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SYNOPSIS OF BIOLOGICAL DATA ON DOGTOOTH TUNA
Gymnosarda unicolor (Ruppell) 1838 (INDO-PACIFIC)

Exposé synoptique sur la biologie du thon
Gymnosarda unicolor (Ruppell) 1838 (Indo Pacifique)

Sinopsis sobre la biología del atún
Gymnosarda unicolor (Ruppell) 1838 (Indo Pacifico)

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1 IDENTITY

1.1 Taxonomy

1.1.1 Definition

Phylum VERTEBRATA
Subphylum Craniata
Superclass Pisces
Class Teleostomi
Subclass Actinopterygii
Order Perciformes
Suborder Scombroidei
Family Scombridae
Subfamily Scombrinae
Genus Gymnosarda Gill, 1862
Species Gymnosarda unicolor (Rüppell) 1838

1.1.2 Description

- Genus Gymnosarda Gill 1862 (Orthotype: Thynnus (Pelamis) unicolor Rüppell; Type locality: Djedda, Red Sea)

Body elongate, fusiform, anteriorly robust with large head; size not exceeding 2.5 m; mouth large, maxilla extending to vertical below anterior third of eye; lower jaw broad and deep; teeth in jaws large, slightly curved, but nearly conical in shape; villiform teeth present on tongue and palatines; vomer edentulous; eyes large; body appearing naked except for greatly reduced corselet and lateral line; scales in corselet elongate and concealed under skin which is usually drawn into longitudinal furrows on either side of dorsals; lateral line conspicuous and undulating posteriorly; two dorsal fins more or less contiguous being separated by distance hardly half diameter of eye; first dorsal with 12 - 14 spines of which third spine longest; dorsal finlets 6 or 7 and anal finlets mostly 6; pectoral not exceeding head length; interpelvic process developed, simple or bifid posteriorly; caudal relatively slender, with a well developed median keel and a pair of low lateral keel on either side; caudal lobes more or less vertical, posterior margin being a wide arc; gill rakers few, strong gill membranes free, operculum slightly undulating at hind margin; vertebrae 38 (19+19).

The genus Gymnosarda is recognised here as being monotypic, although till very recently it was considered or treated as a composite genus embracing also the little tunny (Euthynnus spp.) and the skipjack (Katsuwonus pelamis Linnaeus). Fraser-Brunner (1950) placed Cybiosarda Whitely (1935) (Type = C. elegans Whitely) in the synonymy of Gymnosarda. The affinities of Cybiosarda are more towards Sarda Cuvier than to Gymnosarda, as it differs from the latter in the vomer having villiform teeth; larger number of dorsal and anal finlets (9 or 10 / 7 or 8 respectively), colouration, etc. Some authors have confused the genus Orcynopsis Gill (1862) (type: Scomber unicolor Geoffroy St. Hilaire, 1809) from the eastern Atlantic and Mediterranean with the genus Gymnosarda Gill, but the former characterized by the compressed body; possession of teeth on vomer; spinous dorsal fin with a convex margin, etc., is distinct from Gymnosarda which has not been recorded from the Atlantic or Mediterranean. Günther (1860) proposed Pelamys nuda to replace Gymnosarda unicolor as he considered the latter as well as Scomber unicolor Geoffroy St. Hilaire under the genus Pelamys, but this course will not be necessary at present as Rüppell's and Geoffroy's species belong to different genera.

At the level of higher categories under Scombroidei, Gymnosarda has been subjected to varied treatment. While Fraser-Brunner (1950) considers it as belonging to the family Thunnidae, Kishinouye (1923) places it among the Cybiidae; Fowler (1949) places it under the subfamily Sardinae and more recently Munro (1958 b) relegates it to the family Katsuwonidae.

- Gymnosarda unicolor (Rüppell) 1838

Body proportions for three specimens 523 mm - 685 mm from Andamans are as follows :

Head 3.7 - 3.93; height of body 4.88 - 5.11; first predorsal distance 3.45 - 3.48; second predorsal distance 1.70 - 1.83; prepelvic distance 3.35 - 3.45; preanal distance 1.53 - 1.61; distance between origin of P_2 and A 2.74 - 2.85;

base of first dorsal 3.80 - 3.85; base of second dorsal with finlets 2.76 - 2.79; length of pectoral 5.62 - 5.9; base of anal with finlets 3.40 - 3.53; height of longest dorsal spine 14.4 - 14.8; height of second dorsal 9.25 - 9.86; and height of anal 9.69 - 9.78 in total length measured from tip of snout to fork. Eyes 4.8 - 5.4; length of maxilla 1.9 - 2.0; longest gill raker 7.8 - 9.0; longest gill filament of outermost arch 6.7 - 10.9; longest dorsal finlet 6.04 - 6.16; longest anal finlet 5.6 - 5.96; and distance from origin of pelvic to tip of interpelvic process 4.51 - 4.66 in length of head.

Dung and Royce (1953) have listed morphometric measurements of Gymnosarda nuda (=Gymnosarda unicolor) from different areas of the Pacific as follows: 64 specimens from western Marshall Islands; 1 specimen from eastern Carolines; 2 specimens from Japan and 56 specimens for the Sulu Sea, Philippines. To this may be added measurements of 7 specimens from the Andaman Sea and 2 from off Minicoy, in the Laccadive Archipelago included below. The total length range of these specimens is 446 mm to 1,079 mm. Body proportions expressed as percentages of total length are given below.

Head 24.8 - 28.1; first predorsal distance 28.1 - 31.8 second predorsal distance 54.3 - 58.8 (in one instance 62.1); preanal distance 61.0 to 67.0; prepelvic distance 27.0 - 31.7 greatest depth of body 19.6 - 24.8; length of pectoral 16.6 - 19.9; height of second dorsal 9.9 - 11.8; height of anal 9.7 - 11.6; and diameter of iris 3.8 - 6.0 percent in total length.

Body elongate, fusiform, but posteriorly more slender; first dorsal with a gradually sloping margin from third spine which is longest; jaws equal, snout pointed giving upper jaw a narrow pointed appearance; lower jaw conspicuously deeper (Figure 2a); preopercle slightly notched and with the characteristic striae; maxilla extends to vertical below middle of orbit. When freshly caught, lateral line is very conspicuous gently sloping till vertical below origin of second dorsal from which it undulates slightly to caudal peduncular keel; latter and lateral keels at caudal base are well developed; scales as given for genus.

About eight short conical pointed teeth are present on each side of upper jaw, while lower jaw has on each side about 14 - 15 cannine-like conical teeth about three times as large as those on upper jaw.

Colour when fresh is - dark blue along dorsum and sides of body above level of pectoral; lower half of body silvery white; first dorsal bluish green, outer fins and finlets dusky blue with distal one fourth of second dorsal and anal white. On preservation in formalin, the body turns sooty black along dorsum to dark grey on sides above lateral line and light silvery greyish ventrally; fins and finlets are dusky but tips of second dorsal and anal are conspicuously white; pelvic fin membranes are dark greyish giving the fin a blackish appearance. (Figure 1).

