The Tunas and Tuna-like Fishes of India

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THE TUNAS AND TUNA-LIKE FISHES OF INDIA

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C O N T E N T S

PREFACE

The tunas and related fish species, having a wide distribution mostly in the tropical and sub-tropical regions of the world's high seas, are a rich resource which is being harvested with economic success by all progressive maritime nations who possess large and adequately equipped fishing fleet with trained personnel fully acquainted with the know-how of the fishing techniques. The high seas are open for exploitation by any country which has the necessary means. Although India's tuna fishing at present is unfortunately restricted to close shore waters, there is much valuable published information on the systematics, species distribution , their biology, behaviour in relation to fluctuating environmental conditions, approximate potential resources, etc. The FAO Fisheries Reports published in 1963 incorporating the Proceedings of the World Scientific Meeting on the Biology of the Tunas and Related Species and the Marine Biological Association of India's Proceedings of the Symposium on Scombroid Fishes held in 1962 are the foremost among the recent publications on the subject but these, owing to a limited number of copies only being available for scientific institutions of the world over, are not readily on hand for reference by most scientific workers.

The main objective of this Bulletin is to present the basic information on the biology and fishery aspects of the tunas and tuna-like species in and around the seas of India. This Institute has made valuable contributions to the knowledge on the subject in the past two decades and here, these works and the work done elsewhere by other workers in the field have been summarized and the information compiled for ready reference to the interested scientific workers.

This Bulletin is 23rd in the series issued by the Institute on topics related to Indian fisheries and it is hoped that this will be as much welcomed as the other preceding ones. I offer my sincere thanks to my collaborators and other members of the staff of the Institute who helped me in various ways in bringing out this publication.

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Dec. 2 1970.

I. INTRODUCTION

Tunas are a major constituent of the pelagic-oceanic fisheries in the tropical and sub-tropical seas around the world. Some of the species as the albacore, bigeye, bluefin, skipjack and yellowfin are widely distributed over a great part of the world oceans and support fisheries of considerable importance, being exploited by some of the maritime nations, chief among them being Japan, United States of America, U.S.S.R., China (Taiwan) and Spain. Most tunas are migratory and their movements are related to the shifting features of the oceanic environments. As the fishing grounds are beyond the territorial waters, the different nations exploit the resources from the same productive regions, a fact which warrants international understanding to regulate and conserve the available resources. The estimated tuna and bill fish landings from the Indian Ocean currently stands at about 175 thousand metric tons which is expected to be doubled by 1975. While Japan and U.S.S.R. are the leading nations exploiting the Indian Ocean resources, other countries like Australia, Union of South Africa and Malaysia, Pakistan and Ceylon are also deeply interested in developing their oceanic fisheries. Most of the oceanic species grow to very big size and lend themselves for canning and processing by other methods, the products finding a ready market in all progressive countries.

This Research Institute has been engaged in the study of tunas and billfishes occurring in the Indian seas. Systematics and varied aspects of the biology of these fishes have been studied in detail. While most of the studies are confined to species occurring in close shore waters, the oceanic resources of the Arabian Sea, off the south west coast of India and the Laccadive Sea have also been explored. In the chapters which follow, the basic information so far available has been compiled on the systematics, distribution, biology, life histories, methods of exploitation of the nominal species occurring in the Indian waters.

All the species dealt here belong to a single sub-family viz., Thunninae, under the family Scombridae, sub-order Scombroidei of the order

Perciformes. They are described under the genera *Auxis, Sarda, Gymnosarda, Katsuwonnus, Euthynnus* and *Thunnus,* the last of which including four sub-genera viz., *Thunnus* S. Str., *Parathunnus, Neothunnus* and *Kishinoella.*

At the Dakar Tuna Symposium held in December, 1960, in informal discussions, Talbot from South Africa and Williams from East Africa expressed the opinion that the sub-genera, sometimes also treated as genera, viz., *Neothunnus, Parathunnus, Kishinoella* and *Germo* should be relegated to the genus *Thunnus,* in view of the differences between them having been considered specific rather than generic. At the Pacific Tuna Biology Conference held in Hawai in August, 1961, Collette (1961) also has expressed the same opinion. Rodel and Fitch (1961) considered the generic name *Germo* as identical with Thunnus but retained *Parathunnus, Neothunnus* and *Kishinoella* as distinct generic names.

In the present work the nomenclature adopted is essentially that followed by the various scientists of this Institute and where there is any departure in adopting the earlier names, the reasons for so doing have been indicated in the text at appropriate places. As far as possible the sub-specific names have been dropped, following Collette and Gibbs (1963) and Talbot and Penrith (1963). *T. (Neothunnus) albacares macropterus* and *T. (Neothunnus) itosibi* which were treated separately by Jones and Silas (1960, 1962 and 1963a) have been here considered synonymous following Talbot and Penrith (*Ioc. Cit.*) and Iwai *et al.* (1965) as they represent different growth stages (see figure 14). The key to the identification of the Indian species is very much the same as given by Jones and Silas (1963a) with slight modifications to include the above changes. The double lined mackerel *Grammatorcynus bicarinatus* with double lateral line system is not included here as it is distinct from the tuna and tuna-like forms; *Cybiosarda elegans* which is distinguishable from *S. orientalis* by the presence of spots instead of horizontal lines on the dorsal half of the body, above the lateral line is also not included as it has not so far been recorded from the Indian coasts.

KEY TO THE IDENTIFICATION OF TUNAS

1. First and second dorsal fins separated widely by distance exceeding length of base of first dorsal…………………………….…………………………………………………………… 2

1 a. First and second dorsal fins contiguous or separated by a narrow interspace not exceeding diameter of orbit…………………..……………………………………………………… 3

2. Corselet short, tapering abruptly along the lateral line behind the first dorsal; not more than four rows of scales in a line below second dorsal; total number of gill rakers 39-42…..………………………………….*Auxis thazard* (Lacepede)

2 a. Corselet long, continuing as wide band along lateral line behind first dorsal, with 7-12 rows of scales in a line below seventh dorsal finlet; total number of gill rakers 40-47……...…………………….....………….*Auxis thynnoides* Bleeker

3. Length of maxilla, half or more in length of head; end of maxilla surpass vertical below middle of orbit……...………………………………………………………………………4

3 a. Length of maxilla less than half length of head; end of maxilla does not surpass vertical below middle of orbit………...………………………………………………………………6

4. Vomer without teeth; finlets 6 to 8/5 or 6………….………………………………………5

5. First dorsal spines 18 or 19; maxilla surpassing vertical below posterior border of orbit; 6 to 9 horizontal dark stripes on upper half of body in adult….…………………………..………………*Sarda orientalis* (Temminck and Schlegel)

5a. First dorsal spines 12-14; maxilla reaching to vertical below posterior third of orbit; no dark stripes on body……………………………………………….*Gymnosarda unicolor* (Ruppell)

6. Body naked except for corselet and lateral line…………………………………………………………..……………………7

6a. Body completely scaled; those of corselet and lateral line usually larger……………………………………………………..………..9

7. First dorsal with 15 spines; total gill rakers not exceeding 60; body with conspicuous colour pattern…………………………………….....…8

8. Four to six dark conspicuous longitudinal stripes on lower half of body; gill rakers 14 to 18+ 33 to 42 …………………………………………...………..*Katsuwonus pelamis* (Linnaeus)

8a. No dark stripes on lower half of body; a few black spots on body below pectoral base; gill rakers 7 to 10+22 to 25…………………..………………………*Euthynnus affinis affinis* (Cantor)

9. Origin of second dorsal nearer to posterior end of caudal keel than to posterior margin of orbit ………………………………………..……..10

9a. Origin of second dorsal nearer to posterior margin of orbit than to posterior end of caudal keel……………...............…………………………12

10. Pectoral short, less than head length excluding snout and falling short of vertical below anterior insertion of second dorsal by distance equalling almost its own length; posterior margin of preoperculum rounded ……………………………………......*Thunnus (Thunnus) orientalis* (Temminck and Schlegel)

10 a. Pectoral elongate, one to one and a half times the length of head and surpasses vertical below anterior insertion of second dorsal; posterior margin of preoperculum more or less angular ……………………………..…………………………11

11. Gill rakers on lower limb 19-21; surface of liver markedly striated; vent rounded; distance between tip pectoral and end of caudal keel much less than head length ………………………................*Thunnus (Thunnus) alalunga* (Bonnaterre)

11a. Gill rakers on lower limp 16-18; liver with faint striations on margin only; vent elliptical; distance between tip of pectoral fin and end of caudal keel greater than head length …...*Thunnus* (*Parathunnus*) *obesus sibi* (Temminck and Schlegel)

12. Gill rakers 19-26 of which 13-19 on lower limb; air bladder absent; finlets dusky and only faintly tinged with yellow…..………………………………*Thunnus* (*Kishinoella*) *tonggol* (Bleeker)

12 a. Total gill rakers 27-32 of which 19-20 on lower limb; air bladder present; finlets lemon yellow with narrow dusky edging ……………………..…………(*Thunnus* (*Neothunnus*) *albacares* (Bonnaterre)

(The first four species are considered to be tuna-like fishes and the rest as tunas proper)

II. FRIGATE MACKERELS

Genus ***AUXIS*** Cuvier, 1829

Body fusiform, elongated, rather rounded in cross section. Scales only on the corselet but not on the rest of the body. Jaws with a single row of minute teeth; palate edentulous. Dorsals two and distinctly separate from each other; first dorsal large with ten spines and second dorsal small; six to nine finlets behind dorsal and anal; lateral line curved with small undulations. Caudal portion relatively much shorter than the precaudal portion. Gill rakers long and numerous. No air vessels; vertebrae 39. Branchiostegals 7.

The interpelvic process is large and characterstic of the genus *Auxis*. It is undivided and reaches almost to the tip of the ventral fins.

Distribution: Atlantic, Indian and Pacific Oceans.

AUXIS THAZARD (Lacepede), 1802

Synonyms

Scomber thazard Lacepede, 1802
Scomber bisus Rafinesque, 1810
Thynnus rochenus Risso, 1826
Auxis taso Cuvier, 1831
Auxis vulgaris Cuvier, 1831
Auxis tapeinosoma Bleeker, 1854
Auxis hiva Kishinouye, 1915
Auxis thazard Jordan and Evermann, 1896; Steindachener, 1896;
Fowler, 1928, Smith, 1949; Rivas, 1951; Herre, 1953;
Munro, 1955; Jones and Silas, 1960; 1962& 1963a; Williams, 1963 a.

Common names

Short corseletted frigate mackerel
Tamil – Churai, Urulan – churai, Kutteli-churai.
Sinhalese – Ragodwa.

Description

D^1. X-XI; D^2. 11-13+ 8; P^1. 24; A. 13+7; G.R. 9-10+29-32 = 39-42.
Head 3.2 to 3.8; depth 3.9 to 4.5 in standard length. Snout 3.62 to 4.0; eye 5.0 to 5.8 in head.

Body robust, slightly compressed laterally; head large, snout tapering. Mouth oblique; teeth minute, conical, present on both jaws, absent on palatines, but occasionally a few scattered on vomer. Interorbital wider than eye. Dorsal fins separated by a distance shorter than length of head. First dorsal spine largest, equal to fin base. Scales on corselet and not on the rest of the body. Corselet short but tapers abruptly and extends posteriorly on the lateral line as a narrow band. Caudal peduncle elongated ; lateral keel poorly developed. Caudal widely forked.

Colour:- Bluish above, dark on head, pale or light brow below. Above and behind the corselet oblique black bars present (Fig. 1A).

There is an overlapping of characters between *Auxis thynnoides* and *Auxis thazard* in regard to the nature of the corselet and the gill raker counts. Typically in the former species the corselet is long and broad, and in the latter short and narrow (Fig. 1B and 1C). In juvenile individuals of those two species in same size range, this distinction is very marked. However in adults intermediate conditions are generally met with. In *A. thazard* instead of abruptly tapering behind the pectorals, it sometimes gradually narrows along the lateral line (Fig. 1D). The gill raker counts are generally less in *A. thazard*. Both these characters taken together will help distinction between these two species.

Variability

Meristic counts of the samples from South Africa, East Indies, Ceylon and Australia are given below for comparison with the Indian specimen.

South Africa: D^1. XII; D^2. iv, 10+7-8; A. iv, 10+7; G.R. 10+31=41
(Fowler, 1934)

South Africa: D^1. XI; D^2. 11-12+8; A. 13+7; G.R. 30 (lower limb).
(Smith, 1960)

East Indies: D^1. X; D^2. 11+6-9; A. 14+6-8. (de Beaufort and Chapman, 1951)

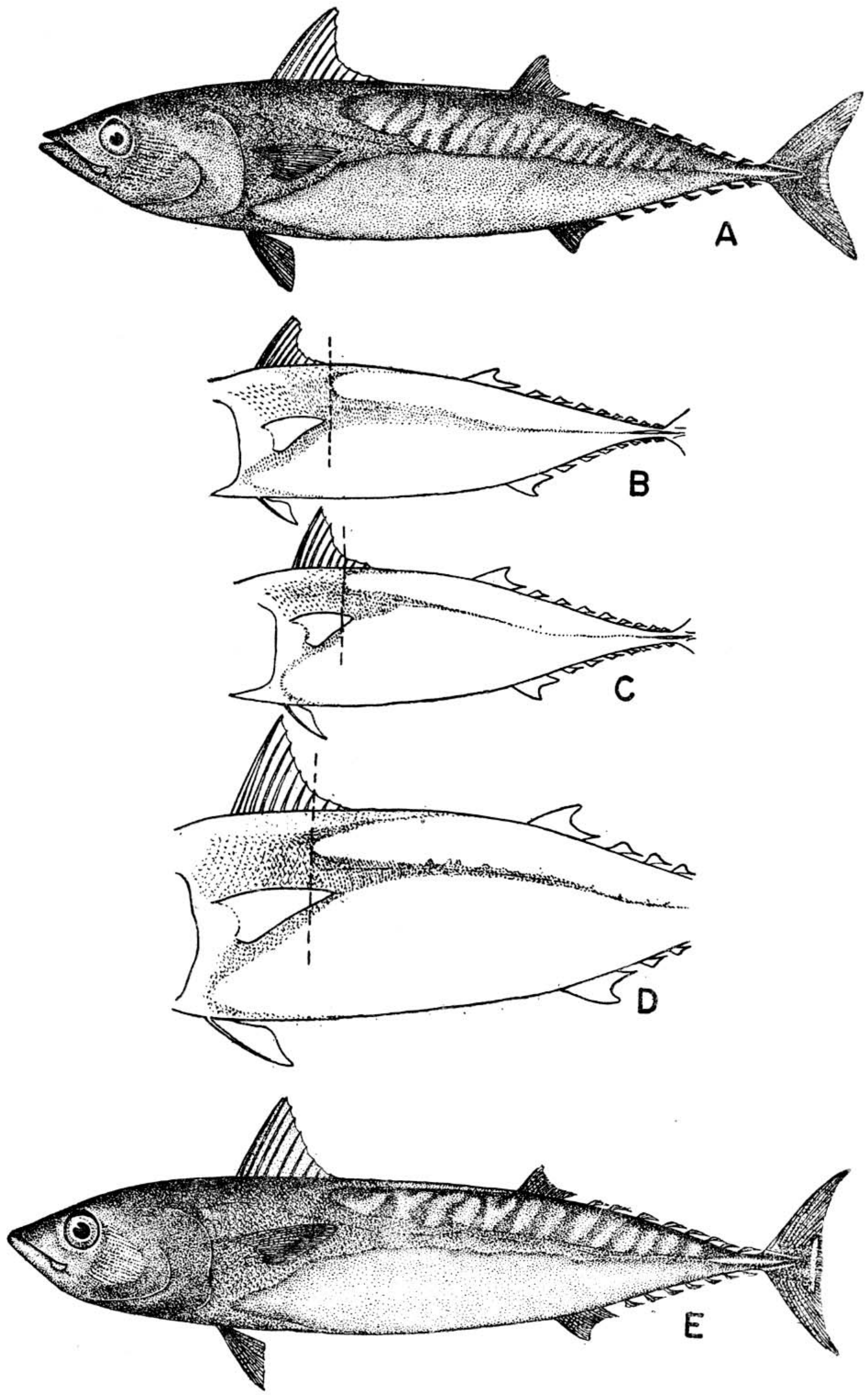


Fig. 1. **A**. Adult ***Auxis thazard*** (Lacepede). **E**. Adult ***Auxis thynnoides*** Bleeker. B-D. Corselet structure in relation to pectoral fin : **B**. ***A. thynnoides*** 255 mm; **C**. ***A. thazard*** 243 mm; **D**. ***A. thazard*** 371 mm (after Jones and Silas, 1963a).

Ceylon: D^1. X; D^2. 11+6-9; A. 14+6-8. G.R. 30 (lower limb) (Munro, 1955).

Australia: D^1. X-XII; D^2. 12+8; A. 13+7; G.R. 10-11+28-32. (Munro, 1958).

Distribution

The general distribution includes Indian, Atlanic, Mediterranean and the Pacific Oceans. In the Indian Ocean it is known from the east coast of South Africa, Gulf of Aden, West and east coasts of India, Laccadives, Ceylon and west coast of Australia.

BIONOMICS AND LIFE HISTROY

Food and feeding

Juveniles between 49 mm and 132 mm of *A. thazard* from Vizhinjam coast, obtained by shore seines showed fish as the major item of food, followed by cephalopods and crustaceans. In the smaller juveniles it was found that the cephalopods were absent, and *Anchoviella* and *Leiognathus* constituted the common fish species (Kumaran, 1962). In Japanese waters *A. thazard* caught by trolling lines showed skipjack, frigate mackerel, jack mackerel, flying fishes, squids, etc. as their food items (Yokota *et al.*, 1961).

Age and growth

In the exploratory fishing operations carried out by R.V. 'Varuna' along the southwest coast of India and Laccadive sea, *A. thazard* has been obtained both in the shelf area and also in the oceanic waters. In the drift net operations carried out 153 speciemens of *A. thazard* were caught ranging in size from 201 to 510 mm,. majority of them falling in size groups between 370 and 430 mm in total length (Silas, 1969).

Reproduction

Sexes are separate. Two specimens of *A. thazard* measuring 416 mm and 442 mm in fork length were obtained from Vizhinjam in the month of November, 1959 showing ovaries in spawn ripe condition. The ovaries were delicate mottled and pinkish pale yellow in colour. Both the specimens were in sixth stage of sexual maturity. Gonad of the smaller of the two weighted 52 g and the bigger 125 g. The ripe ova have an average diameter of 0.97 mm in fresh condition and 0.87 mm when preserved. Each ovum has a large oil globule measuring 0.22 mm (Rao, 1962). Silas (1969) estimated in *A. thazard* 197,223 to 1,056,468 eggs with a mean of 601,400 eggs. According to Rao (*op.cit.*) fish of 44.2 mm long produces 0.28 million eggs per spawning and about 1.37 million eggs during a breeding season.

Larval history and juveniles

Identification of eggs and larvae to species level is not possible with the available information on the subject, but it is well known that they are pelagic. *Auxis* larvae are characterized by the presence of conspicuous chromatophores along the mid-ventral and mid-dorsal lines of caudal peduncle. In the older specimens chromatophores are found along the mid-lateral line also of the caudal peduncle. Jones (1960b) has described larvae of *Auxis* from 3.36 mm onwards. The young larvae has three preopercular spines (Fig. 2B). in the 4.4 mm larvae, the characteristic chromatophores on caudal peduncle are present. The head region has also a group of chromatophores. Teeth are present in both jaws. The preopercular spines are five, with the central one prominent. In the post-temporal region a small spinous growth is also formed on the operculum (Fig. 2C). In the 5.08 mm larva, chromatophores at the caudal peduncle are more conspicuous (Fig. 2D). The 7.94 mm larva has a distinct row of chromatophores on each side of the caudal peduncle. Chromatophores are conspicuous at the head and abdomen. Fins possess spines and rays characteristic of the adult but not in their full complement (Fig. E).

