachi	None	None	18

In Japan also it forms a minor fishery along certain parts of the Kyushu coast where as already mentioned various types of gear are used for its capture.

Fishing seasons :

Along the South West Coast of India the available information points to the fishing season for adult *S. orientalis* to commence from about June and last till about September, although stray specimens may be caught during other months, especially March to June. Juveniles are caught mostly in October–November. It is likely that there may be changes in the duration of the fishing season from year to year. Often during a whole year, good fishing may be restricted to the duration of a fortnight only.

Information is not available about other areas except Japan where the fishing for the oriental bonito may be sporadic or regular throughout the year. When normal, usually more catches result along the West Coast of Southern Kyushu during spring and early summer and along the east coast during summer and autumn months.

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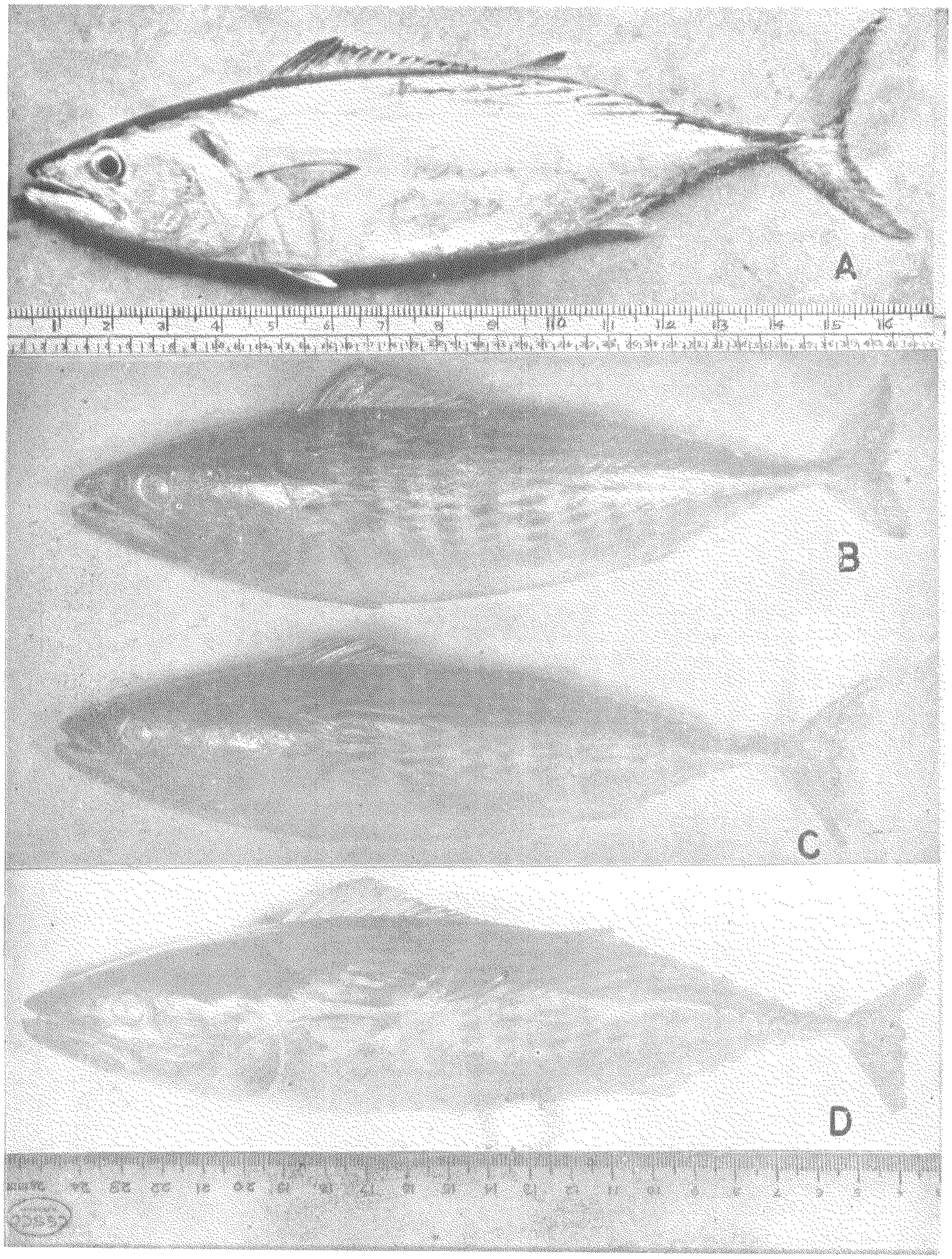
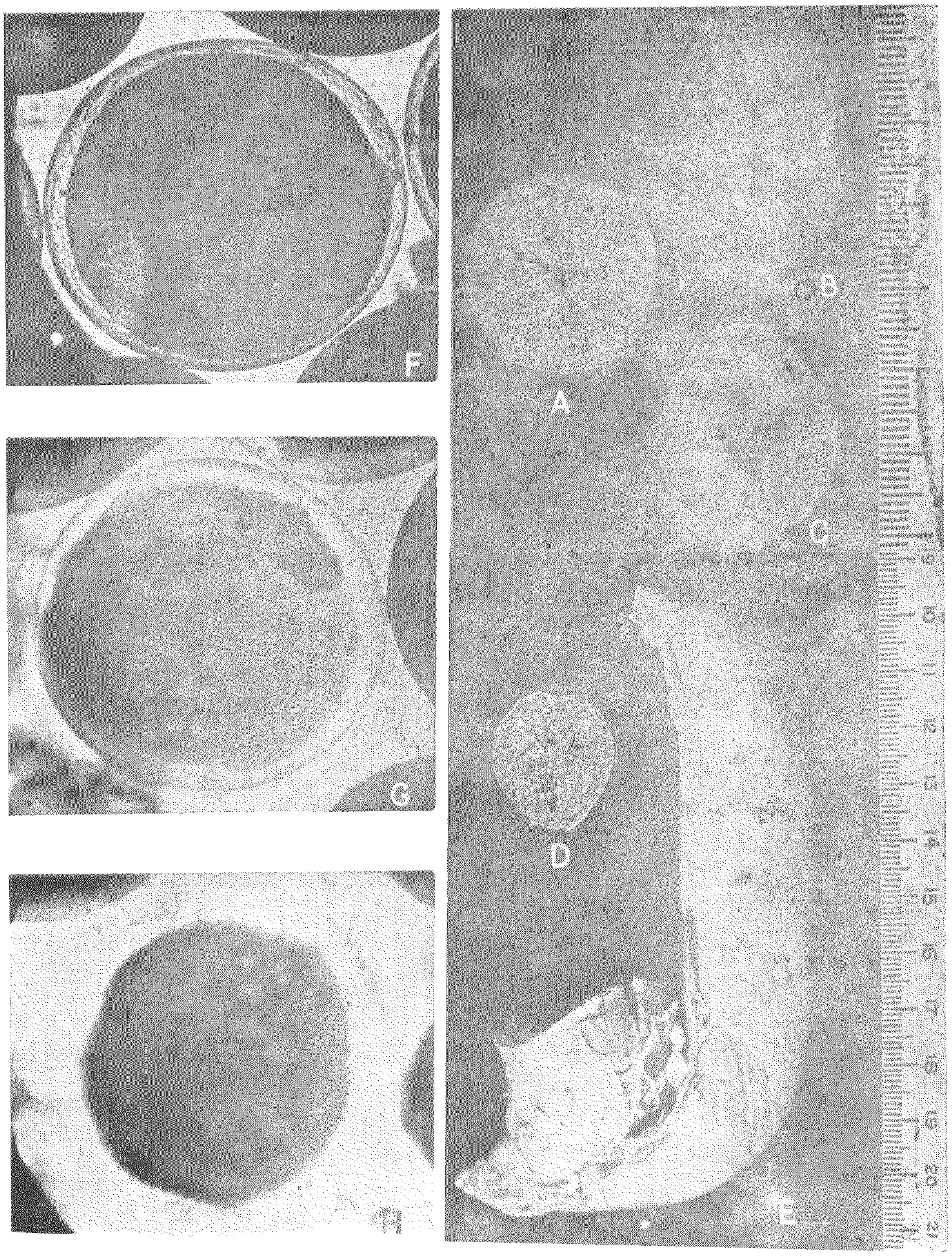


Sarda orientalis (T. & S.) A. Lateral view of specimen 386 mm. from Vizhingam ; B–D. Lateral views of juveniles 195, 198 and 212 mm. respectively showing variations in colour pattern of body.



Sarda orientalis (T. & S.). A and B. Cross sections of ovaries of specimens 386 mm. and 490 mm., respectively showing distribution of larger transparent ova throughout ovary and also the formation of the central lumen into which the ripe eggs migrate (Stage VI). C. Cross section of ovary of specimen 605 mm. showing central lumen from which ripe transparent ova have been removed. D. same—prior to removal of ripe ova. E. ovary of same specimen—part of right ovary removed for showing cross sections C and D. F. ovum with diameter of 0.9 mm. (stage V). G and H. ripe ova, diameter 1.3 mm. lying loose in the lumen of the ovary showing cluster of oil globules (each about 0.15 mm. in diameter) at one pole.