For meristic characters see 1.3.1

Blanc and Postel (1958) figured the visceral organs of a specimen 700 mm weighing 3,400 g and also the liver of the same separately showing the trilobed nature. The viscera of a 685 mm specimen from Andamans is shown in Figure 3. In the ventral view of the viscera the right lobe of the liver is slightly longer than the left, while the median lobe is rudimentary. The caecal mass hardly extends behind the tip of the right lobe of the liver. The spleen is partly hidden. The stomach is relatively long and the narrow, slender intestine runs more or less straight. The stomach has internally about 13 prominent mucous folds, which in the empty stomach are more prominent as ridges (Figure 4). In the above specimen, before preservation, the testes were found in a partly spent and oozing condition (Figure 4). The outer covering of the testes was transparent showing the shrunken portion inside. The distal part of the right testes was rounded and pinkish the rest of the right and left testes being pale yellowish.

For osteological characters, reference may be made to Kishinouye (1923).

1.2 Nomenclature

1.2.1 Valid scientific name

- Gymnosarda unicolor (Rüppell) 1838

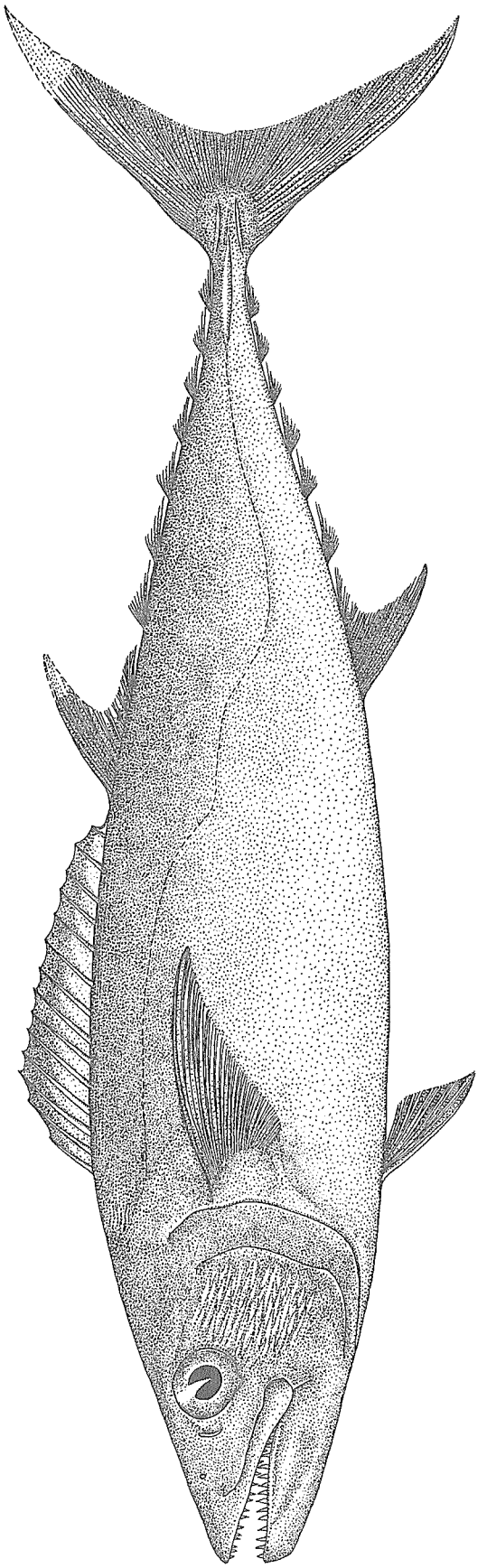
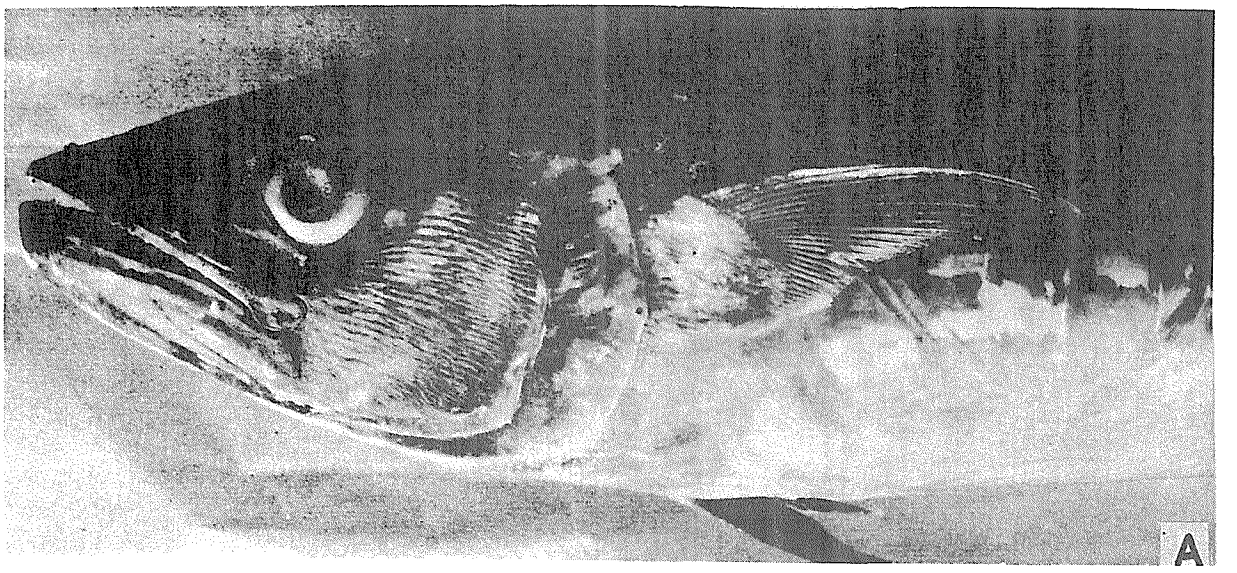


Figure 1. Gymnosarda unicolor (Rüppell)
Specimen 522 mm from Minicoy, Laccadive Archipelago.



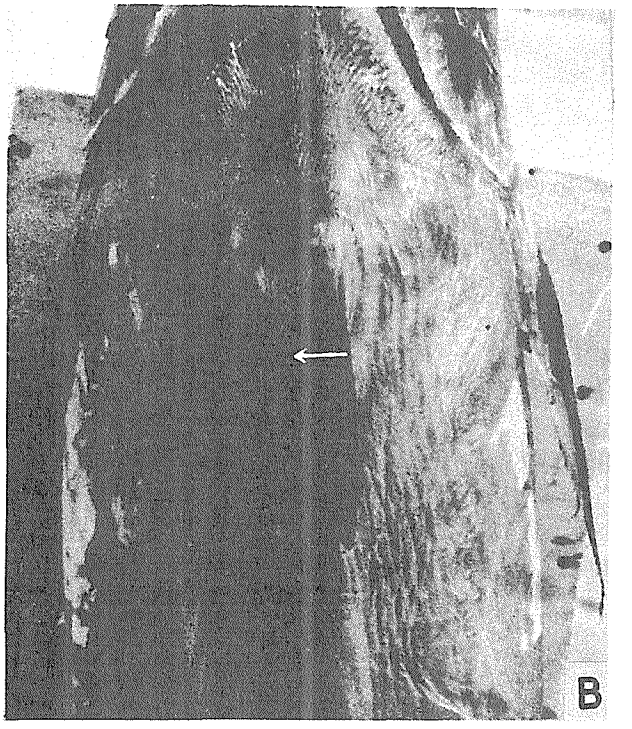


Figure 2. Gymnosarda unicolor (Rüppell)