The various stages of juveniles show the gradual unfolding of the adult characteristics like the corselet scales and the body contours (Fig. 2A). Jones (1960b) has described and figured a few juveniles from 46.8 mm onwards referring them to *A. thynnoides*, but later (1962a) pointed out that the specimens from 44.0 mm to 132.0 mm in length cannot be definitely assigned to *A. thynnoides* as one is inclined to place them under *A. thazard*, if confirmed by gill raker counts. The gill raker counts for the above length range of specimens as seen from his table No. III on page 342, are from 27 to 41. The gill raker counts for juveniles from Phillippine waters as given by Wade (1949) for those measuring between 21.8 mm and 55.0 mm

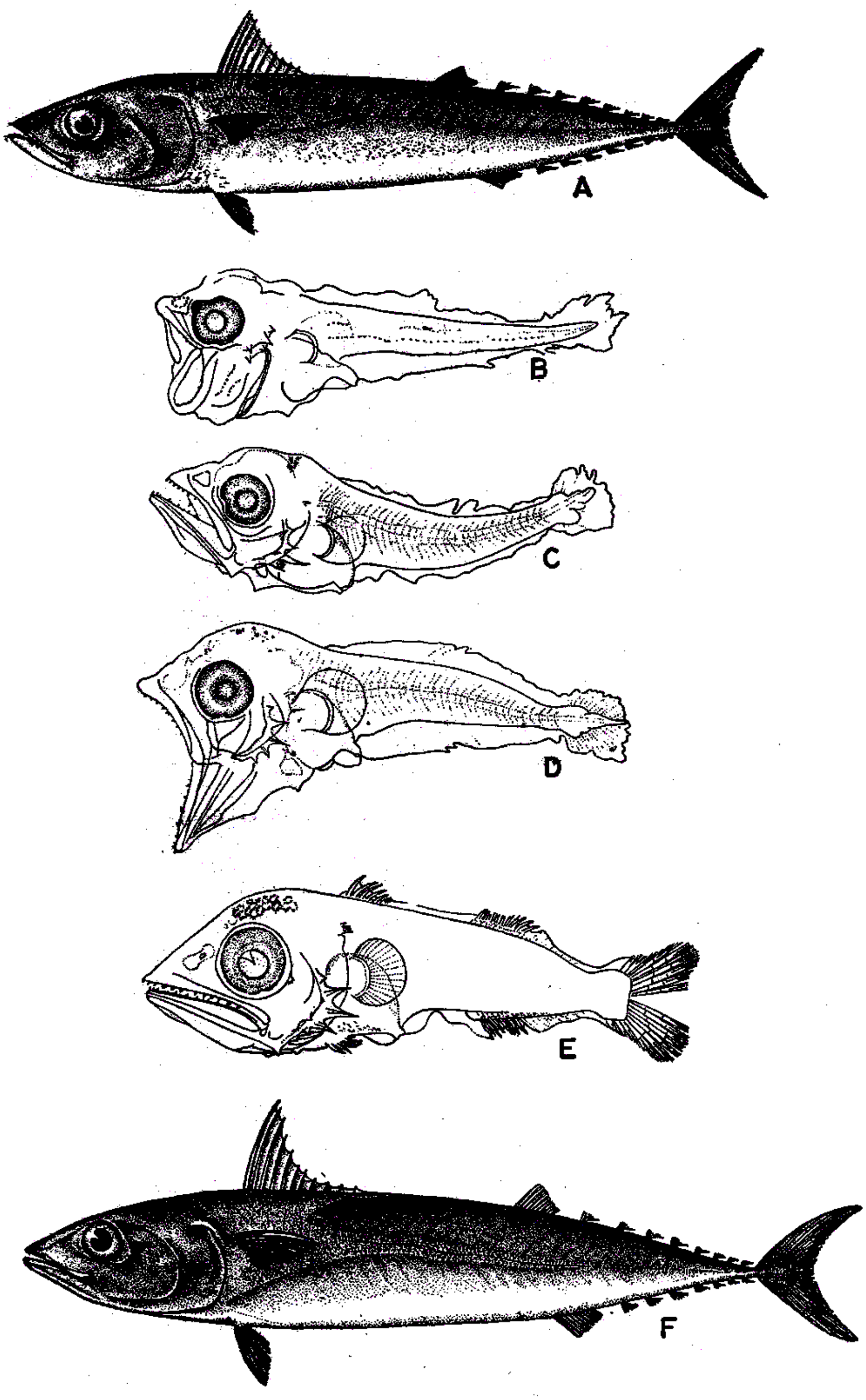


Fig. 2. A. Juvenile *Auxis thazard*. F. Juvenile *Auxis thynnoides*.
B - E. Larvae of *Auxis* sp. : B. 3·36 mm larva ; C. 4.4 mm larva;
D. 5·08 mm larva; E. 7·94 mm larva (after Jones, 1960b).

are between 23 and 42. Idyll and de Sylva (1963 a), based upon the work of earlier authors, state that in the juveniles of *A. thazard* of the pacific, the gill raker counts fall between 40 and 49 and those from Mediterranean between 40 and 45. These counts are definitely on the higher side as they agree more closely with the gill raker counts given by Wade (op. cit.) for *A. tapeinosoma (= A. thynnoides)* in which they vary from 45 to 47.

Competitors, predators, parasites etc

A. thazard has been found in the stomachs of blue marlin, white marlin , sail-fish, barracuda, wahoo and dolphin (Idyll and de Sylva, 1963 a).

The following are the parasites on *A. thazard* as reported by Silas (1962 c) and Silas and Ummerkutty (1962) : Trematodes: - *Hexostoma auxidi, Colocyntotrema auxis, Didymozoon auxis, Opepherotrema planum, Phacelotrema claviforma, Rhipidocotyle capitata* and *Tergestia laticollis.* Cestodes:- *Callitetrarhynchus gracilis.* Copepod: - *Caligus macaroyi* and *C. productus.*

AUXIS THYNNOIDES Bleeker, 1855

Synonyms

Auxis thynnoides Bleeker, 1855
Auxis thazard (nec Lacepede) Jordan and Evermann, 1896; Walford, 1937;
Fowler, 1938; de Beaufort, 1951 (in part); Herre, 1934 (in part);
Molteno, 1948 (in part); Rosa, 1950 (in part); Fraser-Brunner, 1950 (in part).
Auxis rochei Gunther, 1860 (in part).
Auxis maru Kishinouye, 1915
Auxis tapeinosoma Herre and Herald, 1951; Herre, 1953; Jones, 1958; Williams,
1960; Tablot, 1962.

Common names

Long corseletted frigate mackerel.
Tamil - Eli-choorai, Kutteli-choorai
Malayalam - Urulan-choorai (applied to *A. thazard* also)

Description

D^1. X-XI; D^2. 13+ 8; A. 13+7; G.R. 8-12+31-36 = 40-47; Vert. 20+19.

The body proportions expressed as percentage of total length (to fork) as given by Jones (1963a) are as follows.

"Head 23.7 to 26.6; snout 6.0 to 7.6; eye 4.2 to 5.2; snout to end of maxillary 8.2 to 9.1; body height 17.1 to 21.0; first predorsal distance 29.1 to 31.1; second predorsal distance 61.0 to 63.7; preanal distance 66.7 to 69.4; prepelvic distance 25.0 to 29.5; prepectoral distance 25.0 to 28.3; distance between pelvic and anal origin 39.4 to 42.3; height of longest (first) dorsal spine 11.0 to 16.0; height of second dorsal 4.3 to 5.1; pectoral length 11.9 to 13.3; anal length 4.0 to 5.1; the width of body pectoral base about 16.0 to 18.0 percent of the total length"

Mouth oblique, maxillary reaching to below anterior half of the eye. Teeth minute and pointed in both jaws. Interspace between two dorsal fins shorter than head length. First dorsal triangular, the anterior spine longest. Second dorsal with 13 rays. Dorsal and anal finlets 8 and 7 respectively. Origin of pectorals well before that of dorsal. Origin of ventrals behind that of pectoral. Hind margin of corselet running forward from base of second dorsal to above end of pectorals, then making a curve and turning hindwards along the lateral line becoming narrow, but below lateral line again continuing forwards to some distance to about the base of ventrals then making a sharp curve and running hindwards to well behind the posterior end of the ventrals. Caudal incised with the lobes pointed. Caudal peduncle slender with feeble lateral keels (Fig. 1E).

Colour:- Bluish above and silvery below. In preserved specimens deep brown above and light brown below. Some wavy bars laterally above and behind the corselet. A black patch present along the hind ventral border of the eye.

The main character of distinction between this species and *A. thazard* is in the structure of the corselet as pointed out already under the latter species. It may also be recalled that *A. thazard* has lesser number of gill rakers than *A. thynnoides.* As another character of distinction in field identification, it may be stated that the body is almost rounded in *A. thynnoides* and slightly compressed laterally in *A. thazard.*

Variability

The fin formula and the gill raker counts have already been given for the Indian specimens. For comparison, particulars regarding variability of some of the characters of specimens from South Africa (Talbot, 1962), Japan (Kishinouye, 1923), Phillippines (Wade, 1949), Indonesia (de Beaufort, 1951) and Hawaii (Matsumoto, 1960) are given below.

South Africa:	D^1. X-XII; D^2. 11+ 8; A. 14+6-7; G.R. 9-10+32 –34.
Indonesia:	D^1. X; D^2. 11+6-9; A. 14+6-8.
Philippines :	D^1. X-XI; D^2. 10-12+ 7; A. 2, 10-12+7; G.R. 10-12+1+31-35 = 42-48.
Japan:	D^1. IX-X; D^2. 10-12+ 8; A. 13+7; G.R. 10+36.
Hawai:	D^1. X-XI; D^2. 10-11+ 8; A. 12-13+7; G.R. 10-11+1+32-36 = 43-48.

Distribution

Recorded from tropic and subtropic sections of the Indian and Pacific Oceans. In the former it is known from the east and west coasts of India, South Africa and south Australia, and in the latter from the coasts of Indonesia, east Australia, New Guinea, Phillippines, Ryukyu Islands, South Korea, Ogasawara Islands, South Manchuria, Formosa, Japan, Hawaii, Galapagos Island and west coast of America.

BIONOMICS AND LIFE HISTORY

Food and feeding

Juveliles and adults of *A. thynnoides* from Vizhinjam on the west coast of India have been examined for their stomach contents (Kumaran, 1962). In percentage by volume it has been found that fish food formed the major constituents (44. 3%) followed by crustacean food (24.4%), cephalopods (22.7%), chaetognaths (8.2%), polychaetes (1.2%) and insects (0. 6%). The fish food consisted of *Anchoviella, Sardinella, Leiognathus, Hemirhamphus, Sphyraena, Caranx,* etc. Of the crustacean food Megalopa larva were found dominant. The cephalopod food, comprised of squids, was present only in larger fishes; larval stomatopods and *Lucifer* were abundant from specimens from Quilandy coast.

In Japan *A. thynnoides* caught by trolling line had anchovy as the main food item along with other elements in stray numbers, whereas those caught in set nets showed jack mackerel as the dominant item along with anchovy, spotted mackerels and lizard fish (Yokota *et al.*, 1961).

Age and growth

The reported maximum length is 600 mm (Talbot, 1962). The fish caught on Indian coasts are juveniles between 104 and 250 mm in length. Off Japan the range of specimens is from 160 mm to 500 mm, but mostly between 200 mm and 320 mm in length. In Philippines waters they have been found to range from 120 mm to 230 mm. No information is available as to its age in relation to size.

Reproduction

A thynnoides is heterosexual. In Japan waters it has been known that ripening gonads are recorded from April to June, ripe gonads in June and July and spent ones in July and August (Suzuki and Morio, 1957). In Philippines it appears that the spawning period is from November to August, with a peak in the first quarter of the year. From the Laccadive Sea, the larvae of *Auxis* were collected during January- April.

Larval history and juveniles

Auxis larva, the specific identification of which could not be fixed have already been dealt with under the account on *A. thazard*. Jones (1960b) described juveniles of *A. thynnoides* from 181 mm to 209.8 mm in length. These juveniles show almost all the adult characteristics (Fig.2F). The gill raker counts in specimen of this range are between 44 and 46. These counts closely agree with those given for juveniles from Philippine waters for *A. tapeinosoma (= A. thynnoides)* where they range from 45 to 47 in specimens measuring between 32 and 75 mm in length (Wade, 1949).

The known distribution of larvae of *Auxis* is about the same as for the adults.

Competitors, predators, parasites etc

A. thynnoides is known to be preyed upon by tunas and marlins in Queensland waters and Banda Sea (Watanabe, 1962). Along the coast of Japan the oceanic skipjack, the yellowfin, the bluefin, the bigeye tuna and *A. thazard* predate upon this species.

Mortality of the larval frigate mackerel has been found to be very high in the Hawaiian Islands. The cause of death could not be determined but there were no signs of predation, disease or parasitism. Possibly starvation is a factor resulting in mass mortality; that temperature is also a factor bringing about mortality cannot be ruled out (Strasburg, 1959).

III. ORIENTAL BONITO

Genus **SARDA** Cuvier, 1829

Body elongate and more or less fusiform. Scales minute, corselet distinct but small, caudal keel naked, but vertebrae of caudal peduncle with lateral keels. Teeth on both jaws, curved inwards. Palatine with a strong row of teeth, but vomer and tongue toothless. Dorsal part of the body with oblique stripes.

General distribution

Atlantic , Mediterranean, Indian and Pacific Oceans.

SARDA ORIENTALIS (Temminck and Schlegel), 1842

Synonyms

Pelamys orientalis Temminck and Schlegel, 1842
Pelamys orientalis Schlegel, 1850; Gunther, 1860.
Scarda chilensis var. *Orientalis* Stemindachner and Doderlein,
1883(Typographic error for *Sarda)*
Pelamys chilensis (nec Cuvier) Dau, 1878, 1889.
Sarda chilensis (Partim) Chabanand, 1944; Barnard, 1927.
Sarda chilensis (nec Cuvier) Smith, 1949.

Sarda velox Meek and Hildebrand, 1923

Sarda orientalis serventyi Whitley, 1945, 1962.

Sarda Orientalis Kishinouye, 1923; Fraser-Brunner, 1950; Godsil, 1955; Smith, 1961; Jones and Silas, 1960, 1962, 1963a; Talbot, 1962; Kikawa *et al.*, 1963; Silas, 1962 a, 1963a.

Description

D^1. XVII -XIX; D^2. 14-16+ 7-9; P^1. 23-25; A. 13-16+5-7; G.R. 1-4+8-10= 9-14.

Body proportions in percentage of total length for specimens examined from 50 mm to 500 mm are as follows:

Head length 27.5 to 31.9; snout to origin of D^1 -27.1 to 31.5; snout to origin of D^2-53.2 to 62.6; snout to origin of anal – 62.3 to 72.1; snout to origin of P^2–30.2 to 35.0; greatest depth of body – 20.4 to 24.0; length of P^1 -6.7 to 13.7; height of D^2 - 5.1 to 8.7; height of anal 5.8 to 9.1; diameter of iris 3.9 to 5.6 (After Silas, 1962 a).

Head large, maxilla more than half the length of head. Corselet not large, not extending beyond tip of pectoral. Lateral line arched above the pectoral and slightly undulating over the body. Teeth more in upper jaw (10-14) than in the lower jaw (7-12). Finlets 7-8/5.7. Gill rakers small in number varying from 1+8 to 4+10,but mostly around 3+9 in samples from the Indian coasts.

Colour:- In the adult the upper half of the body has about eight bluish lines passing upwards, silvery white below the lateral line. The younger juveniles have varying number of dark transverse bands, which in older ones get divided into narrow longitudinal stripes which ultimately join in the dorsal aspect to give rise to stripes characteristic of the adult (Fig. 3).

According to Fraser-Brunner (1950) *S. chilensis* occurring in the Pacific coast of America from California to Chile is distinguishable by the larger number of gill rakers (9-10+16-17) and a short maxillary which is less than the length of the head and *Sarda sarda* of the Mediterranean and the Atlantic by the gill rakers numbering 7+13, maxillary being about half the length of head and with 8/9 finlets. He considers *S. velox* occurring on the Pacific coast of America and in the Atlantic along the Gold Coast is synonymous with *S. orientalis.*

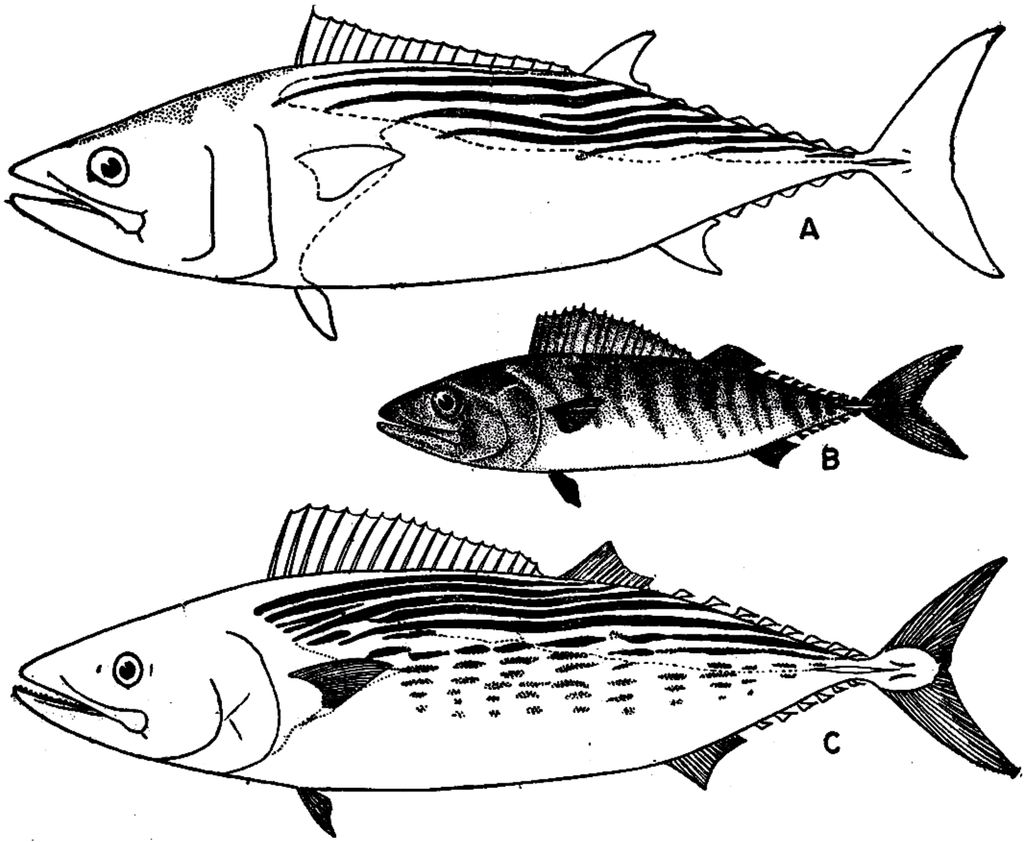


Fig. 3. A. Adult ***Sarda orientalis*** Temminck and Schlegel (after Fraser-Brunner, 1950). B & C. Juvenile ***Sarda orientalis*** showing variation in colouration:

B. 80 mm long; C. 245 mm long (after Jones, 1960b).

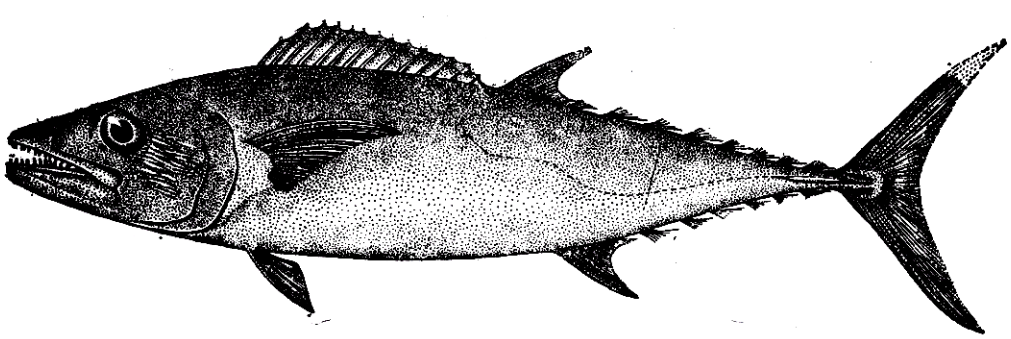


Fig. 4 Adult ***Gymnosarda unicolor*** (Ruppell) 522 mm long, from Minicoy (after Silas, 1963).

Variability

Meristic counts of the samples from South Africa, western Australia and Japan are given below for comparison with the Indian specimens:

Sotuh Africa :	D^1. XVII -XIX; D^2. 14-16+ 6-9; A. ii-iii, 10-12+6-9; G.R. -+8 (Smith, 1948)
West Australia:	D^1. XVII -XIX; D^2. 15+7-8; A. 15+5-6; G.R. 2-4+7-9 (Munro, 1958)
Japan:	D^1. XIX; D^2. 15+ 7-8; A. 15+5-6; G.R. 4+9 (Kishinouye, 1923)
Japan:	D^1. XVIII; D^2. 15-16+ 8; A. 15+6-7; G.R. 2-3+1+8-9 = 11-13 or 14 (Godsil, 1955)

Some abnormalities:- Absence of one of the finlets and shortening of the pectoral fins have been noted (Silas, 1963a).