A. Photograph of head and anterior part of body of a specimen 685 mm from Andamans.

B. Showing undivided inter-pelvic process in the same specimen.

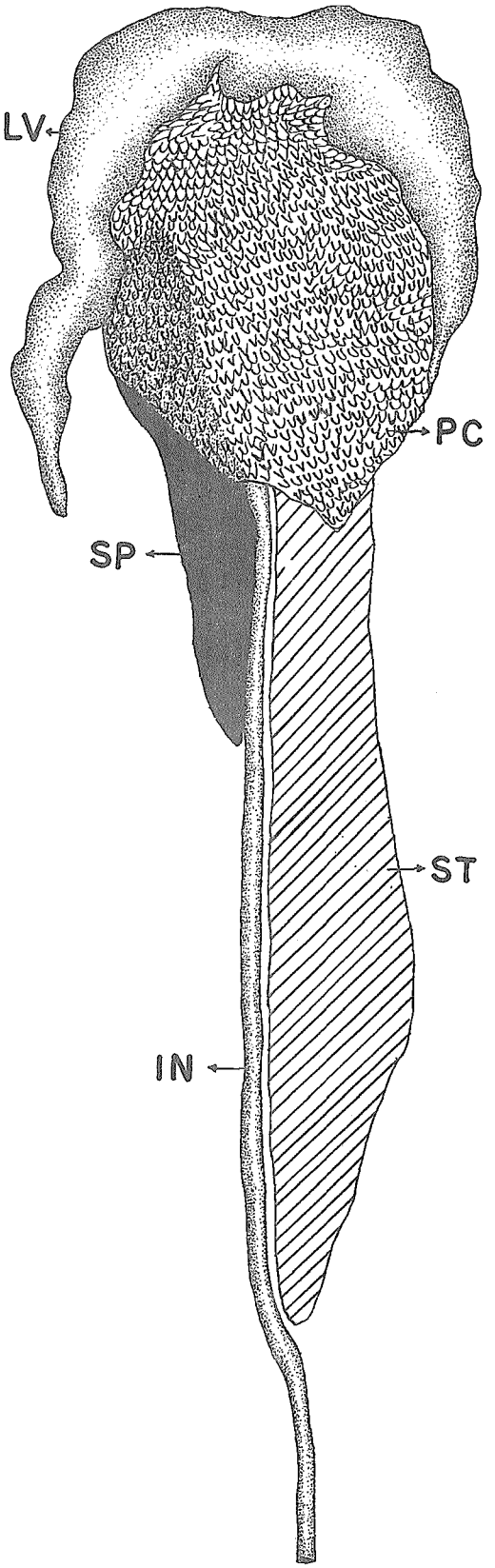


Figure 3. Gymnosarda unicolor (Rüppell).

Ventral view of the viscera in situ in a male 685 mm. (Testes not shown). (IN - Intestine; LV - Liver; PC - Caecal mass; SP - Spleen; ST - Stomach).

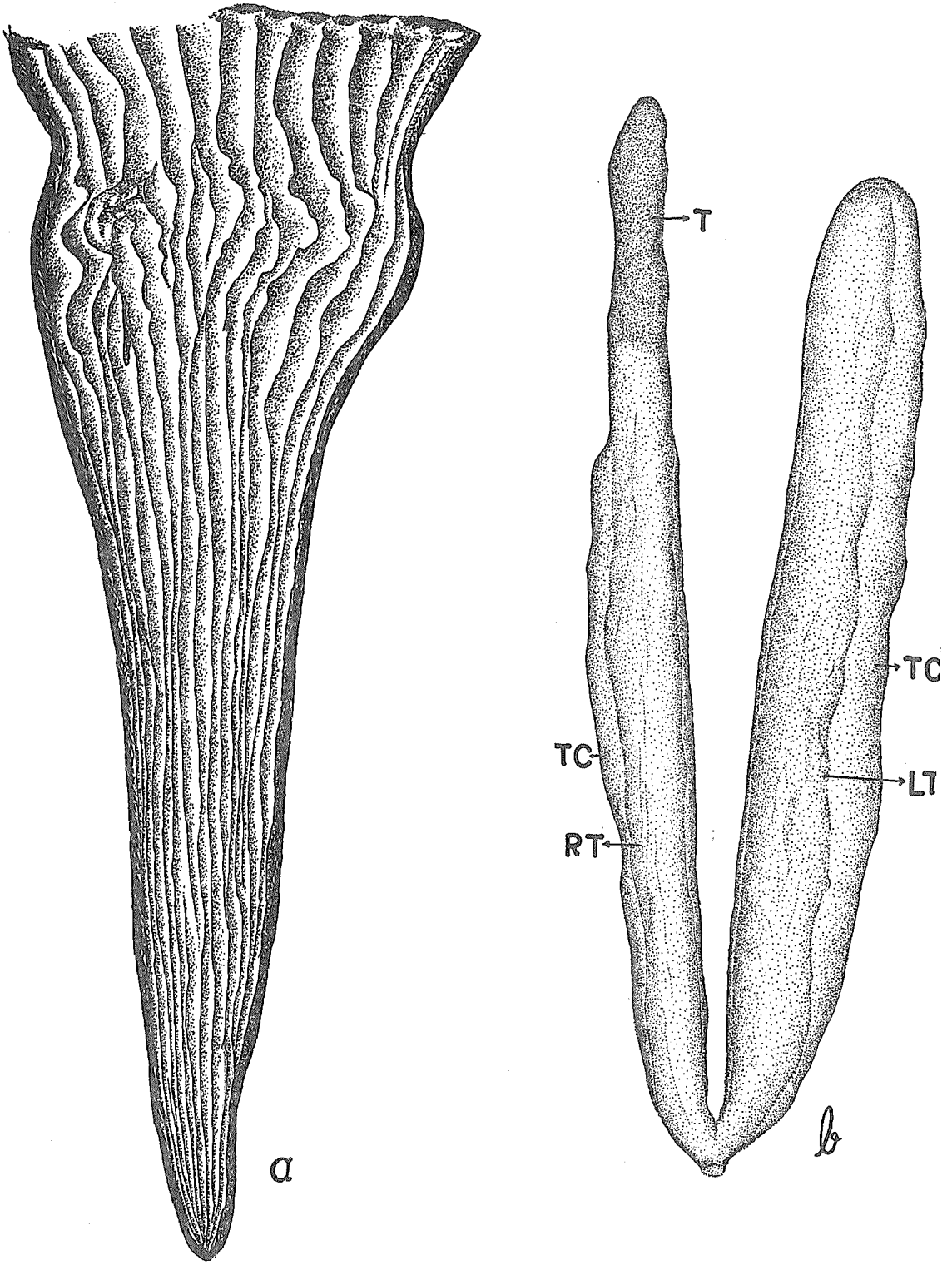


Figure 4. Gymnosarda unicolor (Rüppell)

A. Inner view of stomach - longitudinally slit showing nature and disposition of mucous folds.

B. Partly spent testes of a specimen 697 mm from Andamans:
(LT - shrunken left testes; RT - shrunken part of right testes; T - unspent distal part of right testes; TC - translucent outer covering of testes).