Distribution

The general distribution is in the Indian, Pacific and the Atlantic Oceans. In the Indian Ocean it is recorded from the coasts of Seychelles, east coast of South Africa, Somalia, Arabia, west coast of India and south west Australia. In the Pacific ocean it is known from Phillippines, China, Formosa, Japan, Hawai, Ryuku Islands, Galapagos Islands and the west coast of Central America. From the Atlantic it is known from the Gold Coast in Ghana and near the Block Island.

BIONOMICS AND LIFE HISTORY

Food and feeding

From the examination of individuals measuring from 85 mm to 305 mm in fork length collected from Vizhinjam, Kumaran (1962) has found that the inshore fishes fromed the major food item followed by crustaceans. Among the fish component *Anchoviella* spp. was the most dominant along with *Sardinella*, *Leiognathus, Decapterus* etc. *Squilla* larvae were observed occasionally. Jones (1960) has stated that the food of the adult chiefly consists of fish, crustaceans and squids.

In samples from the trolling grounds of southern Kyushu (Japan) Yabe *et al.* (1953) reported empty stomachs in most and in the remaining ones Anchovies and some unidentified fish comprised its food.

Age and growth

No information is available on the rate of growth of *S. orientalis*. The largest for this species reported from the west coast of India is 700 mm. Smith (1961) states that it attains a size of about 40 inches. Kishinouye (1923) records fish up to 80 cm in length.

Reproduction

The species is heterosexual. Silas (1962a) reported sexual maturity in specimens above 386 mm; in fish between 480 and 605 mm examined in August-September of 1960-61 the ovaries were with ripe ova in running condition.

The spawning season is not fully known, but from the available information on the maturity stages of the gonads during the course of the year, it is found that the species breeds from April to September with peak spawning about July-August.

From Vizhinjam coast i.e. from Trivandrum to Cape Comorin, Silas (1962a) has estimated in two specimens (545-605 mm) the number of larger eggs per spawning to be 0.08-0.15 million, whereas Rao's (1962) observations in four specimens (48 to 55 cm) show them to be 0.21 –0.28 million. The total number of eggs produced during the breeding season was estimated to range from 0.24 million to 0.64 million (Silas, *loc. Cit.*) and 0.91 – 1.15 million (Rao, *loc. cit.*).

The occurrence of females with ripe running ovaries along the coast indicates that the spawning grounds are close by in this region in the neritic waters.

Eggs, larvae and juveniles

The ripe ovum is large, spherical, transparent and pale yellow with an average diameter of 1.13 mm when fresh and 1.04 mm on preservation. Rao (1962) has observed in each egg a single oil globule while Silas(1962a) noticed at one pole a cluster of oil globules 3 to 14 number with an average of 8 for an egg. No information is available on the larvae or post-larvae.

The occurrence of early juveniles from Vizhinjam area is reported by Jones (1960b) and Silas (1962a). The juvenile of 80 mm in length had 12 transverse bands, broad dorsally, tapering at the sides and narrowing and fading on the upper half of the abdomen, which was pale and white (Fig. 3B). In juveniles of 158 to 174 mm in standard length, the transverse bands had subdivided into horizontal streaks. These streaks could ultimately be expected to unite together to form stripes characteristic of the adult. In a juvenile of 245 mm from Vizhinjam, besides 5 to 7 longitudinal stripes, there were on the lower half of the body interrupted bars (Fig. 3 C).

Competitors, predators, parasites etc

Adults *S. orientalis* are caught along with *Euthynnus affinis affinis*, *Auxis thazard*, *Kishinoella tonggol* and *Scomberomorus* spp. in shore seines and gill nets in the south west coast of India. These species appear to be the probable competitors for the food of *S. orientalis* (Silas, 1963 a).

Following are the parasites recorded in *S. orientalis*:

Monogenetic trematode:- *Capsula* sp. from the gills, palate and inner side of the operculum (Silas, 1962c).

Parasitic copepods:- *Caligus bonito* and *Parapetalus* sp. from the gills and buccal cavity (Silas and Ummerkutty, 1962).

IV. DOGTOOTH TUNA

Genus **GYMNOSARDA** Gill, 1862

Body robust in front, elongated, rounded in cross section; maxilla reaching to vertical below anterior third of eye; lower jaw broad; teeth large conical on both jaws, villiform feeth on palatines and tongue, but absent on vomer; scales on reduced corselet elongate. Lateral line prominent, arched over pectoral and undulating posteriorly. First and second dorsal separated by distance, shorter than half diameter of eye; third spine of the first dorsal the longest. Finlets 6-7/6. Pectoral not longer than head. Caudal with well-developed median keel and a pair of low lateral keels. Caudal lobes vertical; gill rakers few; operculum wavy at hind margin; vertebrae 19+19. Monotypic.

Distribution: Indian and Pacific Oceans.

GYMNOSARDA UNICOLOR (Ruppell), 1838

Synonyms

Thynnus unicolor Ruppell, 1838
Pelamys nuda Gunther, 1860; Klunzinger, 1871
Gymnosarda nuda Kishinouye, 1915; 1923; Fowler, 1938; Herre, 1945; 1953;
Umali, 1950; Rosa, 1950; Sette, 1952, Dung and Royce, 1953; Woods, 1953;
Ogilby and Marshal, 1954; Fourmanoir, 1957; Munro, 1958; Hiatt and Strasburg,
1960; Jonklaas, 1962.
Scomber vau Curtiss, 1938.
Gymnosarda unicolor Fowler, 1949; Fraser-Brunner, 1950
Wheeler and Ommanney, 1953; Williams, 1956, 1962;
Smith, 1956; Jones and Silas, 1960, 1962, 1963a;
Silas, 1963b; Whitley, 1962.

Common names

Dogtooth tuna
Japan – Isomaguro – Tokakin
Seychelles – Thon gros yeux

Description

D^1. XIV; D^2. III, ; 10(=13)+7; P^1. 27-28; A. III-IV, 10(=13-14)+6; G.R. 1+1+10-11.

Body proportions in percentages of total length are as follows: Head 24.8 to 28.11; first predorsal distance 28.1 to 31. 8; second pre-dorsal distance 54.3 to 58.3; preanal distance 61.0 to 67.0; pre-pelvic distance 27.0 to 31.7; greatest depth of body 19.6 to 24.8; length of pectoral 16.6 to 19.6; height of second dorsal 9.9 to 11.8; height of anal 9.7 to 11.6; diameter of iris 3.8 to 6.0 (Silas, 1963 b).

Body roundish, stout in front but comparatively slender behind; head longer than depth of body, snout pointed, preopercle striated and notched, jaws equal in length, but lower one deeper, maxilla reaching to vertical below middle of the orbit; teeth conical, well developed on both the jaws, villiform on palatines and tongue, absent on vomer; corselet small with scales elongate; lateral line wavy behind; first dorsal with gradually sloping margin, with third spine the longest; pectoral shorter than head; second dorsal and anal concave on posterior border; other characters as for the genus (Fig.4).

Colour :- Dark blue along the back and sides above the level of pectorals but silvery white below. First dorsal bluish green, other fins and finlets dusky blue, except distal portions of second dorsal and anal which are white.

Variability

The meristic counts in specimens recorded from different regions by different authors are as follows for comparison with the Indian specimen:

Red Sea:	D^1. XII; D^2. I, 10+6; A. III, 10+6 (Ruppel, 1838)
Do.	D^1. XIV; D^2. I, 12-13+7; A. III, 10+7 (Klunzinger, 1871)
Japan:	D^1. XIV; D^2. 13+7; A. 12+6; G.R. 2+10 (Kishinouye, 1923)
Tahiti:	D^1. XII-XIV; D^2. -+7; A+-+6; G.R. -+10-11 (Fowler, 1949)
Zanzibar:	D^1. XII-XIV; D^2. 13+6; A. II, 12+6; G.R. 12-13 (total)(Williams, 1956)
Madagascar,	D^1. XIII-XIV; D^2. 11+7; A. II, 10+6; G.R. 13 (total)
Comores, etc:	(Fourmanoir, 1957)

Australia: D^1. XIII-XIV; D^2. 13+7; A. 12-13+5-6; G.R. 2+10-11 (Munro, 1958)
Bikini Atoll. D^1. XV; D^2. III, 10+7; A. III, 10+6; G.R. 1+1+11 (Schultz, 1960) and Marshals Is.

The interpelvic process is said to be bifid in *Gymnosarda* (Fraser-Brunner, 1950) but in the Andaman specimens, it is like a single median blade, less developed than in *Auxis* (Silas, 1963 b).

Distribution

Red sea, Indian Ocean and the Pacific Ocean.

In Red Sea it is reported from Djedda and in the Indian ocean from south of Zanzibar, Laccadives, Maldives, South east of Ceylon, Andaman Islands, Reunion Islands, Mauritius, Madagascar, Seychelles and nearby islands. In the Pacific the occurrence has chiefly been from the following localities: Marshall Islands, Bougainville Straits, Louisiade Archipelago, Solomon Islands, Ogasawara, Ryukyu Islands, Japan, Tahiti, Philippines, east cost of Australia, New Guinea and nearby islands.

The adult fish is usually found at or near the coral reefs. It has been observed to move solitarily or in very small schools.

BIONOMICS AND LIFE HISTORY

Food and feeding

Very little information is available on the food habits of the Dogtooth tuna. Most of the Andaman specimens had empty stomachs and others had fish food. Observations made elsewhere are also very fragmentary, but they point out that fish and squids comprise their food (Woods, 1953; and Hiatt and Brock, 1948).

Age and growth

No information is available on age and growth. Kishinouye (1923) reports that the species attains 240 cm but the fishes caught off Ogasawara Islands are usually about 100 to 150 cm. The largest specimen obtained from Andamans is only 68.5 cm (Silas, 1963b). Specimens reported from Seychelles-Mauritius area were 78-115 cm (Wheeler and Ommanney, 1953).

Specimens from the western Marshall and Easter Carolines measured 52-108 cm in total length (Dung and Royce, 1953)

Ronquillo (1963) has expressed the length weight relationship of *G. unicolor* by the exponential equation:

$$\text{Log } W = 4.86483 + 3.20623 \log L$$

Where W is weight in lbs and L is length in mm.

Reproduction

The species is heterosexual. Specimens from the East African coast measuring from 126.5 to 145 cm in total length, weighing between 41 and 80 lbs were either mature and in running condition or very nearly ripe (Williams, 1962). A male measuring 68.5 cm in length from Andamans has been found in partly spent and oozing condition. The available data are too meagre to furnish any information on the size at first maturity or spawning periodicity. Kishinouye (1923), however, mentioned that off Ogasawara and Ryukyu Islands the spawning season is about May-June. William's (*loc. cit.)* observations on the East African coast show that it spawns in the north-east monsoon period. Dunstan (1961) states that it spawns in March, August and December in the vicinity of Samarai, Papua with more than one spawning per year, the shedding of eggs taking place in batches. No information is available on eggs, larvae and juveniles.

V. OCEANIC SKIPJACK

Genus **KATSUWONUS** Kishinouye, 1915

Body robust and rounded; teeth on jaws only. Corselet well developed with scales, some of which found scattered outside the corselet also. Space between the two dorsal fins narrow. Pectorals at the level of the eye with about 27 rays. Gill rakers 50-63; vertebrae 20+21 = 41. Longitudinal bands along the lower half of the body. Monotypic.

Distribution: Atlantic, Mediterranean; Indo-Pacific.

KATSUWONUS PELAMIS (Linnaeus), 1758

Synonyms

Scomber pelamis Linnaeus, 1758
Scomber pelamys Bloch and Schneider, 1801
Scomber pelamides Lacepede, 1802
Thynnus pelamys Cuvier, 1831; Temminck and Schlegel, 1844;
Bleeker, 1856; Gunther, 1860; Day, 1889.
Gymnosarda pelamis Jordan and Evermann, 1896
Gymnosarda pelamys Barnard, 1927
Euthynnus pelamis Fowler, 1928; Deraniyagala, 1933;
Smith, 1949; de Beaufort, 1951; Fourmanoir, 1957.
Euthynnus (Katsuwonus) pelamis Fraser-Brunner, 1950;
Deraniyagala, 1952; Williams, 1956.

Katsuwonus pelamys Kishinouye, 1915
Katsuwonus pelamis Kishinouye, 1923; Serventy, 1941; Rosa 1950;
Munro, 1955; Jones and Silas, 1960; 1962; 1963a: 1963b;
Tablot, 1962; Whitley, 1962; Williams, 1962.

Common names

Oceanic skipjack.
India (Laccadives) – Kali-phila-Das; Choora and Metti.
Ceylon – Alaguduva (sinhalese)
Philippines – Gulyasan, Pundahan, Bankulis.
Japan – Katsuwo, Magatsuwo, Mandagagatsuwo.

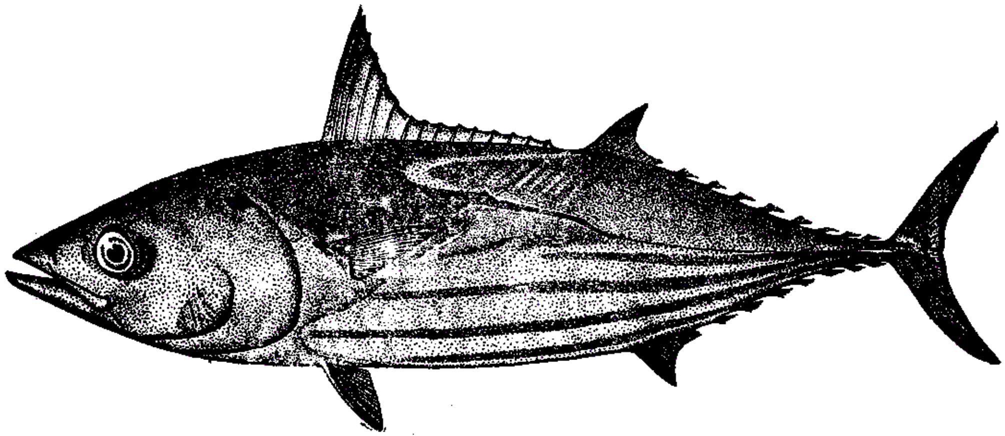


Fig. 5. Adult *Katsuwonus pelamis* (Linnaeus) from Minicoy (after Jones and Silas, 1963b).

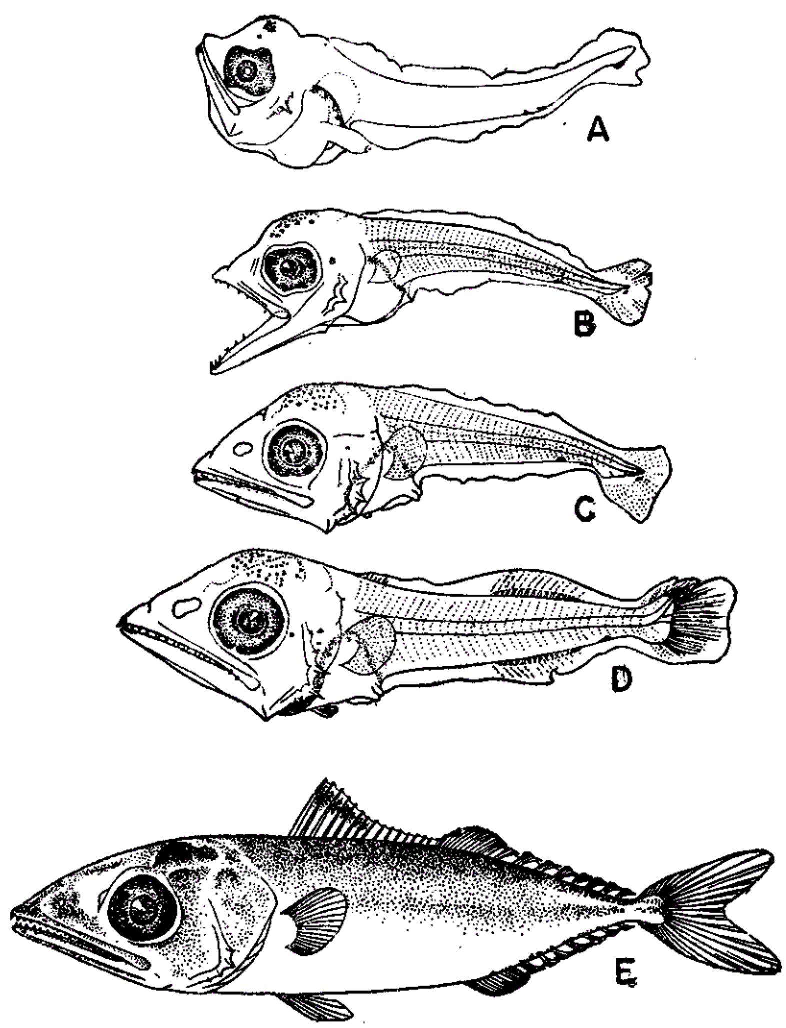


Fig. 6. Larvae and juvenile of *Katsuwonus pelamis* from Laccadive Sea. A. Larva of 2.97 mm; B. 3.60 mm; C. 5.08 mm; D. 7.08 mm long; E. Juvenile of 27.0 mm long (after Jones, 1959).

Description

D^1. XV-XVI; D^2. 13-14+8-9; A. 13-14+7-8; P^1. 26-28; G.R. 14-18+34-39 = 50-55.

The body proportions expressed as percentage of total length for specimens from Laccadive Sea are as follows (Abridged after Jones and Silas, 1963b):

Head 29.6 to 30.7; first predorsal distance 33.6 to 34.9; second predorsal distance 60.5 to 62.9; preanal distance 64.2 to 67.5; prepelvic distance 32.9 to 35.6; greatest depth of body 23.0 to 26.3; length of pectoral 13.1 to 16.7; distance between origin of pectoral and first dorsal 13.1 to 15.5; base of first dorsal 24.5 to 28. 4; base of second dorsal 7.4 to 9.1; caudal spread 25.6 to 26.5; longest (first) dorsal spine 13.0 to 15.6; length of second dorsal 6.0 to 9.3; length of anal 4.6 to 8.4; length of pelvic 10.3 to 11.9; least depth of caudal peduncle 1.9 to 2.2.; length of maxilla 10.2 to 11.9 per cent in total length.

Body robust, deep but tapering strongly posteriorly. Head somewhat compressed and convex above. Snout long and pointed. Mouth oblique,. Maxillary reaching nearly or quite opposite middle of eye. Teeth in single series on jaws but not on palatine and vomer. First dorsal originating a little behind insertion of pectoral. Spines in the first dorsal slender, the anterior ones long and the posterior ones short. Second dorsal somewhat elevated with deep concave margin. Origin of anal slightly in advance of vertical from the base of last ray of second dorsal. Ventral shorter than pectoral. Lateral line curved below second dorsal, then passing straight to caudal base. Trunk naked except corselet and lateral line. Caudal with a strong lateral keel. Caudal fin lunate.

Colour :- Steel blue tinged with violet on back. Half of body and abdomen whitish or pale yellow. 4 to 6 longitudinal dusky to black stripes below lateral line on each side of the body (Fig. 5)

Among the internal characters it may be mentioned the presence of a long gall bladder almost free from liver lobes lying on the dorsal side of the liver and the absence of an air bladder.