1.2.2 Synonyms

Thynnus unicolor	Rüppell, 1838 (nec Geoffroy St. Hilaire 1809)	
Pelamys nuda	Günther, 1860	
	Klunzinger, 1871	
Gymnosarda nuda	Kishinouye, 1915, 1923	
	Fowler, 1938	
	Herre, 1945, 1953	
	Versey-Fitzgerald and La Monte, 1949	
	Umali, 1950	
	Rosa, 1950	
	Mac Innes, 1950	
	Sette, 1952	
	Dung and Royce, 1953	
	Woods, 1953	
	Ogilby and Marshall, 1954	
	Fourmanoir, 1957	
	Migdalski, 1958	
	Munro, 1958 a, 1958 b	
	Hiatt and Strasburg, 1960	
	Jonklaas, 1962	
?Gymnosarda nuda	Chapman, 1946	
Gymnosarda sp.	Fourmanoir, 1954	
Scomber vau	Curtis, 1938	
Gymnosarda unicolor	Fowler, 1949	
	Fraser-Brunner, 1950	
	Wheeler and Ommanney, 1953	
	Williams, 1956, 1962	
	Smith, 1956	
	Blanc and Postel, 1958	
	Jones and Silas, 1960, 1962	
	Whitley, 1962	

1.2.3 Standard common names, vernacular names

See Table I.

1.3 General variability

1.3.1 Specific fragmentation (races, varieties, hybrids)

- Meristic counts

Meristic counts which are given in Table II have been given by several authors.

There is general agreement in the counts except :

1. The count of X first dorsal spines given by Wheeler and Ommanney (1953), may be exceptional for the species, being much on the lower side; so also the count of XV given by Schultz (1960) is the highest on record, the usual count being XII - XIV.

2. The anal finlets are given by Munro (1958 b as 5-6, but 5 anal finlets is unusual and on the lower side, the usual count being 6 or 7.

3. The pectoral rays of 24-26 for the Queensland specimens given by Munro (1958 b) is also on the lower side than for those from the Red Sea, Indian Ocean and Pacific (namely 26-28).

- Varieties

There can be hardly any doubt that a single species occurs in the Indo-Pacific. The data is meagre to comment on the possibilities of varieties occurring in different areas. As already mentioned above, the pectoral and anal finlet counts for the Eastern Australian specimens appear to be on the lower side, but this should be checked with good series of specimens. Surprisingly there is remarkable consistency in the gill raker counts throughout the range of the species.

The morphometric data given by Dung and Royce (1953) indicate that certain characters such as diameter of iris show relative decrease in size and increase in total length, while a character such as "length of head" shows hardly any difference in the ratios with growth.

Fraser-Brunner (1950) laid considerable stress on the interpelvic process as a diagnostic character for even distinguishing genera of Thunnidae. In the case of Gymnosarda, the interpelvic process is said to be as in Sarda and Orcynopsis, but in specimens from the Andamans examined by Jones and Silas (1960) it is not so, being in the form of a single median blade developed to a much lesser degree than seen in Auxis (Figure 2b) and would not appear to be a good diagnostic character in this case.

1.3.2 Genetic data (chromosome number, protein specificity)

- Serology

Suzuki (1961 a) while reporting on blood groups of yellowfin tuna, has given

Table I

Common and vernacular names[1/]

Country	Standard common name	Vernacular name
Australia	Dogtooth tuna	Scaleless tunny White-flesh tuna Pegtooth tuna (Queensland)
British East Africa	Rüppell's bonito	Tunny Jodari (Swahili)
Gulf of Aden	-	Moakaba (Arabic)
India	Dogtooth tuna	
Japan	Isomaguro	Tokakin
Maldives	Dogtooth tuna	
Seychelles	-	Thon gros yeux Thon blanc (young)

1/ Migdalski (1958) remarks that dogtooth tuna is known as "Lizard mouth" because it possesses large teeth.

Table II

Meristic counts of Gymnosarda unicolor

Author	Locality or area	Vertebrae	D_1	D_2+finlets	P_1	A+finlets	Gill rakers
Rüppell (1838)	Dejdda, Red Sea	-	XII	I,10+6	-	III,10+6	-
Klunzinger (1871)	Red Sea	-	XIV	I,12-13+7	26	III,10+7	-
Kishinouye (1923)	Ogasawara and Ryukyu Islands, Japan	38 (19+19)	XIV	13+7	-	12+6	2+10
Fowler (1949)	Tahiti	-	XII-XIV	-+7	-	-+6	-+10-11
Warfel (1950)	Philippines	-	XIV	13+7	-	12+6	1+1+10+12
Wheeler and Ommanney (1953)	Mauritius Seychelles	-	X-XIV[1/]	1,14+6-7	-	1,11-12+6-7	-
Williams (1956)	Off Zanzibar, East Africa	-	XII-XIV	13+6-7	-	II,12+6	12-13 (total)
Fourmanoir (1957)	Madagascar, Comores, Bancs Castor et Leven	-	XIII-XIV	11+7	-	II,10+6	13 (total)
Blanc et Postel (1958)	Reunion Is.	-	XIV	-+7	27	-+6	1+1+11 (=13)
Munro (1958 b)	Off Tropical Queensland, Australia	-	XIII-XIV	13+7	24-26	12-13+5-6	2+10-11
Schultz (1960)	Bikini Atoll, Marshall Islands	-	XV	III,10+7	ii,25 (=27)	III,10+6	1+1+11
Silas (in this synopsis)	Andaman Sea	-	XIV	III,10 (=13) + 7	27-28	III-IV 10(=13-14) +6	1+1+10-11

1/ Given in the text as 'IXIV'.

the agglutinin titer of the sera of several species of fishes including Gymnosarda unicolor (Table III).

Suzuki (1961 b) mentions that anti-human B agglutinin was also found in the sera of Gymnosarda unicolor.

Through the application of Ouchterlomy method of diffusion precipitation analysis, with rabbit immune sera, the presence of species specific differences in serum antigens of certain adult tuna were demonstrated by Ridgeway(1961). The results obtained by the most discriminating sera among those prepared is shown in Table IV.