Variability

The variability of the meristic characters as given by different authors is summarized and presented below:

Africa:	D^1. XII-XVI; D^2. 12-13+8; A.I-III, 12(=13-15)+7-8; G.R. 35 (lower). Smith, 1961).
Do.	D^1. XIV-XV; D^2. 13-15+7-8; A. 14-15+7; G.R. 15-16+38-40 = 53-56 (Williams, 1962)
Do.	D^1. XIV-XV; D^2. 14-15+8; A. 15+7; G.R. 18-20+36-38 = 56 (Talbot, 1962)
Madagascar:	D^1. XV; D^2. 14-16+8; A. 14-16+7; (Fourmanoir, 1957)
Ceylon:	D^1. XV-XVII; D^2. 3,12(15)+8; P1. 27-30; A. 3-4, 12-13+7; G.R. 35-40 (lower) (Deraniyagala, 1952).
Do.	D^1. XV; D^2. ii, 12-14 (=14-16)+8; P^1. ii, 24 (=26); A. iii, 12(=15)+7; G.R. 35 (lower) (Munro, 1955).
Australia:	D^1. XIV-XVI; D^2. 14-16+7-9; P^1. 26-29; A. 14-15+7-8; G.R. 17-21+33-42 (Munro, 1958)
Indonesia:	D^1. XV; D^2. i, 12-14 (=14-16)+8; P^1. ii, 24 (=26); A. iii, 12(=15)+7 (de Beaufort, 1951).
Japan:	D^1. XV-XVI; D^2. 14-15+8; A. 14-15+7; G.R. 16-20+36-41 (Godsil and Byers. 1944).
Hawaii:	D^1. XV-XVI; D^2. 14-16+7-8; A. 15+7; G.R. 19-20+37-42 (Godsil and Byers, 1944).
Eastern Pacific:	D^1. XV-XVI; D^2. 14-15+7-8; A. 14-16+6-8; G.R. 18-22+35-43 (Godsill and Byers, 1944).

Distribution

It is found in the tropic and sub-tropic sections of the Indian Ocean. In the Indian Ocean it has been recorded from the east coast of Africa, Madagascar, Seychelles, Mauritius, Reunion Islands, Aldabra Island, Cocos Island, Somali coast, Gulf of Aden, Laccadives and Maldives; west coast and south east coasts of India, Ceylon, Andaman Sea, west of Java and Sumatra, western Australia and Great Australian Bight and south east of Tasmania.

Katsuwonus pelamis is oceanic and is essentially a surface fish; it is rarely met with in coastal waters where other tunas like *Euthynnus* and *Auxis* are usually found. Off Minicoy and Laccadive the fishing is done in waters about 800 fathoms deep, but hardly about 10 km from the islands. However, the fish enters the lagoons in search of its prey. Off East Africa the fish is reported to be found mainly inside the 100 fathom line (Williams, 1962).

BIONOMICS AND LIFE HISTORY

Food and feeding

Examination of large number of skipjack from Laccadive Sea showed that the food consists chiefly of crustaceans, cephalopods, larval and juvenile fishes. The crustacean food consists of stomatopod larva, megalopa larva, mysids, euphausids, *Acetes* and of these the stomatopod were the most dominant. Of the food fishes found in the stomach mention may be made of the Balistids, Monocanthids and Syngnathids besides a few miscellaneous fishes. The bait fishes found in the stomach were :*Lepidozygus tapeinosoma, Dipterygonotus leucogrammicus, Caesio caerulareus, Archamia lineolatus, Chromis caeruleus, Caesio tile, C. chrysozona, Pomacentrus tripunctatus, Apogon anreus, A. septemstraitus, A. sangiensis, A. frenatus* and *Spratelloides delicatulus.* The bait fishes formed the dominant constituents ranging from 6.9 to 29.7 times the natural food. In the smaller fishes between 40 cm and 50 cm, crustaceans were dominant and in the larger fishes upto 70 cm there were mostly larval and juvenile fishes and cephalopods. It has been found that the food intake in volume is found to increase with the increase in fork length, but decreases with the increase in body weight (Raju, 1962a).

It has been observed by Fourmanoir (1960) that in general the food of the skipjack consists of engraulids, clupeids, cephalopods and planktonic stomatopods. Off Madagascar the main food components noted in the stomach are *Anchoviella commersonni, Spratelloides delicatulus, Sardinella jussieu* and *S. melanura.*

Age and growth

No information on age and growth is available on the skipjack occurring in the Indian Ocean. The observation of this species at Laccadive throws some light on distribution of the dominant size groups occurring in the pole and line catches. The fishing in Minicoy depends on three distinct groups viz. 28 to 45 cm, 45 to 60 cm and 60 to 70 cm. There is not enough evidence to show that these represent the three year classes.

Aikawa and Kato (1938) based on the study of vertebral rings have considered skipjack in the Japanese water that in the 0-year class the fishg grow upto 27 cm, in the first year from 27-37 cm, in the second year

37-46 cm, in the third year 46-55 cm, in the fourth year 55-64 cm, in the fifth year 64-72 cm, in the sixth year 72-80 cm and in the seventh year over 80 cm. Brock (1954) finds that the skipjack from the Hawaiian waters at the end of the first, second, third and fourth years may attain lengths of 41 cm, 69 cm, 79 cm, and 82 cm. Tagging study conducted by Brock (*loc. cit.)* seems to confirm very nearly his earlier findings based on size frequency distribution.

The largest of the specimens on record from Laccadives seem to be in the 871 and 880 mm size group for male and 721 and 730 mm size group for the female.

Reproduction

Skipjack is normally heterosexual. Very occasionally (Raju, 1960; Thomas and Raju, 1962) hermaphrodite individuals were obtained from the Laccadives. Hermaphroditism in this species has also been recorded from the Pacific coast (Nakamura, 1935 and Uchida, 1961). Some abnormalities in the structure of the right or the left ovary have also been noticed in the Laccadive specimens such as enormous development or division into separate lobes (Raju, 1960). Though the sexes cannot be externally made out, Hatai *et al*. (1941) have noted that the sharply pointed lips characteristic of males as distinguished from somewhat rounded lips in the females.

A disparity in the sex ratio was noticed in the skipjack of Minicoy waters with males predominating in most months. Among the smaller groups, a high percentage of females and among the larger groups a high percentage of males have been recorded. The percentage of the males was 73.24 (Raju, 1962b) Tester and Nakamura (1957) have recorded sex ratio for skipjack of the Hawaiian waters landed by pole and line fishing as 61 males to 39 females. According to Wade (1950a) the preponderance of males may be due to their aggressiveness during the spawning which makes them more prompt to strike at the lure.

The smallest specimen from Minicoy with mature ovaries measured 390 mm. Immature gonads were rare in specimens over 450 mm in length and spent ones in large numbers have been encountered between 400mm and 450 mm. The size at first sexual maturity may safely be taken as between 400 mm and 450 mm (Raju, 1962b; Jones and Silas, 1963b). For the species occurring in Hawaiian waters Brock (1954) reported the same size at first sexual maturity. Wade (1950a) recorded a mature female measuring 340 mm in Philippine waters, but most of the ripening females measured over 400 mm in length. Along the Eastern Pacific the minimum size of maturity was about 550 mm and most individuals were not mature below 600 mm (Schaefer and Orange, 1956). It has also been observed that the minimum size at maturity differs in different areas of the Eastern Tropical Pacific (Orange, 1961).

Regarding the spawning season of skipjack, Raju's (1962b) observation at Minicoy indicated a prolonged spawning period extending from February to July. August to October being the final half of the monsoon period there was no regular fishing and the samples obtained from occasional fishing from restricted areas were very few. He has recorded the occurrence of mature individuals in all months except from August to October. It was also stated that fish containing translucent ova were a rarity. Jones (1959) recorded the occurrence of larvae and juveniles during December-April. Although definite range of spawning is not established, from the occurrence of mature adults and early larval stages it has been concluded that spawning may take place from about January to April and from June to early September, with peak in January and June. There are indications of fractional spawning in January to April, but it is not known whether the same fish recoups to have a second spawning in June-September period, when spent ones have been observed.

From the gonadial examination, the spawning period of the skipjack in the Pacific Ocean has been reported by different workers as follows: Schaefer and Marr (1948) – January to March in Central America; Brock (1954) – February to September in Hawaiian waters; Marr (1948) – April to August in Marshall Island; Yabe (1954) May to August in Japanese waters. By the presence of larvae the spawning period has been presumed to be all the year round with peak from September to April in Philippines waters (Wade, 1951) and in all months except April and December in Central Equatorial Pacific (Matsumoto, 1958).

Among the skipjack of Minicoy ranging between 418 mm and 703 mm in length, the fecundity varies from 0.15 million to 1.97 million of the most mature eggs. The relationships between fecundity and length and fecundity and weight have been studied in detail and it is found that the latter appears to give a better indication than the former (Raju, 1962c).

Schafer (1961) reported the fecundity of skipjack from Gulf of California, varying from 407 to 1327 thousand eggs in specimens ranging from 659 to 699 mm in total length. Yoshida as cited by Waldron (1963) finds in specimens from Marquesas Island fecundity varying 0.1 million eggs in fish of 43 cm in length to 2.0 million in fish of 75 mm.

Eggs, larvae and juveniles

From Minicoy Island no fish was obtained with fully ripe ova in the normal ovaries, However, some fully ripe transparent ova have been noted in a hermaphrodite gonad (Raju, 1960), the largest egg measuring 0.809 mm in diameter with a golden yellow oil globule. Yoshida's (*loc. cit.)* observation shows that the eggs which are spherical and transparent, have a distinct straw coloured oil globule, the eggs ranging from 0.85 mm to 1.12 mm with a mean diameter of 0.96 mm and the oil globule about 0.14 mm in diameter. The running ripe ova described by Brock (1954) were spherical to slightly oval with an average diameter of 1.25 mm, with a single oil globule from 0.22 mm to 0.45 mm in diameter. Yabe's (1954) observation from Japanese waters showed that the ripe eggs ranged from 0.80 to 1.17 mm, averaging 1.0 mm with an oil globule of an average diameter of 0.32 mm.

The earliest larval stages described from the Laccadive Sea by Jones (1959) are 2.63 mm and 2.9 mm in total length. The presence of rather inconspicuous spines on the preoperculum, four chromatophores over mid-brain, a patch of chromatophores at the tips of the mandible, a prominent chromatophore at the base of the caudal fin below the notochord, two other chromatophores mid-ventrally in the posterior third of the length and some chromatophores also on the dorsal surface of the abdominal sac are characteristic of these early larval states. Some of the later stages are shown in figures 6 A, B, C and D.

Jones (1959) has described a juvenile measuring 27 mm long. The maximum width of this is about 1/5 the total length. Teeth are well developed and the angle of the mouth reaches about a vertical below the middle of the eye. The preopercular spines are considerably reduced; the pelvics and the pectorals are of the same length; finlets are connected by a thin membrane and other structural characters of the adults have also made their appearance. The colouration is dense dorsally on the head and body. The first dorsal has prominent chromatophores on the fin membranes; chromatophores are absent ventrally on the body, but they are present in a row on each side along the basal region of the anal fin and finlets (Fig. 6E)

Some of the larval stages has been described by Kishinouye (1926) from Ryukyu Island, Yabe (1955) from the same region and nearby localities, Matsumoto (1958) from Central Pacific, north and south of Equator, Wade (1950b) from Philippine waters, Schaefer and Marr (1948) from Marshall Island and Schaefer (1960) from the Eastern Pacific.

Competitors, predators, parasites etc

In the Laccadive Sea mixed shoals of adult yellowfin and skipjack have been frequently met with. Since the food habits of these two species are similar, the possibility of their competition for food cannot be ruled out. The whale shark is also found associated with shoals of *Euthynnus* and *Katsuwonus*, chasing after the food fishes like *Anchoviella* and *Spratelloides* sought after by all the three species (Fourmanoir, 1960). In the Laccadive Sea *Coryphaena hippurus* was also found associated with shoals of skipjack and yellowfin.

Among the predators mention may be made of the large sharks of the genus *Charcharinus* and the marlins, *Makaira* spp.

Some cestode, trematode, nematode, acanthocephalid and copepod parasites on skipjack have been reported by various authors. Some of them have been listed by Silas (1962c) and Silas and Ummerkutty (1962). The more important among the monogenetic trmatode parasites are *Capsula* spp., *Hexostoma grossum*(Goto), and *Pseudaxine* sp; among the digenetic trematode parasites are *Atalostrphion* spp., *Didymocystis* spp., *Didymophroblema* sp., *Didymozoon* spp., *Koellikeria* spp., *Lobatozoum* sp., *Neodiploterema* sp., *Synococelium* sp., *Dinurus* sp., and *Hirudinella* sp., among the cestode parasites are *Tentcularia bicolor* (Bartels) and among the copepod parasites are *Caligus* spp., and *Lepeophtheirus* sp.

VI. LITTLE TUNNY

Genus **EUTHYNNUS** Lutken in Jordan and Gilbert, 1882

Body elongate and fusiform with a well developed corselet. Teeth minute on both jaws, present or absent on vomer and palatine. Two dorsals more or less contiguous. Second dorsal and anal short; dorsal finlets 8 or 9 , anal finlets 6 or 7. Gill rakers well developed.

General distribution:- Atlantic, Mediterranean and Indo-Pacific.

Four species are distinguishable: *E. alletteratus* (Rafinesque) found in the Atlantic and Mediterranean (also probably extending to South Western Indian Ocean around South Africa); *E. affinis* with two sub species *E. affinis affinis* (Cantor) in the Indian Ocean and western part of western Pacific and *E. affinis yaito* Kishinouye in the Pacific Ocean; *E. lineatus* Kishinouye in the eastern Pacific (Jones and Silas, 1962).

EUTHYNNUYS AFFINIS AFFINIS (Cantor), 1850

Synonyms

Thynnus affinis Cantor, 1850; Gunther, 1860.
Auxis taso (nec Cuvier) Bleeker, 1850
Thynnus thunnina (nec Cuvier) Bleeker, 1852; Day, 1889; Gunther, 1876; Klunzinger, 1884.
Euthynnus alletteratus (nec Rafinesque) Deraniyagala, 1933; Serventy, 1941.
Euthynnus alletteratus affinis (in part) de Beaufort, 1951.
Euthynnus alletteratus affinis mendis, 1954; Munro, 1958.
Euthynnus yaito (nec Kishinouye) Blanc and Postel, 1958.
Euthynnus affinis Wheeler and Ommanney, 1953; Munro, 1955; Steintz and Ben-Tuvia, 1955; Jones, 1960a.
Euthynnus affinis affinis Fraser-Brunner, 1949; Williams, 1956; Jones and Silas, 1960; 1962; 1963a.

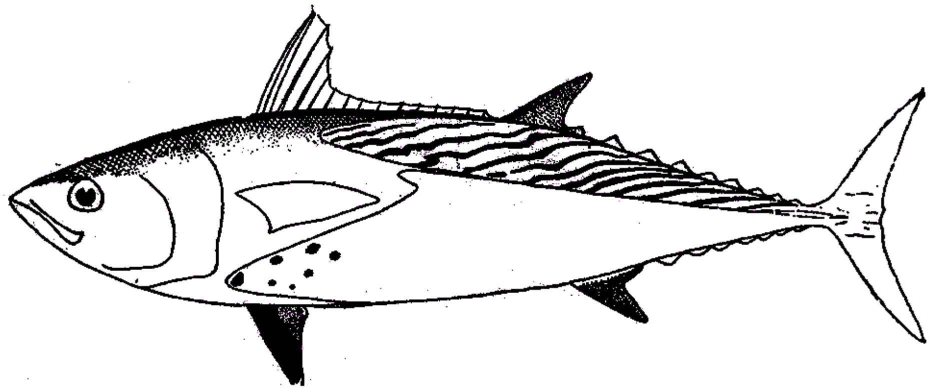


Fig. 7. Adult *Euthynnus affinis affinis* (Cantor) (after Fraser-Brunner, 1950 given as *Euthynnus* (*Euthynnus*) *affinis affinis*).

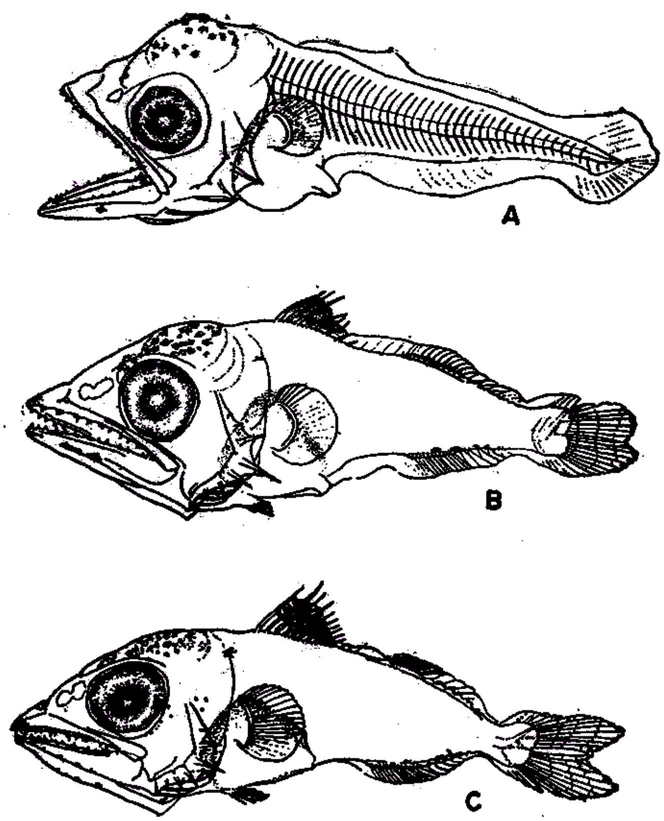


Fig. 8. Larvae of *Euthynnus yaito*. A. 4.6 mm long; B. 7.6 mm long and C. 9.6 mm long (after Matsumoto, 1958).

Common names

Little tunny or mackerel tuna.
India – Suraly (Tamil)
Ceylon – Shurai (Tamil);
Atavalla, Ragodura, Sureya (Sinhalese)
Malaya - Tongkol, Kembel-mas, Tombal-mas (Malay).

Description

D^{I}. XIV; D^{2}. 11-14+8-9; A. 12-15+6-8; P^{1}. 24-28; G.R. 7-10+22-25.
Head 3.2 to 3.5; depth 3.6 to 4.0 in standard length. Eye 5.6 to 6.8 in head, 1.5 to 2.0 in snout.

Mouth oblique, jaws equal, teeth minute and conical on both jaws as also on vomer and palatines, scales on corselet but not on body, those in the back better developed; Hind margin of the corselet is demarkated by a line in the base of the second dorsal fin to a point slightly behind the pelvics, presenting on its way two deep emarginations. First dorsal separated from the second dorsal by narrow space about equal or less than eye diameter. First dorsal spine longest and equal to postorbital. Second dorsal and anal short, followed by dorsal and anal finlets. Caudal peduncle with prominent median keel and two small ones on either. Caudal broadly lunate (Fig. 7).

Colour:- Bluish black above and silvery white below. Behind the corselet and dorsal to the lateral line are a number of blue black broken wavy lines directed hindward and upwards. One to eight small dark spots below the level of the pectoral fin (may be absent either on one or both sides). Pelvics blue black except on the inner edges of lighter hue.

Variability

Variability in meristic counts of *E. affinis affinis* from different countries is shown below (abridged after Williams, 1963 b).

South Africa: D^{I}. XV-XVI; D^{2}. 11-13+8; A. II-III, 10-12+6-8; G.R. 25(lower) (smith, 1960).
East Africa: D^{I}. XV-XVII; D^{2}. 11-13+8; A. 13-14+6-7; G.R. 7-10+22-23 = 29-33 (Williams, 1956)

East Africa: D^{I}. XIV-XV; D^{2}. 11-12+8; A. 12-14+6-7 (Morrow, 1954).

Madagascar: D^{I}. XV; D^{2}. 11-13+8; A. II-III, 11-12+7-8; G.R. 25 (lower) (Fourmanoir, 1957)

Pakistan (West): D^{I}. XV; D^{2}. III, 10-11+8; A. III, 11+8; P^{1}. 26 (Cent. Fish. Dept., 1955).

Ceylon: D^{I}. XIV-XV; D^{2}. 2.10+8; A. 3. 11-12+7; P^{1}. 28; G.R. 22- 24 (lower) (Deraniyagala, 1952).

Do. D^{I}. XV; D^{2}. II, 18+8; A. II, 12+7; P^{1}. 2,24; G.R. 24 (lower) (Munro, 1955).

Indonesia: D^{I}. XV; D^{2}. 2. 11+8; A. 2. 12+7; P^{1}. 24; G. R. 24 (lower) (de Beaufort and Chapman, 1951).

Distribution

It is wide-spread along the east coast of Africa, Madagascar, Seychelles, Mauritius, in the Red sea, Gulf of Aden, along the coast of Pakistan, west and east coasts of India, Laccadives, Maldives, Ceylon, Burma coast, Andamans, Malaya, South of Java (Indonesian waters) and along the coast of western Australia.

BIONOMICS AND LIFE HISTORY

Food and feeding

On the west coast of India from Vizhinjam observations on *E. affinis affinis* ranging in size from 41 mm to 660 mm in fork length showed that molluscs (56.5%), fishes (38.3%) and crustaceans (5.2%) comprised their food. The fish components were mostly *Anchoviella* spp. *Megalaspis*, *Decapterus* and *Leiognathus*. There was also a fair proportion of unidentified fish including larvae. In one specimen of 100 mm length, a juvenile of 38 mm *E. a. affinis* was also observed. *Sepioteuthis* and *Loligo* comprised the cephalopod food. A very insignificant proportion of ptreropods was also met with. Of the crustacean items, the important ones were the stomatopod larvae followed by penaeid prawns, phyllosoma larvae and megalopa larvae (Kumaran, 1962). In specimens obtained by multiple trolling off Tinnevelly coast (east coast of India) the stomachs were found to be about half to gorged condition, mostly with Euphausids and penaeid prawns. Some of the stomachs showed remains of squids, cuttlefish, stomatopod larvae and partly digested clupeids (Silas, 1962b).

In the East African waters Williams (1963b) observed 29.4% of the stomachs of *E. a. affinis* to be empty and in the rest the occurrence of food group was fish 71%, squid 21%, crustacea 21% and zooplanktonic organisms 8%. The fish consisted chiefly of *Atherina* sp. and clupeids. Crustaceans were mostly stomatopod larvae.

In specimens caught in Seychelles 43.8% of the stomachs were empty and in the rest the occurrence of food items has been as follows: fish and fish remains –59.3%, cephalopods – 12.3%, small gastropods – 3.1%, macro-planktonic crustacea including megalopa larvae – 25%. The fish food chiefly consisted of the blue mackerel (*Caesio* sp.), flying fish, *Diptery-gonus* and eel remains. One interesting finding here is that the sea grass *Cymodocea* sp., some gastropods and other bottom fishes have also been occasionally met with. This indicates that *E. a. affinis,* in addition to surface feeding, looks for food along corals and sandy bottoms (Wheeler and Ommanney, 1953).

Ogilvie *et al.* (1954) found that among the stomachs of *E. a. affinis* (caught off north Somalia) only 4.9% were empty and the rest showing fish food, prawns and inidentified remains. Among the fish food the chief component was *Sardinella sirm* followed by *Selar crumenophthalmus, Thrissocles baelema, Sillago sihama, Mugil* and *Leiognathus* sp.

Age and growth

According to Wheeler and Ommanney (1953) the rate of growth observed in *E. a. affinis* around Seychelles is 0 to 25 cm in the first year, 25 to 45 cm in the second year, 45 to 65 cm in the third year and 65 cm and above in the fourth year and above.

The length/weight relationship for the East African specimens has been expressed by the following formula by Morrow (1954):

$$W = 1.63\times 10^{-6} L^{3.16}$$

Where W = weight in pounds and L = length in centimeters.

The greatest recorded size from Seychelles is 87 cm weighing 19 lbs. (Wheeler and Ommanney, 1953). Smith (1960) states that it grows upto 120 cm.

Reproduction

Sexes are separate. For *E. a. affinis* on Seychelles the sexual maturity is reported to occur between 50 and 65 cm, in East African specimens between 55 and 60 cm and in Mauritius specimens at 55 cm in total length (Williams, 1963 b).

The ripe ovaries of *E. a.affinis* have been found to be large and distended occupying the entire body cavity. In fresh condition they were soft and well vascularised. They appeared pale pinkish and mottled on the surface due to the presence of ripe translucent ova among the opaque ones. The ripe ovum was spherical, transparent having a diameter of 0.99 mm with a single oil globule about 0.25 mm. samples of *E. a. affinis* examined round the year from Vizhinjam showed that individuals were either immature,or in maturing condition in January-March, in advanced stages of maturity (V and VI) in April to June and in mature or spawning condition thereafter upto August; from September to November they were in spent condition. Thus it appears that the spawning period for this species is from about April to September with a peak from May to August, which coincides with the south west monsoon (Rao, 1962).

In he western part of the Indian Ocean in Seychelles the breeding season has been shown to extend from October/November, coinciding with the north west monsoon, to April/May, with a peak from January to March. Along the East African coast the spawning season is from January to July and in Madagascar area in November/December (Williams, 1963b).

From the size frequency distribution of ova diameter measurements it is presumed that the eggs are liberated in several successive batches within the same spawning season. In fish measuring from 48 cm to 65 cm in length with ovaries weighing from 80 g to 350 g, the number of ova estimated to be produced per spawning varied from 0.21 to 0.68 millions and the total number of ova for the entire breeding season from 0.79 to 2.5 million (Rao, 1962). In seven specimens obtained in the drift net catches along the south west coast of India, the estimated number of ova ranged from 493,617 to 1,393,882 with a mean of 866,900 (Silas, 1969).

From the available information, it is known that the spawning grounds of *E. a. affinis* are coastal, at least within 200 metre line (William, 1963b).

Larval history and juveniles

From the published accounts there is no information on the larvae of *E. a. affinis*. From the Laccadives Sea Jones and Kumaran (1962) reported the occurrence of these larvae but they have not been described for want of a connected series to enable their identity beyond reasonable doubt.

Wade (1950b) and Matsumoto (1950) have described the larval stages of the closely related sub-species viz., *E. a. yaito* from Philippines and Hawaiian areas. In a larva of 4.6 mm in total length (Fig. 8A) the head length is one third; the myomeres are 40; abdominal sac is triangular; the teeth are 12 on the upper jaw and 9 on the lower; preopercle has 3 long spines; the central one longest. Median fins are present with strong striations representing rays. Pectoral fins show similar striations and the pelvic fins are absent. Chromatophores 3 on the forebrain, about 15 over the mid-brain, a single one on the middle of the mandible, about 5 of them along the mid-ventral margin of the trunk near the caudal margin.

In a 7.6 mm larva (Fig. 8B) the first dorsal fin is fully pigmented; mandible has 4 or 5 chromatophores in the anterior half. Snout length greater than the diameter of the orbit. Teeth are 16 on both the jaws; preopercle have 7 spines. First dorsal has 8 spines; the second dorsal and anal fin rays are under formation. The caudal has 9+9 rays; pelvic fins have one spine and 5 rays each; pectorals have 5 rays only; myomeres are 40 to 41.

The 9.6 mm larva (Fig. 8C) shows already resemblence to the juvenile. The pigmentation is heavy on the dorsal fin and is extensive on the snout. Chromatophores extend over 2/3 the length of the mandible. Preopercular spines are 6. There are 13 spines on the first dorsal fin; second dorsal and anal have each 13 rays. Finlets are poorly developed.

The larvae of *E. a. yaito* and *E. lineatus* resemble each other in most of the characters but in the former the myomeres are 40 or 41 while in the latter 38 or 39.

Juveniles measuring from 24.5 mm to 32.1 mm in length collected from the west coast of India have been described in detail by Jones (1960a). In 24.5 mm long juvenile all the larval characteristics are lost except the preopercular spines; the lateral line is indistinct, the colouration is deep and there are 13 vertical bands laterally on each side. Lateral line distinct and corselet present at the base of pectorals.

Competitors, predators, parasites etc

This species has been collected from the stomachs of striped marlins and white sharks. Shoals of *E. a. affinis* were always seen along with small tunas belonging to other species. Even in mixed shoals it is of interest to note that the individuals of the species are very much of the same size. In Ceylon such mixed shoals of *Euthynnus* are often met along with frigate mackerel. On the East African coast the mixed shoals consist of yellowfin tuna, skipjack, frigate mackerel and *Megalaspis* along with *E. a. affinis.*

The more common trematode and copepod parasites are listed below after Silas (1962 c) and Silas and Ummerkutty (1962):

Trematodes:- *Capsala gouri, Rhipidocotyle septapapillata.*

Copepods:- *Anuretes branchialis.*

VII. ORIENTAL BLUEFIN TUNA

Genus **THUNUS** South, 1845

"Teeth small and sharp pointed, a single row in each jaw; body thick, rounded, and spindle-shaped, covered generally with very small scales, but about the chest are some much larger and rougher, forming a kind of corselet, which divides posteriorly into numerous points; on each side of the tail a horizontal , longitudinal, sharp, cartilaginous keel in addition to the two little crests seen in the mackerels (sic); first dorsal fin continued almost to the commencement of the second; false fins or finlets between the latter and the caudal fin; no free spine in front of the anal fin; bracnhiostegous rays seven" (South, 1845).

This genus includes the following subgenera: (1) *Thunnus* S. Str., (2) *Germo*, (3) *Parathunnus*, (4) *Neothunnus* and (5) *Kishinoella*, with characters described as given below (After Jordan and Hubbs, 1925; Jones and Silas, 1962; Talbot and Penrith, 1963).

In *Thunnus* and *Germo* (1) the cutaneous blood vessel passes through the myotome of the fifth vertebra and (2) the surface of the liver is striated with venules. In *Thunnus* (a) the pectoral fin is short, about half the length of the head and (b) the dorsal and anal lobes are also short. In *Germo* (a) the pectoral fin is long, reaching the anterior dorsal and anal finlets and (b) the dorsal and anal lobes are moderately long.

Irrespective of the relative length of the pectoral fin, based upon the other characters viz. the nature of the cutaneous blood vessel and appearance of the liver surface as indicated above, the sub-genera *Thunnus* and *Germo* are treated as one under the former sub-genus, *Thunnus*.

In the rest of the three subgenera (1) the cutaneous blood vessel passes through the myotome of the seventh vertebra and (2) the surface of the liver is not striated with venules.

In *Parathunnus* (1) the posterior cardinal vein is not contiguous with the cuverian ducts, (2) the vascular plexus is on the inner side of the liver, (3) the pectorals are long reaching near to the end or extending beyond the second dorsal and (4) the dorsal and anal lobes are moderate.

In *Neothunnus* and *Kishinoella* (1) the posterior cardinal vein is contiguous with the cuverian ducts and (2) the vscular plexus is in the haemal canal.

In *Neothunnus* (1) the air bladder is well developed, (2) the pectorals are long, extending beyond middle of second dorsal, (3) dorsal and anal lobes are much elongated, as long as head and (4) the gill rakers are about 30.

In *Kishinoella* (1) the air bladder is absent, (2) the pectorals are short, reaching to about the end of first dorsal and (3) the gill rakers are about 26.

THUNNUS (THUNNUS) ORIENTALIS (Temminck and Schlegal), 1844

The taxonomy of the bluefins from various parts of the world is in much confusion. The typical bluefin of the Eastern Atlantic and Mediterranean was originally named *Thunnus thynnus* (Linnaeus) and this at sub-genus level is *Thunnus (Thunnus) thynnus*. In the Pacific and Indian ocean generally three names (at specific level) are now recognized viz. *Thunnus (Thunnus) orientalis* (Temminck and Schlegel) (Indian Ocean and Asiatic coast of North Pacific), *Thunnus (Thunnus)saliens* Jordan and Evermann (Pacific, coast of North America) and *Thunnus (Thunnus) maccoyii* (Castlenau) (Australia and New Zealand). It is not known whether *T. (T.) maccoyi* of Australia is identical with what is called *Indo-maguro* by Japanese occurring on the eastern part of Indian Ocean. However, Talbot and Penrith (1963) synonymised the species *maccoyii* with *orientalis*. It is also not fully established whether the bluefin occurring on the coasts of Japan, South Africa and India are identical at the specific level. Hence their inclusion is only provisional until good series from all these areas are critically examined for morphometric and meristic characters. The general contention is that the species are localized but no information is available about their movements.

Synonyms

Thynnus orientalis Temminck and Schlegel, 1844
Thunnus maccoyii Castelnau, 1872.
Orcynus schlegelii Steindachner and Doderlein, 1885.

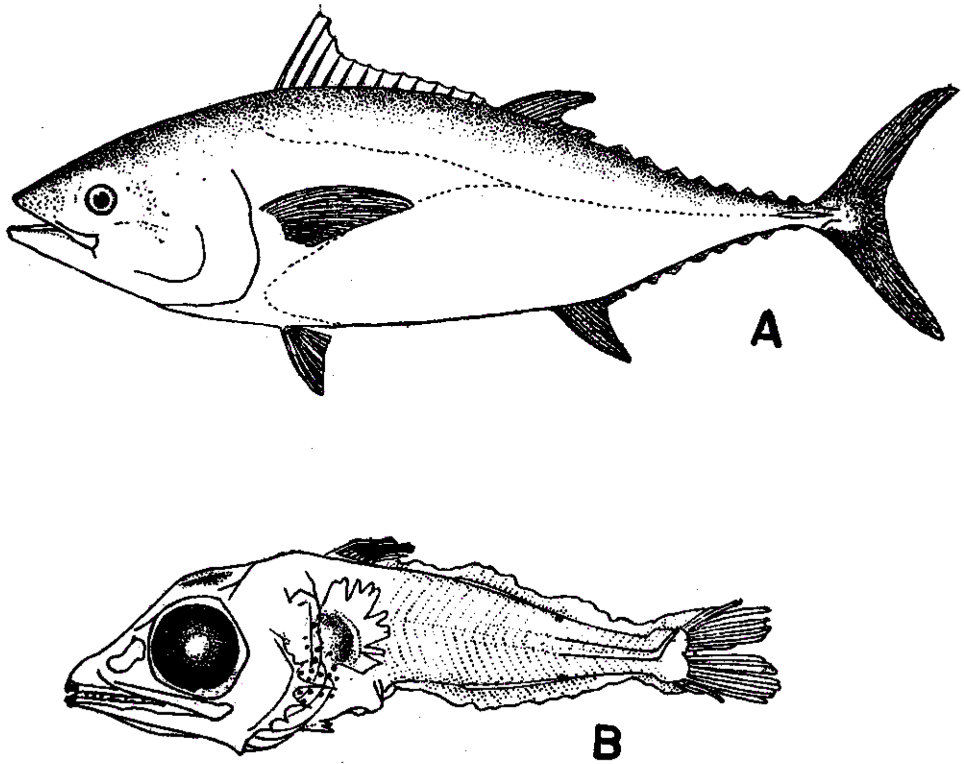


Fig. 9 A. Adult *Thunnus* (*Thunnus*) *orientalis* (Temminck and Schlegel) (after Godsil and Byers, 1944–given as *Thunnus orientalis*);
B. Larva of *Thunnus* (*Thunnus*) *orientalis* 6.8 mm in total length (after Yabe *et al.*, 1961–given as *Thunnus orientalis*).

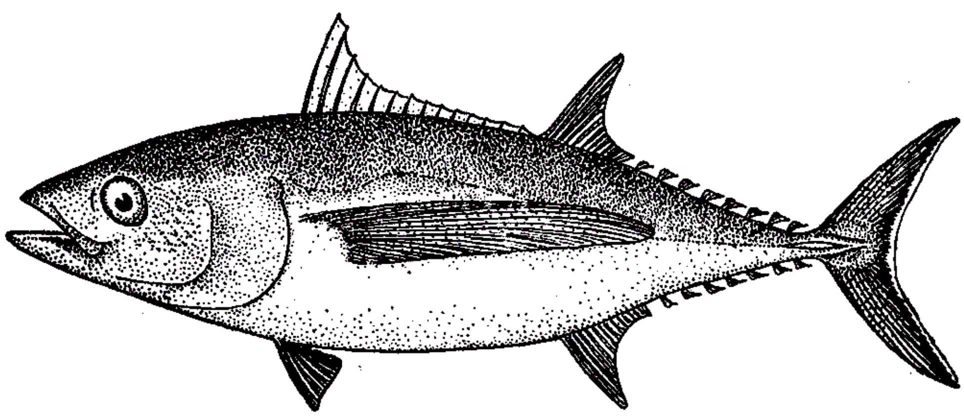


Fig. 10. Adult *Thunnus* (*Thunnus*) *alalunga* (Bonnaterre) (after Iwai *et al.*, 1965–given as *Thunnus alalunga*).

Thunnus orientalis Kishinouye, 1915; Jordan and Evermann, 1926;
Rosa, 1950; Yamanaka *et al.*, 1963.
Thunnus saliens Jordan and Evermann, 1926
Thunnus phillipsi Jordan and Evermann, 1926
Thunnus maccoyii Jordan and Evermann, 1926; Serventy, 1941; Rosa, 1950.
Thunnus thynnus maccoyii Serventy, 1956a; Munro, 1958; Robins, 1963.
Thunnus thynnus orientalis Jones and Silas, 1960; Talbot and Penrith, 1963;
de Jaeger, 1963.
Thunnus (Thunnus) thynnus orientalis Jones and Silas, 1962, 1963a.

Common names

Oriental bluefin tuna
Japan – Maguro-shinmaye, Komeji, Kochuyu, Senaga, Goto, Oomaguro.
Hawaiian Is. – Black tuna, Ohi.
China – Tai Yu.

Description

D^I. XIII-XIV; D^2. 14-16+7-9; A. 13-14+7-8; G.R. 31-36.

Morphometric measurements based on specimens 970-1695 mm from South Africa expressed as percentage of fork length are given below (After Talbot and Penrith, 1963).

"Head 29 to 31; depth 26 to 28; eye 3.1-4.1; maxilla 11 to 13; pectoral length 20 to 23; first dorsal height 11 to 14; snout to first dorsal origin 30 to 32; snout to second dorsal origin 54 to 56; snout to ventral origin 32 to 35; snout to anal origin 59 to 62".

Body robust, roundish but slightly compressed in cross section. Slender conical teeth on both jaws; villiform teeth on palatine and pterygoid. Interpelvic process bifid. Pectoral short terminating much in front of the margin of the second dorsal fin. Scales absent on head; body finely scaled, those on cheeks and corselet large (Fig. 9A).

Colour:- Dorsum blue black, abdomen silvery grey with pale lines alternating with rows of dots. First dorsal grey, second dorsal blue black, tips yellowish. Finlets yellowish. . Pelvic dusky. Caudal keel yellowish, occasionally dark.

Air bladder present; liver densely striated with blood vessels with lobes sub-equal.

Variability

The variability of meristic characters of *T. (T.) orientalis* from Japanese waters is given below (after Yamanaka *et al.,* 1963).

D^{I}. XIII-XIV; D^{2}. 14+8-9; A. 13-15+7-8; G.R. 12-13+24-26
(Kishinouye, 1923)
D^{I}. XIV; D^{2}. 14+(1)8; A. 13+(1) 8. (Temminck and Schlegel, 1842).

The gill raker count for *T. (T.) orientalis* from the Asiatic coast of North Pacific is 36-39, but in South African specimens it is 31-36. in *T. t. thynnus* from South Africa the gill raker count ranged from 41 to 43. (Jones and Silas, 1962; Talbot and Penrith, 1963).

Distribution

Indo-Pacific: South Africa, eastern Indian Ocean, south of Java, Japan, China, Hawaiian Islands, along the western Australia, Tasmania and New Zealand.

BIONOMICS AND LIFE HISTORY

Food and feeding

Specimens captured off South Africa showed the food component in percentage by volume as follows: Fish – 64.3; prawns – 29.8; squids – 3.7; tunicates – 1.6; amphipods – 0.4; megalopa larvae – 0.1 and other items – 0.1. Among the fish components are chiefly *Merluccius capensis* and *Lepidopus caudatus; Funchalia woodwardi* Johnson forms main item under prawns. 23.6% of the stomachs are found to be empty (Talbot and Penrith, 1963).

The bluefin in the Japanese waters is known to feed on varied kinds of fish, mostly pelagic in habit as sardine, anchovy, flying fish, scad, sand eel, etc. but fishes living at the bottom have also been found in the stomachs. Of the crustaceans *Euphausia, Sergestes,* larvae of brachyura and stomatopoda, as also amphipod spp. have been found in the stomachs (Yamanaka *et al.*, 1963).

There seems to be no feeding during night; most of the feeding activity is just after sunrise, gradually slackening thereafter till evening, when there is again an increase. It was observed that the largest specimens have been caught in fair numbers during afternoon period. It appears that the feeding is by sight and pursuit of the prey. Some of the fish and prawn species found in the stomach being typically deep water forms, there is indication that the fish feeds in deeper layers of water. These observations were made from the results of the long lining off South Africa (Talbot and Penrith, 1963).

Age and growth

According to Aikawa and Kato (1938) the one year old fish are 43-69 cm (weighing 2.3 to 8.3 kg), the two year old 69-94 cm (8.3-21.6 kg), the three year old 94-118 cm (21.6-41.0 kg)), the four year old 118-145 cm (41.0-73.0 kg), the five year old 145-168 cm (73.0 – 110-0 kg), the six year old 168-190 cm (110-144 kg), the seven year old 190-210 cm (144-185 kg), the eight year old 210-230 cm (185-230 kg) and the nine year old 230-250 cm (230-300 kg). Their conclusions are based on examination of 7th and 12th vertebrae.