"For example, when testing our most discriminating anti-albacore serum, we find that there are seven distinguishable precipitation lines with albacore serum, four of which cross react with yellowfin serum, five with bigeye serum, four with skipjack serum, three with Euthynnus serum and two with dogtooth serum. Thus, with this serum, the number of lines (antigens) which distinguish albacore from the other species are as follows: three with yellowfin, two with bigeye, three with skipjack, four with Euthynnus and five with dogtooth." (Ridgeway, 1961). Considerable variability between discriminatory ability of various tuna antisera were found indicating that anti-dogtooth, anti-albacore and anti-bigeye antisera possess considerable discriminatory power, while the discriminatory qualities of even the best anti-yellowfin, anti-skipjack and anti-Euthynnus antisera are not very great,

Table III

Agglutinin titer of sera of Gymnosarda unicolor
(after Suzuki, 1961 a)

Sera of fish 1/		Cells of yellowfin tuna 2/																	
	a:	4	5	6	7	8	9	16	17	18	19	20	21	22	24	25	26	27	29
(S - 62)	1/1	-	-	+	+	+	-	-	+	-	-	-	+	-	-	-	-	-	-
Gymnosarda unicolor	1/2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1/4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1/ Sera of fish collected in the western Pacific N7° - 8°, E145° - 149°.

2/ Erythrocytes of yellowfin tuna ..... collected in eastern Pacific, S5° - 6°, W128° - 129°

Note: a: 4-9 and 20 are Y - negative type

Table IV

The distinction of species of adult tuna by means of double diffusion precipitation analysis of their sera with antisera prepared in rabbits (after Ridgeway, 1961).

Antiserum	Serum (Tuna species)	No. of precipitation lines	No. of distinctive lines
Anti-Albacore	Albacore	7	-
	Yellowfin	4	3
	Bigeye	5	2
	Skipjack	4	3
	Euthynnus	3	4
	Dogtooth	2	5
Anti-Bigeye	Bigeye	11	-
	Albacore	8	3
	Yellowfin	8	3
	Skipjack	5	6
	Euthynnus	5	6
	Dogtooth	3	8
Anti-Yellowfin	Yellowfin	9	-
	Albacore	8	1
	Bigeye	8	1
	Skipjack	5	4
	Euthynnus	5	4
	Dogtooth	3	6
Anti-Skipjack	Skipjack	3	-
	Albacore	2	1
	Yellowfin	2	1
	Bigeye	2	1
	Euthynnus	2	1
	Dogtooth	1	2
Anti-Euthynnus	Euthynnus	6	-
	Albacore	5	1
	Yellowfin	5	1
	Bigeye	5	1
	Skipjack	5	1
	Dogtooth	5	1
Anti-Dogtooth	Dogtooth	11	-
	Albacore	4	7
	Yellowfin	4	7
	Bigeye	6	5
	Skipjack	4	7
	Euthynnus	4	7

2 DISTRIBUTION

2.1 Delimitation of total area of distribution and ecological characterization of this area

The occurrence of Gymnosarda unicolor has been reported from the following areas:

Red Sea: Djedda

Indian Ocean: Off Mafia Island; south of Zanzibar, Minicoy, Laccadive, Maldive Islands; Basses Reef south east of Ceylon; off Port Blair, Andamans; St. Davis, Reunion, Mauritius, Madagascar, Comores, Banes Castor and Leven, Rodriguez, Seychelles, Aldrabra Islands; Hawkins, South Amirante, St. Brandon and Constant Banks

Pacific Ocean: Eniwetok, Marshall Islands; northern and western Marshall Islands, Emerald Reef; north east of Basses group; off Nubara Island; Bougainville Straits; Loluei Port, Kieta Harbour; Cannae Rock; off Woodlark Island; Carteeret group; Feni Island; Tami Island; Seeadler Harbour; Gasurata; Louisiade Archipelago; Solomon Islands; Langhalan Island; New Ireland; New Britain; Admirality Island (New Guinea or Papua); Ogasawara Island; Tokaiu (Ryukyu Islands, Japan); Tahiti; ? Gizo Island in north Solomons; and the following localities from the Philippines - Zambauga, Mindano; Lubang Island; Tailan Island, off north coast of Camarines norte Province, Luzon; off Verde Island; Verde Island passage; Tubataha Reef; Sulu Sea; Gulf of Leyte; off east coast of Leyte and Si Amil Island off east coast of British North Borneo.

According to this information the geographical distribution of the species ranges from longitude 40°E to about 155°E and from latitude 30°N to about 35°S, this area covering parts of the tropic and sub-tropic sections of the Indian and Pacific oceans (Figure 5).

There are hardly any reports of Gymnosarda unicolor having been caught in the high seas. Invariably they are caught near reefs adjacent to islands or the mainland and as can be seen from Figure 5, most of the records are from the vicinity of areas where live coral reefs are known to occur.

2.2 Differential distribution

Primarily a reef dweller - see under 2.1.

2.2.1 Areas occupied by eggs larvae and other junior stages: annual variations in these patterns, and seasonal variations for stages persisting over two or more seasons. Areas occupied by adult stages; seasonal and annual variations of these

- Adults

All indications are that adult Gymnosarda unicolor is found close to coral reefs. Underwater observations off Basses Reef, Ceylon (Jonklaas, in litt.) indicate that the fish is found solitary or in groups of five or six. Williams (1959, 1962) suspects that some of the shoals seen off east African coast, may represent Gymnosarda or mixed schools of Gymnosarda and yellowfin. If so, it is not known whether during any particular season or phase of life the fish moves about in large shoals. However, six specimens taken by surface trolling were all from very close to the fringing reef.

Large Gymnosarda unicolor are caught by surface trolling or hand lines or on rare occasions landed by pole and line using live bait (along with yellowfin) at Minicoy. At Minicoy, on rare occasions one or two specimens may be spotted among large catches of yellowfin and P.T. Thomas (in litt.) informed the author that invariably on such occasions fishing was carried out close to the reef for yellowfin. The fish could have been attracted to the live bait as it is highly unlikely that they are from mixed schools. Minicoy fishermen know Gymnosarda unicolor only as a rarity in their catch and have never seen it in shoals. Jonklaas (1962) reports seeing this species underwater close to the entrances to lagoons in the Maldive Islands. Schultz (1960) also mentions that "This species (Gymnosarda nuda = Gymnosarda unicolor) was the most frequently caught of all the tuna in the