In South Africa 930 to 1770 mm long specimens were reported with distinct modes at 950 mm, 1100 mm and 1250 mm and rather indistinct ones at 1400 mm, 1500 mm, 1600 mm and 1700 mm of fork length. Fish measuring 829 mm in length are considered over four years of age (Serventy, 1956a; Talbot and Penrith, 1963).

The length/weight relationship of this species along the South African coast is given below (after de Jaeger, 1963):

$W = 6.394 \times 10^{-5} \times L^{2.92}$ for males

$W = 4.831 \times 10^{-5} \times L^{2.98}$ for females.

Where ‘W’ in lbs and ‘L’ in cm. The length range from 88 cm to 172 cm, the corresponding weight ranges were from 35 to 220 lbs. It may be presumed that 172 cm long bluefin would be 8 years old, if the growth rate of this species and the Mediterranean bluefin are comparable.

Kishinouye (1923) has remarked that the fish attains a maximum length of 3 metres and weighs more than 260 kg in weight.

Reproduction

The species is heterosexual. In the areas where this has been caught, it was found in ripe condition. Mimura (1958) considers that the breeding population along the western coast of Australia is composed of fish from 1300 mm to 1800 mm in fork length.

On the Japanese coast the spawning season seems to be from April to July, with peak about May, starting earlier in the south and delayed in the north. Individual fish seems to spawn only once in a year. Estimates on fecundity show that eggs in the ovary vary in proportion to the size of the fish. specimens weighing between 270 and 300 kg had about 10 million eggs. Such fish are in the 9th year of age according to Aikawa and Kato (1938). The principal spawning ground appears to be near Luzon-Ryukyu Islands.

Eggs, larvae and juveniles

The mature egg which is almost colourless, transparent and spherical is 0.85-1.00 mm in diameter (Nakamura, 1938; Kawana, 1935). It has a few oil drops.

Some planktonic larvae about 6.5 mm in length have been tentatively identified by Matsumoto (1961) as belonging to *T. (T.) orientalis*. In larva about this size (Fig.) chromatophores are present on tips of both jaws. A very characteristic feature of the larvae of this species is the presence of a pair of distinct chromatophores on the mid-dorsal and mid-ventral line posteriorly in the trunk. Pigmentation is recognizable in the first dorsal in early larva which becomes heavier in later stages (Yabe *et al*., 1961).

Competitors, predators, parasites etc.

It is presumed that all other tunas, spearfish, *Scomberomorous*, etc. are the competitors for the available food in the environment.

The main predators on this species appear to be killer-whales and sharks. The juveniles have many enemies like the seals, dolphins, spearfishes, sword-fishes, sharks and large tunas.

The parasites are mostly copepods and trematodes, found on the surface of the pectoral fins, the inner side of the opercle, gill lamellae, nasal and anal cavities. Among the internal parasites are the nematodes in the alimentary canal, circulatory system, muscles and the viscera.

Kubo (1961) states that tuna schools migrate northward around Japan from spring to summer and southward from autumn to winter. There seems to be a strong instinct to form schools. Adult and juvenile tuna form separate dense groups according to their size. Schools are sometimes distinguishable with jumping members, or members, or members swirling near the surface; schools may be found in association with birds or accompanied by whales (Yamanaka *et al.*, 1963).

VIII. ALBACORE

THUNNUS (THUNNUS) ALALUNGA (Bonnaterre), 1788

Synonyms

Scomber alalunga Bonnaterre, 1788
Scomber germon Lacepede, 1800
Scomber germo (Commerson) Lacepede, 1802
Orcynus germon Cuvier, 1819
Orcynus alalonga Risso, 1826
Germo alalunga Jordan and Evermann, 1896; Meek and Hildebrand, 1923; Molteno, 1948; Smith, 1949.
Germo germo Jordan and Seale, 1906; Jordan and Evermann, 1926.
Germo alalunga Barnard, 1927
Thunnus alalunga South, 1845; Jordan, Tanaka and Snyder, 1913; Jones and Silas, 1960; Idyll and Donald de Sylva, 1963b; Talbot and Pernrith, 1963; De Jaeger, 1963.
Thunnus germo Kishinouye, 1923; Serventy, 1941; Godsil and Byers, 1944; Yoshida and Tamio Otsu, 1963.
Thunnus (Thunnus) alalunga Fraser –Brunner, 1950; Jones and Silas,1962;1963a.

Common names

Albacore.
Japan – Binnaga, Bincho, Tomboshibi, Kantara.
Philippines – Albakora, Kiyawon.

Descriptions

D^{I}. XIII-XIV; D^{2}. 13-15+7-8; A. 15-16+7; G.R. 7-9+19-21= 27-30.

Body proportions expressed as percentage of fork length for specimens from South Africa are given below (after Talbot and Penrith, 1963):

“Head 29 to 30; depth 25 to 27; eye 5.3 to 5.7; maxilla 10 to 12; pectoral length 40 to 42; first dorsal height 11 to 12; second dorsal height 11 to 11.9; anal height 11 to 12; snout to first dorsal origin 31 to 34;

snout to second dorsal origin 58 to 60; snout to ventral 33 to 34 and snout to anal 62 to 66"

Body moderately robust. Head conical, mouth terminal. Teeth small, conical, uniserial in jaws; vomer and palatine with minute teeth. Maxillary reaching vertical to first one third of the eye. Interorbital broadly convex. First dorsal long, second dorsal short and interspace very short. Pectoral long, saber shaped reaching to the first anal finlet. Pelvic thoracic. Pectoral, second dorsal and anal distinctly concave on the posterior border. Caudal portion short. Caudal peduncle with keel on each side. Caudal lunate. Body covered with minute scales, about 120 in the lateral line. Corselet small and indistinct; corselet scales enlarged anteriorly lateral line arched in front and straight behind (Fig. 10).

Colour:- Steel-blue on dorsum and sides; silvery on abdomen, whitish spots on the sides of the abdomen; dorsal and caudal dusky brown, pectoral blackish, other fins pale, keel on caudal peduncle blackish.

Air bladder wide, running full length of body cavity.

Variability

Some of the meristic counts of albacore reported from various regions are summarized and given below (after Yoshida and Tamio Otsu, 1963):

Japan:	D^{I}. XIV; D^{2}. 15-16+7-8; A. 14-15; G.R. 8-9+19-21 = 27-30.
Hawaii:	D^{I}. XIII-XIV; D^{2}.. 16+7; A. 15+7; G.R. 8-9+20 = 28-29.
California:	D^{I}. XIII-XIV; D^{2}. 15-16+7-8; A. 14-15+7-8; G.R. 8-10+19-21 = 28-30.
North west-tern Carib-bean	D^{I}. XIII-XIV; D^{2}. 15+8; A. 14-15+7-8; G.R. 7-9+19-20 (Bullis and Mather, 1956).

Some variations in the number of dorsal spines and gill raker counts observed in specimens from the major oceanic regions are shown below:

Indian ocean:	D^{I}. XIII-XIV; G.R. 7-9+19-22 = 27-31.
North west Pacific:	D^{I}. XIII-XIV; G.R. 7-10+18-22 = 25-32.
South west Pacific:	D^{I}. XIII-XIV; G.R. 7-10+18-22 = 26-31.

Suzuki *et al.* (1959) have found striking difference in the blood group frequency of albacore from Indian Ocean and north Pacific Ocean.

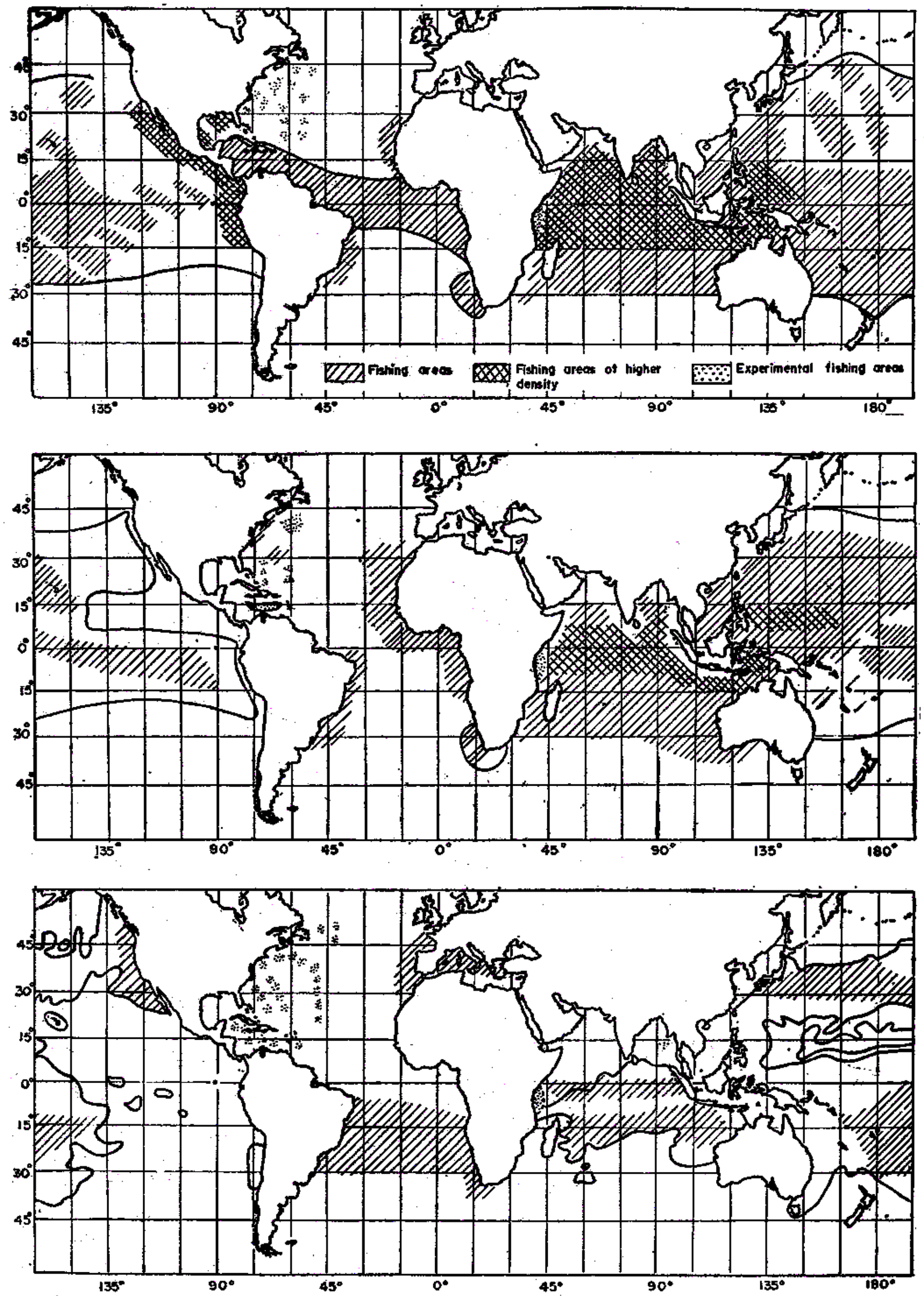


Fig. 11. Geographical distribution of tuna species (after Laevastu and Rosa, 1963). Top: Distribution and relative abundance of yellowfin; Middle: Distribution and relative abundance of bigeye; Bottom: Distribution and relative abundance of albacore.

Marr and Sprague (1961) have concluded that the Indian Ocean samples were drawn from a mixture of two or more inter-breeding population and the Pacific Ocean samples from single inter-breeding population.

Distribution

Albacore is cosmopolitan in distribution in Indian, Pacific and Western Atlantic Ocean. In the Indian Ocean the distribution range is from about 10^0 N to 30^0 S latitude from Australia to east coast of Africa. It has however not so far been recorded from the Indian coasts. On the eastern side of north Pacific, it is recorded from Baja California to the Gulf of Alaska; on the western north Pacific it is found from Equator to about 45^0N latitude. In the south Pacific it occurs from Equator to 45^0S from the east coast of Australia to Chile. In the western Atlantic it is known from the middle Atlantic coast of United States to Brazil, but not extending into the Gulf of Mexico. It has also been recorded in the eastern Atlantic along western coast of South Africa from Orange river to Cape Point (Fig. 11).

BINOMICS AND LIFE HISTORY

Food and feeding

In the western Indian Ocean fishes of the families Triacanthidae, Plagyodontidae, Carangidae and Gempylidae were noted in 10% or more of the albacore stomach. Isopods, decapods and stomatopods also occurred in 10% or more of the stomachs (Koga, 1958). The food of Albacore from South China Sea has been found to comprise of squids, octopus, stomatopods, barracuda, hair-tails, flatheads and *Mene maculata* (Kanamura and Yazake, 1940). In the north eastern Pacific the albacore food has been found to be squid, saury, black cod and lantern fishes (Powell, 1950). From the Equatorial South Pacific Koga (1958) has found that in 10% or more of the albacore stomach examined, fishes belonging to Playgyodontidae, Triacanthidae, Acinaceidae, Ostraciidae and Menidae were represented; also squids were present in more than 50%, decapod crustaceans 15% and *Octopus* 10% of the stomach examined.

Talbot and Penrith (1963) noted the important food components of *T. alalunga* from South African coast to be fish (40.4%), squid (39.1%), amphipod (8.1%), prawns (4.8%) and crustacean larvae (5.1%). Occasionally heteropods, pteropods, anomuran larvae, euphausids etc, were also met with among the stomach contents. They also noted that only a small number (9.7%) of stomachs examined were found empty.

From the nature of the stomach content it is judged that the albacore feeds at all levels from surface waters to depths of at least 80 fathoms. Feeding seems to be during day time, the period of intensive feeding being in the early morning.

Age and growth

The albacore of the North Pacific has been studied for its age and growth by Clemens (1961) and Bell (1962 a & b) by tagging experiment and scale reading. The results arrived at in respect of the length in cm at different age groups in fork length by the two methods are as follows:

Age	I	II	III	IV	V	VI	VII
Tagging	52.0	65.0	76.0	85.0	93.0	100.0	105.0
Scale reading	57.3	65.7	77.4	83.7	87.8	-	-

It has been found that the albacore caught all the year round from South African region have revealed modal lengths at 650, 750, 830, 900, 980 and 1030 mm, probably representing the respective age groups from 3 to 8 (Talbot and Penrith, 1963).

The length/weight relationship of albacore of South African region, as observed by De Jaeger (1963) is expressed as:

$W = 5.088\times 10^{-5} \times L^{2.98}$ for males

$W = 3.094 \times 10^{-5} \times L^{3.09}$ for females

Where ‘W’ is weight in lbs. and ‘L’ is length in cm.

The largest size taken from South African region was 1191 mm in fork length. The albacore from the waters around Hawaii are stated to be the largest of the species in the Pacific Ocean and the one recorded by Otsu and Uchida (1959) measured 128 cm in length weighing 93 lbs.

Reproduction

The species is normally heterosexual. Off South Westerm New Caledonia a single hermaphrodite individual was recorded by Legand, as cited by Yoshida and Otsu (1963).

From the Western Pacific the smallest mature female fish measured 87 cm long (Ueyanagi, 1957) and from the Central Equatorial Pacific 89.1 cm (Otsu and Uchida, 1959). From South Pacific Otsu and Hansen (1961) observed a mature individual at 86 cm. The age at maturity has not been thoroughly studied but it is presumed that the albacore is about 6 years old when it attains first sexual maturity.

On the basis of gonad maturity, in the western North Pacific, the fish appears to spawn during the summer months with June and July at its peak (Ueyanagi, 1957). Otsu and Uchida (1959) found evidence of albacore spawning Hawaiian waters in summer months. It is generally believed that in the North Pacific spawning occurs in summer under the influence of North Equatorial current. In the South Pacific Otsu and Hansen (1961) have observed the possibility of the albacore spawning during January and March. Thus it appears in the South Pacific the spawning season is six months out of phase with that in the North Pacific.

In the Indian Ocean albacore with highly developed ovaries from south of Sunda Island was observed in February (Ueyanagi, 1955) indicating probably spawning occurring during or about that month. For South African albacore spawning is said to be about October to April.

Very little information is available on the frequency of spawning in albacore, but Otsu and Uchida (1959) from the frequency distribution of the modes in ova come to the conclusion that the species may undergo multiple spawning or atleast spawns twice during a single spawning season.

The available information indicates that the spawning grounds of albacore are in the tropical and subtropical oceanic waters of the Pacific and Indian Oceans.

For the albacore of the Pacific, the fecundity estimate varied from 0.8 to 2.6 million eggs (Ueyanagi, 1955 and 1957; Otsu and Uchida, 1959).

Eggs, larvae and juveniles

Yoshida and Otsu (1963) report ripe albacore eggs measuring 1 mm in diameter, with conspicuous golden yellow oil globule. In the Mediterranean sea Sanzo (1933) recorded pelagic eggs of *Orcynus germo* Lutken (= *T. alalunga)* in the plankton. These eggs varied between 0.84 and

0.94 mm in diameter, each with a single oil globule measuring about 0.24 mm in diameter. By rearing them upto seven days in the laboratory, he was able to observe the very early larval stages. From the material collected in 'Dana' expedition during 1928-30, Matsumoto (MS) was able to tentatively identify the larval albacore which according to him possessed two characteristic chromatophores on the ventral edge of the body in the 28th and 33rd myotomes and single chromatophore on the dorsal edge of the trunk.

Competitors, predators, parasites etc

There seems to be certain amount of competition between albacore and yellowfin, bigeye and *Alepisaurus* for the available food in the environment (Yoshida and Otsu, 1963).

The black marlin, yellowfin, striped marlin and short nosed spearfish are some of the predators on juvenile albacore (Yabe *et al*., 1958).

The parasites on albacore on the Pacific Ocean listed by Yoshida and Otsu (1963) are *Elythrophora brachyptera* and *Didymocystis opercularis* within the operculum, *Didymocystis alalongae* in the gill arch, *Platocystis alalongae* on the skin, *Melanematobothrium guernei* in sub-maxillary muscle and *Hirudinella spinulosa* and *Contracaecum legendrei* in the stomach.

IX. BIGEYE TUNA

THUNNUS (PARATHUNNUS) OBESUS SIBI (Temminck and Schlegel), 1844

Synonyms

Thunnus sibi Temminck and Schlegel, 1844
Parathunnus sibi Jordan and Hubbs, 1925; Jordan and Evermann, 1926; Herre, 1953; Alverson and Peterson, 1963.
Germo sibi Jordan and Jordan, 1922
Thunnus mabachi Kishinouye, 1915
Parathunnus mebachi Kishinouye, 1923; Godsil and Byers, 1944; Munro, 1957; Mimura *et al.*, 1963a.
Thynnus obesus Lowe, 1839
Thunnus obesus Collette, 1961 (in part); Talbot and Penrith, 1961; 1963; Talbot, 1962; De Jaeger, 1963.
Parathunnus obesus mebachi Jones and Silas, 1960
Thunnus (Parathunnus) obesus mebachi Jones and Silas, 1962
Thunnus (Parathunnus) obesus sibi Jones and Silas, 1963a.

Common names

Bigeye tuna
Japan – Mebachi – Bachi, Daruma, Yawara.
Hawaiian Islands – Daruma, Darumasibi, Ahi.

Description

D^{I}.XIII- XIV; D^{2}. 14-15+8-9; A. 13-14+8-9; G.R. 7-9+18-20 = 26-28.

Morphometric measurements based on specimens 1280-1885 mm, from South Africa expressed as percentage of fork length are given below (after Talbot and Penrih, 1963):

Head 24 to 29; depth 25 to 28; eye 3.5 to 4.6; maxilla 10 to 11; pectoral length 20 to 27; first dorsal height 11 to 13; second dorsal height 13 to 16; anal height 13 to 16; snout to first dorsal origin 26 to 31; snout to second dorsal 52 to 54; snout to ventral origin 29 to 33; snout to anal 60 to 62.

Body broad, caudal portion short, head and eye fairly large. Dorsal contour of body arched and ventral contour deeply curved. Length of head about equal to depth of body. Second dorsal and anal narrow and falciform. Origin of second dorsal very close behind the spinous dorsal. Spinous dorsal posteriorly convex. Pectoral fin scarcely passing beyond the origin of the second dorsal in the large specimens, but in younger ones passing up to vertical below the first dorsal finlet and the middle of the anal. Scales large, particularly on the corselet, 190 in number along lateral line. Lateral line having a wavy course above the pectoral. Caudal wider than height of the body (Fig. 12 A).

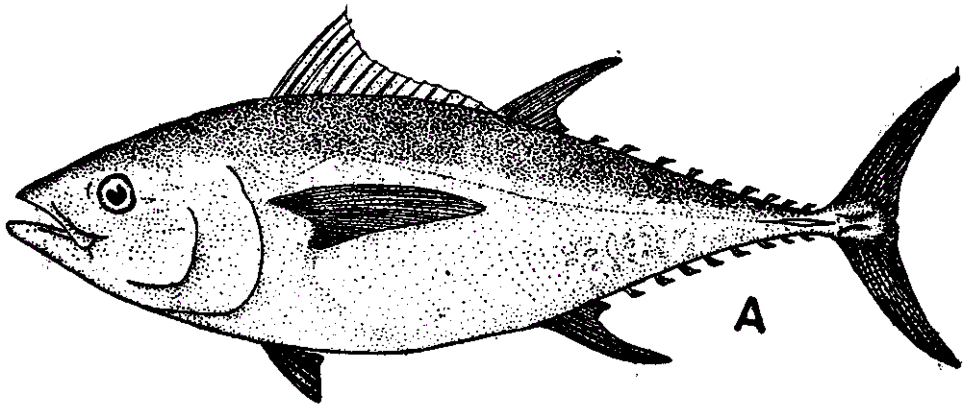
Colour:- Dorsum black to greenish blue, sides and belly silvery white. Iris with bluish tint. Dorsal fin grayish with yellowish margin. Finlets yellow. Pectorals dorsally black and grayish ventrally. Ventrals grayish yellow. Anal whitish with yellow tips. Anal finlets grayish with yellow. Young specimens with sides grayish with transverse rows of colourless lines and colourless dots.

Air bladder well developed and divided at anterior end. Liver striated but striations few and peripheral in position.

Most authors (Fraser-Brunner, 1950, Jones and Silas, 1960; 1963a; Rivas, 1961; Collette, 1961) have recognised that the bigeye tuna of the Atlantic and the Indo-Pacific belongs to the same species *obesus* under sub-genus *Parathunnus.* However, the speciefic name *sibi* Temminck and Schlegel, 1844 and *Mebachi* Kishinouye, 1915 have been used by some authors to distinguish the Indo-Pacific form. Of these two names *sibi* has priority over *mebachi,* although the latter name is more often used by scientific workers. The nomenclature adopted here is after Jones and Silas (1963a) who provisionally distinguish the Indo-Pacific form from the Atlantic bigeyes tuna only at sub-specific level.

Distribution

The bigeye tunas are world-wide in their distribution. *T. (P.) obesus* is known from the Atlantic Ocean along the coasts of South America, Caribbean Sea and the west coast of Africa. *T. (P.) sibi* has a distribution in the Pacific extending north to about 43^0 and south to about 37^0 in southern Australia. In the Indian Ocean *T. (P.) obesus sibi* extends to about 300 south in temperate and tropical waters (Fig. 11)



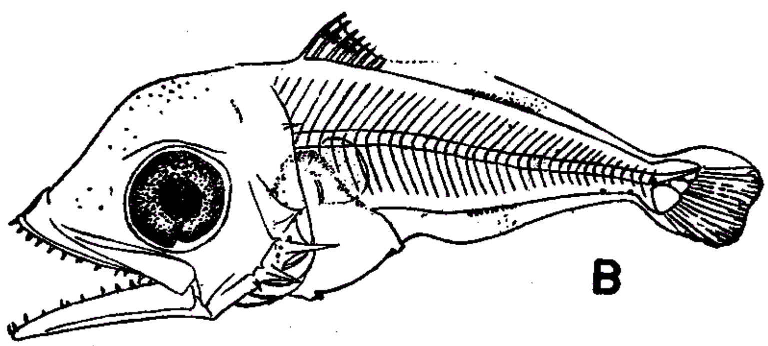


Fig. 12. A. Adult ***Thunnus*** **(*Parathunnus*)** ***obesus sibi*** (Temminck and Schlegel) (after Iwai ***et al.***, 1965-given as ***Thunnus obesus***);
B. Larva of ***Thunnus*** **(*Parathunnus*)** ***obesus sibi*** 6.05 mm long (after Matsumoto, 1961-given as ***Parathunnus mebachi***).

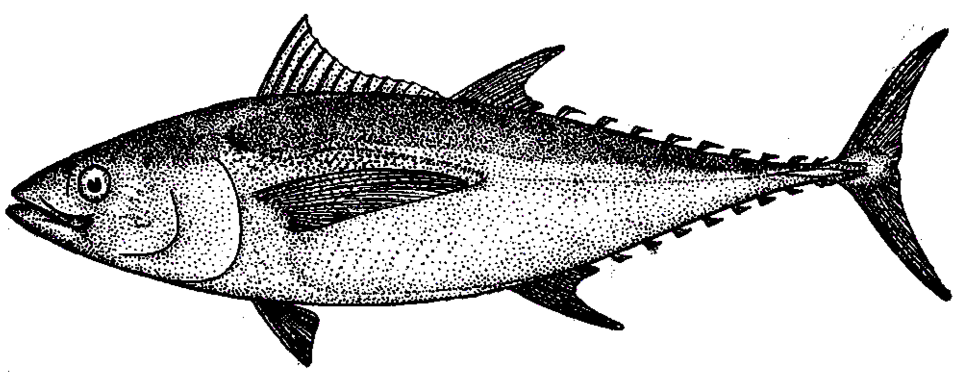


Fig. 13. Adult ***Thunnus*** **(*Kishinoella*)** ***tonggol*** (Bleeker) (after Iwai ***et al.***, 1965-given as ***Thunnus tonggol***).

BIONOMICS AND LIFE HISTORY

Food and feeding

The bigeye of the western Indian Ocean is stated to include for its diet juvenile fishes like *Sphyraena* and skipjack as also decapods and molluscs (Koga, 1958). In the eastern Indian waters it feeds chiefly on squids, variety of fishes, amphipods, etc. Watanabe (1960) observes a close relation between the food of the fish and fish fauna in the regional sea.

In the bigeye of the Central Pacific taken by long lines King and Ikehara (1956) found in the stomachs seven orders of invertebrate group, two orders of tunicates and 36 families of fishes; fish forming 62%, squid 33%, other molluscs 3% and crustaceans 2% by volume. Bramidae, Lolinginidae, Gemphylidae, Ommastrophidae, Thunnidae, Paralepididae and Alepisauridae formed the important items by volume in the order given.

In the Eastern Pacific, the bigeye caught by long lines has been found to feed on cephalopods (63%), fish (22%) and crustaceans (15%). The more important items of food have been found to be members of Ommastrephidae, Portunidae, Trachipteridae, Gempylidae, and Katsuwonidae.

Talbot and Penrith (1963) in *T. obesus* off South Africa coast have reported that its food consists of fish (50.7%), squids (38.8%), prawns (10.1%), tunicates (0.2%), amphipods (0.1%) and other items (0.1% by volume). The important fish components have been *Merluccius capensis, Alepisaurus ferox* and *Lepidopus caudatus;* the squids were represented by *Histioteuthis bonelliana* and *Loligo reynaudi; Funchalia woodwardi* formed the prawn component. These authors consider that *T. obesus* feeds during day and more particularly in the morning and evening. Watanabe's (1958) findings are that it feeds to a large extent at nights. Talbot and Penrith (*loc. cit.)* state that as the fish feeds by sight there should be atleast some low illumination, either sunlight or moonlight for feeding.

Alversion and Peterson (1963) report that the fish feeds from surface waters to depths about 425 feet. The younger fish less than 100 cm in length usually feed in the surface waters in compact schools, often in company with other tunas as skipjack and yellowfin, in the vicinity of continental land masses, island etc. whereas the large fish are either solitary or form small groups which feed at greater depths in oceanic regions.

Age and growth

According to Suda (1961) and Alverson and Peterson (1963) the one year lod bigeye are 45-50 cm (weighing 6.2 lbs.), the two year old 70 cm (16.6 lbs.), the three year old 94 cm (39.4 lbs.), the four year old 116 cm (71.2 lbs.)the five year old 138 cm (121.4 lbs.) and the six year old 155 cm (170.7 lbs.). Iversen's (1955) length/ weight relationship equation for bigeye tuna is log weight (lb) = -7.1167 + 2.9304 log total length (mm). De Jaeger (1963) has expressed the length/weight relationship of the bigeye in the exponential form $W = 1.8172 \times 10^{-4} \times L^{2.72}$ for males and $W = 1.2840 \times 10^{-4} \times L^{2.79}$ for females, where W is weight in lbs. and L is length in cm.

Alverson and Peterson (1963) have indicated that 236.4 cm long specimen weighing 435 lbs. was the largest captured off Peru; this appears to be about 9 or 10 years old.

Reproduction

The species is heterosexual. According to Kikawa (1953) the size at first sexual maturity seems to be between 90 and 100 cm (35 to 46 lbs.). On the basis of Suda's (1961) length/weight relationship proposed for this fish, it is approximately 3 year old at first spawning.

Kume (1962) finds that the bigeye in the Indian Ocean attains minimum size of 92 cm in fork length at first spawning. Nakamura (1959) finds evidence to show that the bigeye in the Indian Ocean spawns through out the year in low latitudes. The observations of Ueyanagi and Yukinawa (1953), Yukinawa and Watanabe (1956) and Kume (1962) show that the species spawns in a wide area from east to west from January to March in the Indian Ocean. From the observations of the above authors, the spawning grounds in the Indian Ocean for bigeye appear to extend over a very wide area from east to west from 6^0N to 10^0S.

Mimura *et al.* (1963a) believe that the Pacific bigeye spawns between 10^0S and 12^0N, with centre of activity in the Equatorial Counter Current. It appears therefore that spawning occurs in tropical waters with climax in Equatorial waters both in the Pacific and Indian Oceans.

In the Equatorial region of the Pacific the bigeye seems to spawn throughout the year. In 0^0 to 12^0N the peak spawning is between April and September. In 0^0 to 20^0S the peak spawning is in January to March (Kikawa, 1961/0. Yuen (1955) has found in the bigeye tuna residual eggs in early stages of resorption together with developing eggs in late maturing or mature stages, indicating atleast two spawning in close succession.

According to Yuen (1955) in fish weighing between 39 kg and 107 kg, the ovary weight ranged from 970 g to 2818 g, with estimated number of mature eggs in a pair of ovaries varying from 2.9 million to 6.3 million . He has found curvilinear relationship between the number of eggs spawned and fish weight; the larger fish generally tend to have more eggs per spawning, with wide variations among fish of same size.

Eggs, larvae and juveniles

Kume (1962) states that the mature eggs of bigeye from the mid-Indian Ocean are buoyant, transparent, spherical and each with a single oil glouble; the diameter of the eggs ranges from 1.03 to 1.08 mm and the oil globule from 0.23 to 0.24 mm. Kume (loc. cit.) has succeeded in fertilizing the eggs under laboratory conditions and when they were kept in water of 28.1^0C to 29. 4^0C produced larvae 21 hours after fertilization. The just hatched larva has measured 1.5 mm in length.

The larva of *P. obesus sibi* measuring 6.05 mm (Fig. 12B) described by Matsumoto (1961) is characterized by the following structures: 40 myotomes in the trunk, origin of second dorsal on the 16th myotome, prominent pigmentation in the first dorsal fin and absence of pigmentation over the fore-brain, at the symphysis of the pectoral girdle and along the dorsal margin of the trunk exclusive of the caudal. Pigmentation along the ventral edge of trunk, which is characteristic of this species is absent in *N. albacares.*

Yabe *et al*. (1958) have described bigeye juveniles measuring 143-173 mm in standard length collected from the stomach of adult fish in the Pacific and Indian oceans. They have a series of denticles on upper and lower jaws; villiform teeth are present on vomer and palatine; the pectoral fin is long reaching the 17th vertebra, the first dorsal spines are 13 or 14; finlets are 8 behind dorsal and anal; liver has three well separated lobes with the middle one the longest and no striations are present on the margin of the liver which is characteristic of the adult.

The food of the juveniles as revealed by the stomach contents consists of cuttlefish and the young of other fishes. It appears that tuna young 10 to 30 cm in length, irrespective of species, depends on same items of food (Yabe *et al.,* 1958).

Competitors, predators, parasites etc.

Koga (1958) has reported that the food preference for the bigeye, yellowfin and albacore are identical. Watanabe (1960) also finds no basic difference in the food items of tunas and marlins in a wide area from pacific to the Indian Ocean. All large carnivorous fishes inhabiting the same area as the bigeye tuna are apparently potential competitors for food.

To adult bigeye tuna, large billfishes and killer whales appear to be serious enemies. The smaller bigeye tuna are preyed upon by many fishes as spearfish, swordfish, blue marlin and large forms of any other carnivorous fish in the environment.

A sporozoan parasite *Hexacapsula neothunni* is found to parasitise several species of tunas, including the bigeye. The infection from this parasite brings about a condition in the muscles known as "Jelly meat". It is stated that the bigeye has relatively stronger resistance to this parasite than the yellowfin (Asakawa and Suda, 1957). In the gill lamellae of this fish, *Hexacotyle* has been found as an external parasite and a species of Filariadae within the superficial muscles (Kishinouye, 1923)

X. YELLOWFIN TUNA

THUNNUS (NEOTHUNNUS) ALBACARES (Bonnaterre), 1788

What are known by yellowfin tunas are worldwide in their distribution, but geographically known under separate names. The general opinion is that all of them come under one species viz.*Thunnus (Neothunnus) albacares* (Bonnaterre), 1788. There is no doubt that there are certain recongnisable differences in morphometric measurements and in other characters of the yellowfin tunas from different parts of the world. It may be pointed out that *Neothunnus itosibi* Jordan and Evermann has been treated here only as a growth stage of *T. (N.) albacares* following Iwai et al. (1965).

synonyms

Scomber albacares Bonnaterre, 1788
Thynnus albacora Lowe, 1839
Thynnus macropterus Temminck and Schlegel, 1844
Germo macropterus Jordan and Snyder, 1901; Jordan and Seale, 1906;
Fowler, 1928.
Thunnus macropterus Jordan, Tanaka and Snyder, 1913; Kishinouye, 1915; ‘
Mendis, 1954.
Neothunnus macropterus Kishinouye, 1923; Serventy, 1941; Munro, 1955;
Jones and Silas, 1960: Mimura *et al.,* 1963b.
Thunnus albacares Talbot, 1962; Talbot and Penrith, 1962, 1963.
Neothunnus itosibi Jordan and Evermann, 1926; Smith, 1935; Molteno, 1948;
Jones and Silas, 1960.
Thunnus (Neothunnus) itosibi Jones and Silas, 1962, 1963a.
Thunnus (Neothunnus) argentivittatus Deraniyagala, 1952
Thunnus (Neothunnus) albacares macropterus Jones and Silas, 1962, 1963a
Thunnus (Neothunnus) albacares Schaefer *et al.*, 1963.

Common names

Yellowfin tuna.
India – Soccer (Madras); Kannalimas (Minicoy Island).

Ceylon – Kelavalla, Horealla (Sinhalese); Kalavalai (Tamil).

Japan – Kiwa, Masibi, Gesunaga , Hatsu.

Indonesia – Genlang, Kadawoeng, Geelvin, Toniji.

Description

D^1. XIII; D^2. 14+9; A. 14-15+8-9; G.R. 9+21.

The body proportions expressed as percentages of total length as given by Talbot and Penrith (1963) are as follows:

"Head 24 to 29; depth 24 to 28; eye 3.2 to 6.2; maxilla 9.6 to 12; pectoral length 24 to 29; first dorsal height 11 to 13; second dorsal height 13 to 34; anal height 11 to 38; snout to first dorsal origin 30 to 32; snout to second dorsal origin 49 to 56; snout to ventral origin 27 to 33; snout to anal origin 56 to 62."

Body fusiform, head small, caudal portion long. Scales minute,about 270 on lateral line. Body fully scaled corselet distinct with large scales, pectorals reaching about to the origin of the second dorsal, except in very large specimens where it is comparatively shorter, second dorsal and anal very much elongated in larger specimens.(Fig. 14).

Colour:- Body blue black above, sides grayfish with oblique transverse lines and series of silvery white dots, alternating with them. Iris greenish yellow. Pectorals blackish or greenish, tinged with yellow. Ventrals and anal finlets yellow. Most of the fins and finlets have narrow black rim.

Air bladder narrow and long, not divided anteriorly. No venules on the surface of the liver. The right lobe of the liver is long and the left lobe sometimes divided into two.

Variability

It appears that the yellowfin in the Pacific Ocean and other parts of the world are divisible into sub-populations which do not interbreed or breed only to a limited extent. These sub-populations are distinguishable based on differences in structural characteristics including body dimensions and other measurements (Schaefer *et al.*, 1963). Investigations carried out on the Pacific yellowfin tuna by tagging experiments and morphometric

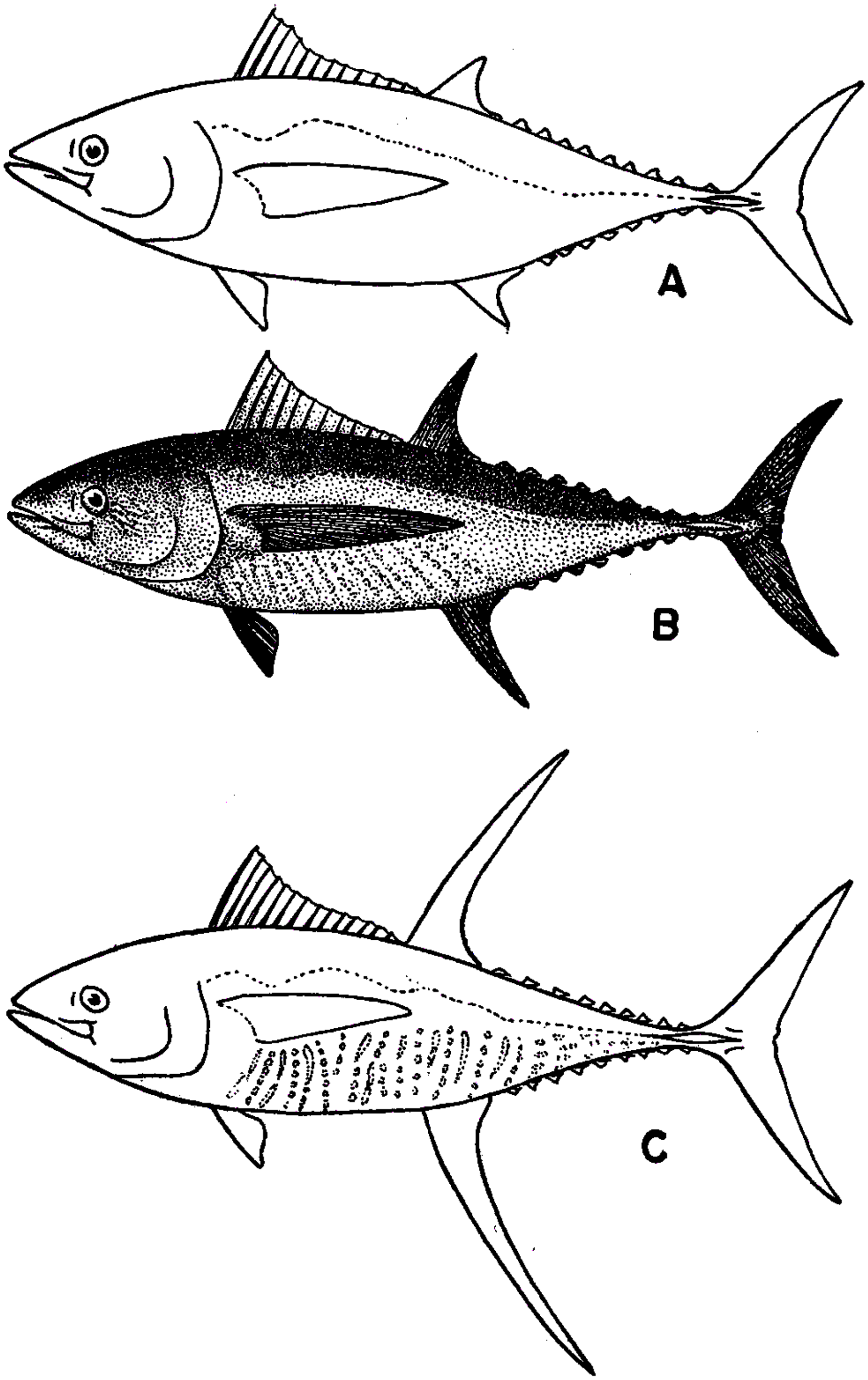


Fig. 14. Growth stages of ***Thunnus (Neothunnus) albacares*** (Bonnaterre) (after Iwai *et al.*, 1965 - given as ***Thunnus albacares***) :
A. 37·9 cm; B. 72·7 cm and C. 130·9 cm in fork length.

studies have indicated the presence of such population units but their exact taxonomic status is still in doubt.