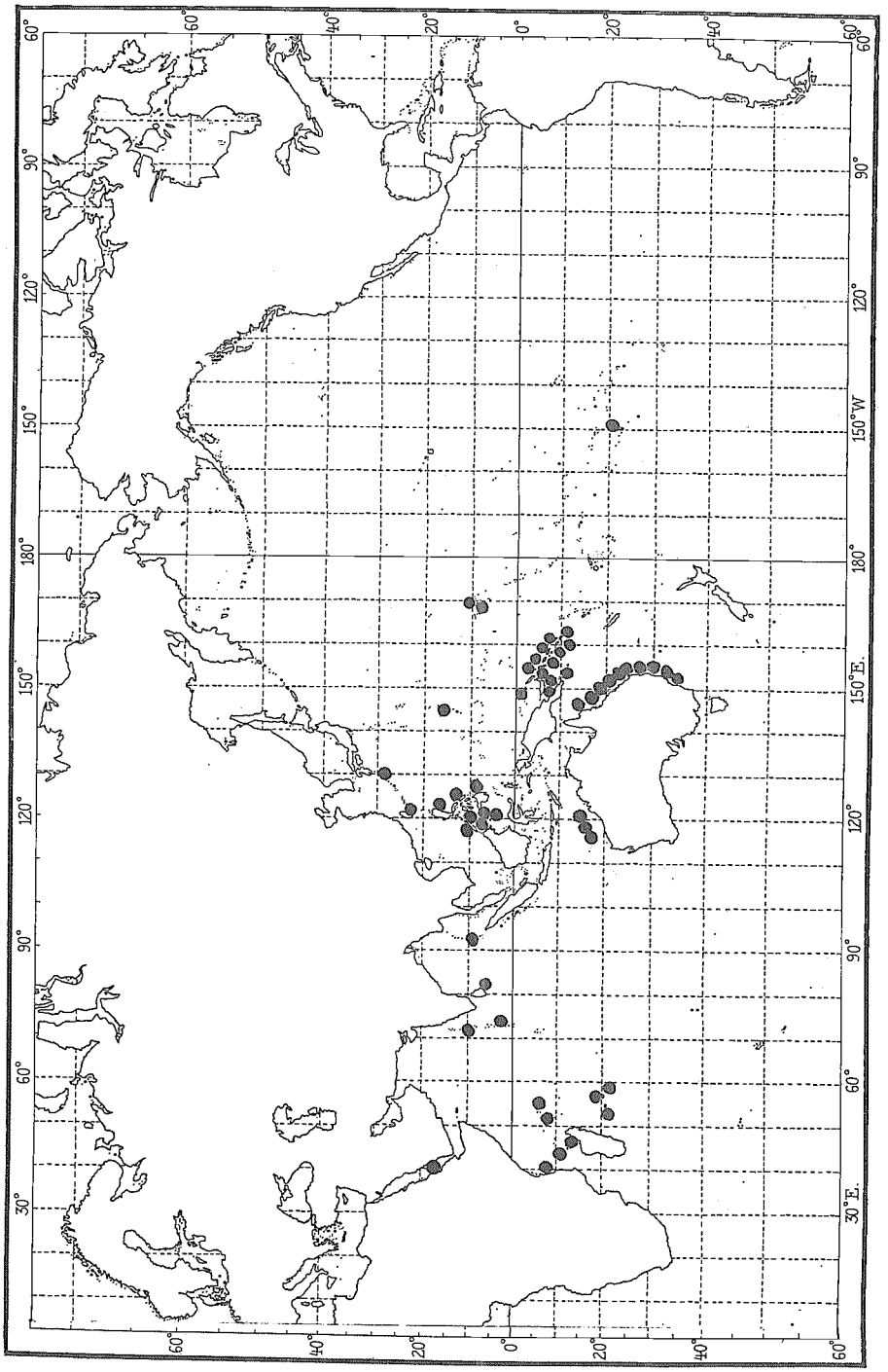


Figure 5. Geographical distribution of Gymnosarda unicolor (Rüppell). Black circles indicate localties from where the species has been collected one or more times.

northern Marshall Islands, being especially abundant in the entrances into the lagoons".

2.3 Behaviouristic and ecological determinants of the general limits of distribution and of the variations of these limits and of differential distribution

Nothing is known about the behaviouristic and ecological determinants of larval and post-larval stages. The distributional patterns of half grown and adults indicate that temperature may be an important factor for limiting the habitat of the species to mainly tropical waters. Within this range as mentioned under 2.2 it is characteristically found in the vicinity of reef building corals. However, its non-occurrence around Hawaiian waters in the Central Pacific and further eastwards is interesting.

"Voracious fish, resorting to rocky bottoms of coastal waters in small shoals of tens or scores, devouring Caesio, Decapterus, etc. Not found in offshore waters." (Kishinouye, 1923). He also gives the temperature range of this species as 20°C - 28°C.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality (hermaphroditism, heterosexuality, intersexuality)

Heterosexual. No external observable characters are known to distinguish males and females.

3.1.2 Maturity (age and size)

A serious limitation to maturity studies is the comparative rarity of the species, and it is not often that mature specimens are taken. All female specimens examined from the Andamans and Laccadives appear to be immature, the gonads just developing. A male 685 mm was obtained in a partly spent and oozing condition during the last week of February from Andamans.

According to Williams (1962) in east African waters from off the east coast of Mafia Island, Tanganyika "Three specimens were taken on 8th January 1953, two on 3rd December 1955 and one on 17th January 1956; specimens were also lost in those days". The maturity data of these in the order of capture were as follows :

Tl.cm	Wt.lb	Gonad maturity
142	78	Mature running V
125	45	Mature running V
121	41	Mature running V
137	70	Mature nearly ripe IV
126.5	48	Mature ripe IV
145	80	Not recorded

Kishinouye (1923) reports that this species attains a large size of about 240 cm with a weight of about 80 kg (176 lbs) "but fishes now commonly caught at Ogasawara Islands are 100 cm - 150 cm in length and 20 kg - 30 kg (44 - 66 lbs) in weight". Williams (1962) remarks that specimens taken by game fishermen off Mafia ranged from 40 lbs to just under 100 lbs; those reported by Wheeler and Ommanney in the Seychelles - Mauritius area were from 78 cm - 115 cm at 12 lbs - 38 lbs. The maximum size for Philippine waters is given as 48 lbs with an average of 16 lbs (Herre, 1945). From western Marshall Islands and eastern Carolines, Dung and Royce (1953) have given morphometric data on fish 52 cm - 108 cm in total length weighing from 4 1/2 lbs to 41 lbs. Ogilby and Marshall (1954) mention that off Queensland waters "examples of 50 lbs and 90 lbs are captured though the average size is much smaller. Although said to reach 8 feet in length, Queensland examples are about 4 feet or so". Migdalski (1958) speaks of a specimen 151 lbs taken off Tahiti (Fitzgerald and La Monte 1949) while another specimen, a 75 pounder was taken on rod and reel in the vicinity of Seychelles Islands, Indian Ocean. Fourmanoir (1957) noted a large specimen (143 lbs) captured off the Mauritius. A male 685 mm examined by the author at Andamans in February 1960 was partly spent and oozing. These scattered data of disjunct size groups throws little light on maturity stages, nor is any information available about the age of these investigated mature specimens.

3.1.4 Fertilization (internal, external)

External. As in the case of other scombroids, the eggs should be pelagic.

3.1.6 Spawning

- Spawning seasons (beginning, end and peak)

Only scanty information is available. Off Ogasawara and Ryukyu Islands, Kishinouye (1923) mentions that the spawning season is May - June, when better catch is also expected. Speaking of specimens collected from northern Marshall Islands, Schultz (1960) remarks that "during the spring it is in a spawning condition". Williams (1962) remarks that "from the six specimens caught it seems likely that the species spawn off the Mafia coast (Tanganyika, east Africa) in the north east monsoon". Dunstan (1961) has found the species to spawn in March, August and December in the sea east of Samarai, Papua.

- Number of spawnings per year, frequency

Information is scanty. Dunstan's (1961) findings (see also Whitley, 1962) would indicate more than one spawning per year, and during each spawning period (March, August and December) the shedding of eggs in batches. Kishinouye (1923), Schultz (1960) and Williams (1962) refer to only a single spawning season per year.

3.7.1 Spawning grounds

The discovery of a Papuan spawning ground east of Samarai in March 1958 (Dustan, 1961; Whitley, 1962) appears to be the only definite known spawning area of this species. Suspected spawning grounds include: (1) off Mafia Island, Tanganyika, east Africa (Williams, 1962) northern Marshall Islands (Schultz, 1960); off Ryukyu Islands, Japan (Kishinouye, 1923); and off Port Blair, Andamans (see under 3.1.2).

This species is found essentially in the upper layers close to reefs. As in the case of the double-line mackerel Grammatorcynus bicarinatus (Quoy and Gaimard), or the wahoo Acanthocybium solandri (Cuvier), it may not undertake extensive migrations, and it may not be wrong to presume that spawning may be localised, the fish breeding in the vicinity of the reefs along which they occur.

3.3 Adult history

3.3.1 Longivity

No information except some observations in size attained given under section 3.1.2.

3.3.2 Size

See under 3.1.2.

3.4 Nutrition and growth

3.4.1 Feeding (time, place, manner, season)

Available information is very scanty. According to Kishinouye (1923) "Voracious fish ..... devouring Caesio, Decapterus, etc". Specimens caught in the northern Marshall Islands were frequently found to have Caesio and Pterocaesio in their stomachs (Schultz, 1960). Hiatt and Strasburg (1960) who examined two specimens mention that "neither of these specimens, caught by hook and line near a pass in the Evinetok Lagoon had food in their stomachs, although others were often seen in small schools slashing through the dense schools of round herring near the pier ..... the senior author noted the stomachs of this species at Bikini to contain scads (Decapterus sanctaehelenae) as well as pelagic squid, flying fishes, and other small schooling types." (Hiatt and Brock, 1948). Woods (1953) mentions Decapterus muroadsi as forming an item of the food of this fish in northern Marshall Islands. Fourmanoir (1957) mentions Caesio as an important food item. Most of the specimens examined by the author from the Andamans and Laccadives had empty stomachs while two had small quantities of digested unidentifiable fish remains.

3.4.2 Food (type, volume)

A detailed study of the food and feeding habits of the dogtooth tuna is wanting. Data given under 3.4.1 indicate fish to be the main food item while squids have also been noted in the stomach inclusion.

3.5 Behaviour

3.5.1 Migration and local movements

No information on migration.

Kishinouye (1923) mentions that the fish is found in coastal waters with rocky bottom. Hiatt and Brock (1948), Hiatt and Strasburg (1960) and Schultz (1960) report this species from the entrance of lagoons or their vicinity. Hiatt and Strasburg (1960) further mention that "this species seems to swim more than species of either Katsuwonus or Euthynnus which also occur inside the lagoons and in the surrounding seas". Jonklaas (1962) has conducted underwater observations on this species off Basses Reef, Ceylon and in the Maldives where he has also observed them at the entrance of lagoons. In the Laccadives at Minicoy Island, the fish has not been observed in the lagoon, but on rare occasions one or two are landed by pole and line along with yellowfin, when fishing is carried out close to the reef. All these may be in agreement with Kishinouye's (1923) remark that the species is "Not found in offshore, waters", though pelagic, rapid swimming

and carnivorous in habit. However, Williams' (1962) remarks on tuna shoals off east Africa that "It is thought possible that some of the Type I and III surface tuna shoals may, in fact, be composed, or partially composed of Gymnosarda unicolor (Rüppell)" is interesting.

3.5.2 Schooling

Most of the available information point to Gymnosarda unicolor as moving in very small schools of a few specimens as Kishinouye (1923) mentions "in small schools of tens or scores". The suspected occurrence of pure or mixed schools of Gymnosarda off the east African coast off Mafia Island (Williams, 1962) appears quite unusual. Our present state of knowledge of the species does not permit us to infer as to whether the species resorts to associating in larger schools during certain periods, or whether it associates with other tunas as often as skipjack and yellowfin are known to mix.

3.5.3 Reproductive habits

As in some other scombroids, it is likely that spawning may be over an extended period, when eggs may be shed in more than one batch. Dunstan's (1961) observation indicates more than one spawning season in the same year. See under 3.1.6.

4 POPULATION

4.1 Structure

4.1.1 Sex ratio

No definite information.

Of seven specimens examined from the Andamans, two were males, one female and the rest very immature. Two specimens listed by Dung and Royce (1953) from the western Marshall Islands, 16 are males, 19 females and the rest sex indeterminate.

4.6 Relation of population to community and ecosystem, biological production, etc.

The only available information appears to be given by Hiatt and Strasburg (1960) where they class Gymnosarda nuda (=Gymnosarda unicolor) as a species of both the midwater and surface communities, since like some larger carnivorous fishes it ranges rather widely, entering both areas on occasion. In the Marshall Islands "The important species in the surface community are listed below:

Family Mobulidae (manta rays) - M. alfredi; family Dussumieridae (round herrings) - S. delicatulus; family Belonidae (needle fishes) S. jcisa, S. gigantea; family Hemiramphidae (half-beaks) H. affinis, H. laticeps; family Atherinidae (silversides) - A. ovaloua, A. pinguis; family Scombridae (tunas) - G. nuda, K. pelamis, E.a. yaito; family Sphyraenidae (barracuda) - S. genie; family Carangidae - S. sanctipetri".

The important species in the mid-water community are the following:

Family Carcharhinidae (Gray sharks) - C. melanopterus, C. menisorrah; family Trikidae (smooth dogfishes) - T. obesus; family Holocentridae (squirrel fishes) - M. berudti, M. microphthalmus; family Aulostomidae (trumpet fish) - A. chinensis; family Fistularidae - F. petimba; family Atherinidae (silversides) - S. temmincki family Scombridae (tunas) - G. nuda, K. pelamis, E. a. yaito; family Sphyraenidae (barracuda) - S. genie; family Carangidae (Jacks) - T. bailloni C.f.jordani, C. melamphygus, S. sanctipetri, E. bipinnulatus; family Serranidae (groupers) V. louti, P. leopardus, P, truncatus; family Lutjanidae (snappers) - L. monostigmus, L. bohar, L. vitta, A. virescens, L. miniatus".

(Hiatt and Strasburg, 1960) (Figure 6).

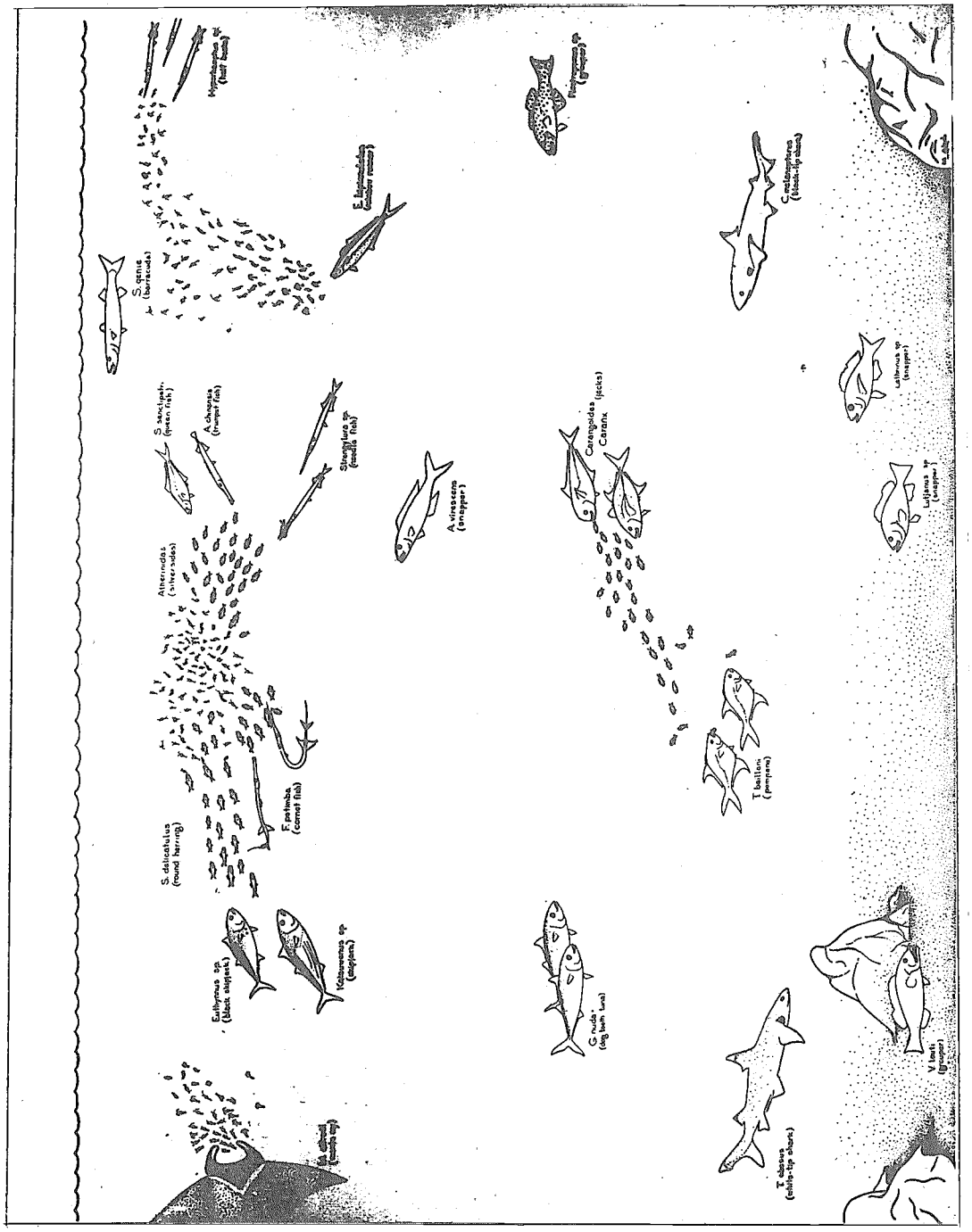


Figure 6. The mid-water and surface community in the coral reefs of Marshall Islands showing the typical habitat of Gymnosarda unicolor (after Hiatt and Strasburg 1960).

5 EXPLOITATION

5.1 Fishing equipment

5.1.1 Fishing gear

"Caught with harpoons, hand-lines and trolling lines at the Ogasawara and Ryukyu Islands. Caught 20 m - 200 m off with hooks dressed with live baits." (Kishinouye, 1923). For catch data by surface trolling reference may be made to Wilson, Nakamura and Yoshida (1958) and Yoshida (1960) for the Marquesas area (Pacific) and Williams (1962) for east African waters. At Andamans it is caught with hand lines, while at Minicoy they are occasionally taken in pole and line fishing using live bait.

5.1.2 Fishing boats

No special boats are used for fishing for Gymnosarda unicolor. However, two typical Andamans fishing boats used for hand line fishing from which other scombroids such as Kishinoella tonggol (Bleeker), Grammatorcynus bicarinatus (Quoy and Gaimard) Scomberomorus spp., Acanthocybium solandri (Cuvier) etc. are regularly caught are shown in Figures 7a and 7b).

5.2 Fishing areas

5.2.1 General geographic distribution

There are no areas in which a specific fishery for Gymnosarda unicolor exists. Information available indicates that they are caught in small numbers regularly at certain seasons at Port Blair Andamans; certain parts of the Philippines; outside the reefs off Queensland, and near Ryukyu Islands and Ogasawara Island, Japan. See also under 2.1.

5.2.2 Geographical ranges (latitudes, distances from coast, etc.)

See under 2.1.

5.2.3 Depth ranges

Hiatt and Strasburg (1960) class this as belonging to surface and mid-water community. In Andamans it is usually caught from waters about 20 - 50 fathoms deep.

5.3 Fishing seasons

5.3.1 General pattern of fishing season

Off Ogasawara and Ryukyu Islands, Kishinouye (1923) mentions that a better catch is expected in the spawning season, May and June, though it is caught all the year round. No definite information from other areas. See also under 3.1.6.

5.3.2 Duration of fishing season

No information except that given under 5.3.1 and in the Andamans most of the specimens caught are between January and March.

5.3.5 Factors affecting fishing season

No information except Kishinouye's (1923) statement that "Bites hooks readily in the twilight. When there is no tidal current the fish is easily caught. A better catch is expected in the spawning season .....".

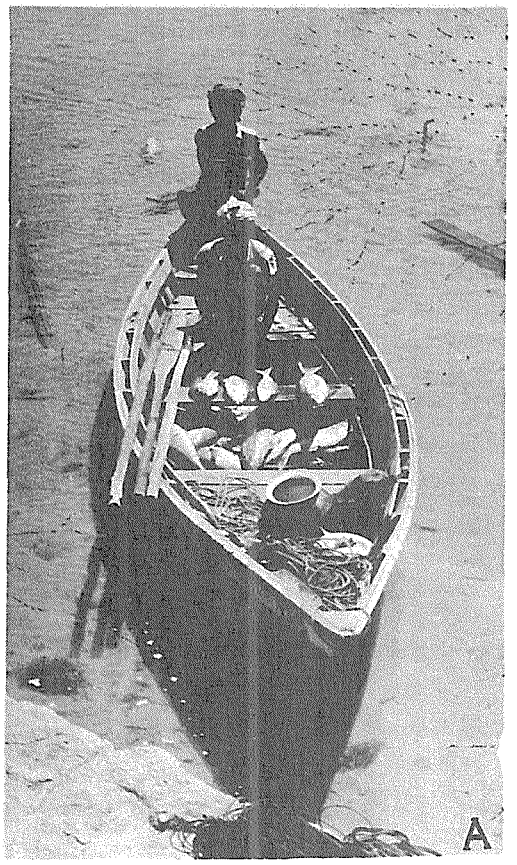


Figure 7. Two types of Andaman fishing boats (a and b) from which scombroid fishes are caught with hand lines from the reefs off Port Blair.