Distribution

Thunnus (Neothunnus) albacares is mostly distributed in the tropical and sub-tropical regions of the indian and Pacific Oceans and mostly in the tropical waters of the Atlantic Ocean (Fig. 11).

In the Indian waters specimens were recorded from the Laccadive Sea, Andaman Island, Gulf of Mannar and off Madras and Maharashtra coasts.

BIONOMICS AND LIFE HISTORY

Food and feeding

Examination of large number of yellowfin from Minicoy caught by pole and line fishing showed that the food consists chiefly of fishes (72.04%), crustaceans (26.28%) and miscellaneous items (1.7% by volume). About 58% of the stomachs were empty. The fish food consists of Dussemieridae, Gempylidae, Balistidae, Tetrodontidae, Dactylopteridae, Carangidae, Exocoetidae, Ostraciontidae, Apogonidae, Pomacentridae and Syngnathidae. Of the crustacean item, mysids, stomatopods, megalopa larvae and crab larvae were the more important ones. Parasites (*Hirudinella* spp.) were found in most of the stomachs (Thomas, 1962).

Thunnus (Neothunnus) albacares from South African region is known to feed on fish (77%), prawns (10.8%), squid (10.2%), megalopa (1.2%) and tunicates and others (comprising 0.8% by volume). Only 10.7% of the fishes were found with empty stomachs. The fish component was constituted by *Scomberosox saurus, Sardinops ocellata, Cyclichthys* sp. *Scomber japonicus* and many other small fishes. *Abrali gilchristi* and *Loligo reynaudi* formed the squid component; prawns were represented by *Funchalia woodwardi* (Talbot and Penrith, 1963).

Reintjes and King (1953) have found in the stomach of yellowfin of Central Pacific, fish representing 38 families and invertebrates belonging to 10 orders. Of these only 7 families of fish and 3 orders of invertebrates have been found to contribute more than 2% of the total volume of food. In the stomach of yellowfin from the Eastern Pacific Alverson (1963) reported the occurrence of fish belonging to 43 families and invertebrates under 12 orders, but only 6 families of fish and 2 orders of invertebrates have been found to contribute to more than 77% of the total volume of the stomach contents examined. The three major components are fish – 47%, crustaceans – 45% and cephalopods – 8% by volume. The conclusion arrived at is that " the diet of the yellowfin changes in response to the distribution of the prey and the failure of a specific food to be present does not in itself limit the distribution of the yellowfin tuna".

Major feeding time appears to be early in the morning, feeding gradually slackens after 11.00 A.M. and improves by evening. Lines set after sunset and hauled before dawn caught nothing indicating absence of feeding during night (Talbot and Penrith, 1963).

In South African region *T. albacares* is caught in large numbers and is the commonest taken by surface trolling. In gears with 3 fathom long lines also large numbers are caught but in long line gear operated between 15 and 80 fathoms only few are caught. These observations clearly indicate that the fish feeds mostly in the upper layers (Talbot and Penrith, 1963).

Age and growth

The estimation of growth by age in the yellowfin tuna of the Pacific and Indian Ocean arrived at by different authors is hown in Table 1. Almost all authors are in agreement that the yellowfin tuna grows at a rapid rate and enters the commercial fishery at about the end of its first year of life.

Table 1

Growth by ages of yellowfin estimated by different authors
(After Mimura *et al.*, 1963b)

Age	Kimura (1932)	Aikawa and Kato (1938)	Moore (1951)	Nose *et al.* (1957)	Yabuta *et al.* (1960)
0	-	38	54	52.4 21.5	54.3
I	62	54	103	64.3 ± 18.0	92.3
II	81	70	136	76.3 ± 14.7	120.1
III	106	85	155	87.6 ± 11.7	139.9

Table 1 (Contd.)

Age	Kimura (1932)	Aikawa and Kato (1938)	Moore (1951)	Nose *et al.* (1957)	Yabuta *et al.* (1960)
IV	120	100	168	98.9 $\pm$ 8.6	154.1
V	134	115	-	109.0 $\pm$ 6.3	-
VI	-	130	-	119.3 $\pm$ 4.9	-
VII	-	145	-	127.1 $\pm$ 4.9	-
VIII	-	160	-	135.1 $\pm$ 5.9	-

Yabuta *et al.* (1960) observed that the growth rate of fish from the Pacific Ocean has presented no variation from that of the Indian Ocean. Hennemuth (1961) has observed that the rates of growth of yellowfin from Western, Central and Eastern Pacific regions were similar. In the Eastern Pacific the fish first enter the surface fishery when they complete one year of their life; recruitment is completed when the fish are 18 months old weighing 7.5 lbs; subsequent growth is rapid and the fish attains a weight of nearly 150 lbs when they are four years old.

Talbot and Penrith (1963) find that the growth of the yellowfin at Cape and Zanzibar is about 40 cm a year. The results of tagging experiments reported by Blunt and Messersmith (1960) and Yabuta and Yukinawa (1961) show for Pacific yellowfin tuna an individual range of growth 20 to 40 cm a year.

The length/weight relationship for the two sexes obtained by De Jaeger (1963) from South Africa are as follows:

$W = 1.796 \times 10^{-5} \times L^{3.18}$ for males

$W = 8.800 \times 10^{-5} \times L^{2.85}$ for females

Where 'W' is weight in lbs and 'L' is length in cm. For East African specimens Morrow (1954) has expressed the length/weight relationship as $W = 0.960 \times 10^{-6}\ L^{3.16}$. Tablot (MS) opined that for a given length the yellowfin tuna from tropical Pacific weighs more than that from East Africa.

Mimura *et al.* (1963b) show that the largest of the yellowfin from the Indian Ocean was 171 cm long as shown by records of the Nankai Regional Fisheries Research Laboratory. However, fish over 170 cm are reported to be rare. The longest of the specimens obtained from Andamans by this Institute measured 130 cm long.

Reproduction

The species is heterosexual. Mimura *et al.* (1963b) state that no definite information is available on the size at first sexual maturity of the fish. from the available records on the gonadial stages of maturity, it appears that fishes at zero age are immature, some of the fish at one year age show sexual maturity and fishes at two year age join sexual activity. Maturity in relation to length of fish indicates that at 70 cm length only some individuals showed maturity whereas the gonads of all fish measuring 120 cm or larger have indicated participation in sexual activity. Nakamura (1939) states that sexual development is related to the elongation of the second dorsal and anal fins, which commences when the fish are about one metre in standard length (Fig. 14). It may be of interest to state that Wade (1950a) has observed that yellowfin in the Pacific matures at about 54 cm in male and 64 cm in female.

Throughout the tropical Pacific the yellowfin spawns all round the year with peak spawning at different times. Some isolated observations in the Indian Ocean indicate that yellowfin tuna in the western region spawns about February and in the Sunda Sea in February or slightly after. Kikawa, as reported by Mimura *et al.* (!963b), finds that the gonad index of fish collected in a wide area north of 10^0S is generally high round the year, but comparatively higher from January to June.

Regarding frequency of spawning, the available information indicates that the individual fish spawns more than twice a season. Observations by most authors clearly indicate that yellowfin enter sexual activity in western tropical waters of the Indian Ocean and in the Sunda Sea. According to Kikawa (*loc. cit.)* as stated earlier, the entire Indian ocean north of 10^0S provides good spawning grounds especially in the northern latitudes.

For Pacific yellowfin the number of eggs corresponding to the size of the fish is expressed by June (1953) by regression Y = 125,000 X – 2,853,000, where 'X' denotes the weight of the fish in kg and 'Y' the number of maturing ova. In the weight range from 47 kg to 88 kg the estimated number of ova has been found to vary from 2.37 million to 8.59 million. It may be noted that fish spawns more than twice in a season. It has been estimated that one to eight million eggs are spawned at one time (Mimura *et al.* 1963b; Schaefer *et al.*, 1963)

Eggs, larvae and juveniles

June (1953) describes the ripe eggs of yellowfin to measure from 0.76 to 1.23 mm in diameter. When they are about to be spawned certain morphological changes take place, with the result that they become translucent and reveal a conspicuous golden yellow oil globule, about 0.26 mm in diameter. Schaefer and Orange (1956) state that the mature eggs measure 0.9 to 1.2 mm.

Larvae have been collected from about all the tropical waters of the Pacific Ocean from the surface layer above the thermocline, drifting with currents. Several authors, including Wade (1951) and Matsumoto (1958) have described the yellowfin larvae and outlined their distribution in the Pacific Ocean. The identity of the very small larvae described by some of the authors has not been fully established as they appear very similar to the larvae of the bigeye tuna.

The larvae and post-larvae described by Matsumoto (1958) range 3.9 mm to 14.25 mm in total length. Jones (1959) and Jones and Kumaran (1962) have figured and described some of the larval stages measuring between 3.88 mm and 9.54 mm collected from the Laccadive Sea and one measuring 10.56 mm from the Gulf of Mannar. In the earliest stage (Fig. 15A) the jaws are equal,. Teeth few and rudimentary, preopercular spines not prominent, caudal fin about protocercal, fins devoid of finrays; chromatophores on the mid-brain and a few isolated ones in the caudal fin below notochord.

In a larva 10.56 mm figured by him there is the general appearance resembling the early juvenile. Preopercular spines are present; full complement of rays has appeared in all fins except in the dorsal and anal fins; finlets are connected by a thin membrane. There is a distinct patch of chromatophores below the orbit (Fig. 15 B).

In a larva measuring 14.25 mm figured and described by Matsumoto (1958) from the Central Pacific waters, the body is much deep near the insertion of the second dorsal fin; the head is very large being 39.7% in total length; snout is equal to the diameter of the orbit; 13 to 14 teeth are found in upper and lower jaws; six opercular spines are still visible. The first dorsal is with 14 spines, its outline convex; second dorsal and anal have each 15 rays and 8 finlets. The caudal has 18+19 rays; pelvic fins are large, as long as pectoral; pigmentation characteristic of juveniles has started appearing; first dorsal fin is completely and prominently pigmented; a line of chromatophores is present at the bases of the first and second dorsals and first two finlets (fig. 15C).

Wade (1950b) has figured and described some of the juvenile stages of *Neothunnus macropterus (= Thunnus (Neothunnus) albacares)* collected from Philippine seas. The juveniles can be identified by the presence of entirely black first dorsal and by the relatively deep ad heavy body. In a juvenile of 37.5 mm in fork length figured by him, there are 5 well-defined, dark vertical bands (Fig. 15D).

In juvenile yellowfin collected from the stomach of adult tunas, minute teeth have been noticed in both the jaws and villiform teeth on vomer and palatine. The pectoral fin are short and originate anterior to first dorsal base. Second dorsal and anal are short; left liver lobe is short but the right one long (Yabe *et al*., 1958).

Competitors, predators, parasites etc.

Yellowfin, albacore and bigeye tunas in the Indian Ocean depend upon the same items of food available in the environment. In the tunas of the Pacific Ocean too the food habits are similar. It has also been expressed that the tunas and the marlins compete for the same items of food.

Large tunas, billfishes, sharks and the killer whales are the chief among the predators on yellowfin tuna.

Hexacapsula neothunni, mention of which has already been made under the bigeye tuna, causes in this species also what is known as “Jelly meat”. Copepoda and treamatodes are found as external parasites on the fins, the inner side of the opercle, gill lamellae, oral and nasal cavities; chief among the internal parasites in the alimentary canal, circulatory system, muscles and viscera are nematodes and trematodes (Schaefer *et al.,* 1963; Mimura *et al.,* 1963b). For other parasites, reference may be made to Silas (1962c) and Silas and Ummerkutty (1962).

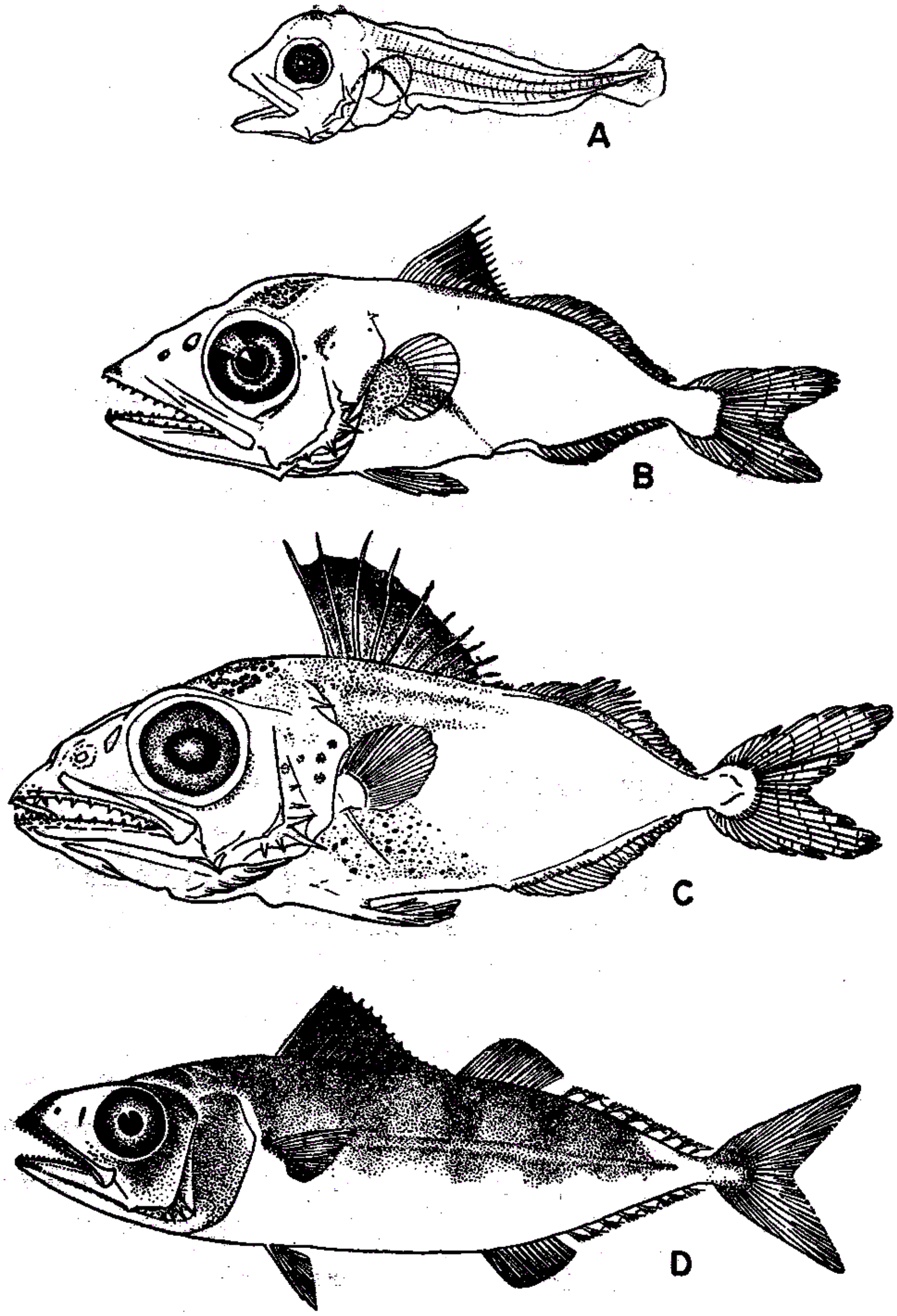


Fig. 15. Larval and juvenile stages of *Thunnus (Neothunnus) albacares* :
A. Larva of 3·88 mm in length ; **B.** Larva of 10·56 mm in length (after Jones, 1959 - given as *Neothunnus macropterus*) ;
C. Larva of 14·25 mm in length (after Matsumoto, 1958 - given as *Neothunnus macropterus*) ; **D.** Juvenile of 37.5 mm in length (after Wade, 1950 - given as *Neothunnus macropterus*).

XI. NORTHERN BLUEFIN TUNA

THUNNUS (KISHINOELLA) TONGGOL (Bleeker), 1852

Synonyms

Thynnus argentivittatus Cuvier, 1831
Thunnus tonggol Bleeker, 1852; Gunther, 1960; Duncker, 1904.
Thunnus rarus Kishinouye, 1915
Neothunnus rarus Kishinouye, 1923; Deraniyagala, 1933.
Kishinoella rara Jordan and Hubbs, 1925; Jordan and Evermann, 1926; Herre, 1945.
Neothunnus tonggol Jordan and Evermann, 1926
Thunnus tonggol Tortonese, 1939; de Beaufort, 1951; Mendis, 1954; Collette, 1961.
Thunnus argentivittatus Rivas, 1961
Kishinoella tonggol Serventy, 1941; 1942; Rosa, 1950; Herre, 1953; Munro, 1955; Jones and Silas, 1960; 1963a; Jones, 1963b.
Thunnus (Kishinoella) tonggol Fraser-Brunner, 1950; Jones and Silas, 1962; Rosa and Laevastu, 1961.

Common names

Northern Bluefin tuna
India – Kerachoora, Kethal (Malayalam)
Gethal, Gethar (Kanarese)
Khavalya gedar (Marathi)
Indonesia – Aboe –aboe, Madadiang, Tongkol lomoro.

Description

D^1. XII-XIII; D^2. 14+8-9, P^1. 31; A. 14+8; G.R. 6-8+16-19 (=22-27).

Head about 4 to 4.3, height 3.5 to 4 in fork length. Eye about 5 in head. Mouth oblique, maxilla reaching vertical about the middle of the eye; Teeth conical and large in single series in jaws, small ones on vomer and palatines; Conselet with two emarginations situated posteriorly. First dorsal spine equal to snout; following spines decreasing gradually in length; posterior ones very small. Anterior portion of the upper edge of the first dorsal concave; posterior portion rather straight. Second dorsal and anal falcate, deeply concave on their inner border. Dorsal and anal finlets normally 9 each; the first finlet in the dorsal and anal series is occasionally fused with the second dorsal or the anal as the case may be. Pectoral shorter than head. Origin of ventrals a little behind that of pectorals. Caudal keel very large; caudal lobes much expanded. Lateral line slightly wavy in front, arched over the pectoral and running almost straight in the posterior half of the body (Fig. 13).

Colour:- Dorsum grayish blue, sides silvery grey with colourless elongated spots in about five longitudinal rows. Anal silvery, all other fins grayish. Tips of second dorsal and anal tinged with yellow. Dorsal and anal finlets yellowish with grayish margin.

Liver not striated, no air bladder present.

Variability

From the available information it is observed that there is no appreciable difference in the finray counts for the species in the Indian Ocean. But some slight variations in the gill raker counts are noticed. Meristic counts of *T. (K.) tonggol* observed in specimens from various parts of the Indian Ocean are given below.

Ceylon:	D^1. XIII; D^2. 4,10+9, P^1. 32; A. 2, 10+8; G.R. 17 (lower) (Deraniyagala, 1952).
Do:	D^1. XII-XIII; D^2. II, 12+8-9; P^1. 2, 27; A. II, 12+8-9 (Munro, 1955).
Sunda Archi-Pelago:	D^1. XII-XIII; D^2. 2,11-12+8-9; P^1. 2, 27; A. 2,11-12+8-7. (de Beaufort, 1951).
Australia:	D^1. XI-XIV; D^2. 14-15+8-9, P^1. 31-35; A. 13-14+8-9; G.R. 5-8+14-17 (Munro, 1958).
Western Australia:	D^1. XII-XIV; D^2. 14+9, P^1. 30-35; A. 14+8; G.R. 5-8+14-18 (= 19-26) (Serventy, 1956b).
Do.	D^1. XI-XIV; D^2. 14-15+8-9, A. 13-14+8-9; G.R. 5-6+14-17 (Whitley, 1962).

Some of the specimens observed from Gujarat coast showed the absence of characteristic spots. One specimen obtained from Mangalore, showed abnormality in dorsal fin count; it has only 6 spines instead of 12-13 characteristic of the normal ones (Jones, 1963b).

Distribution

Its distribution in the Indo-Pacific is known from the Somalian coasts, Red Sea, Gulf of Aden, West Pakistan, west and east coasts of India, Laccadive and Maldive islands, Ceylon, Andaman Island, Malaya, Singapore, Sunda Archipelago, western, northern and eastern Australia, Philippines to Japan.

BIONOMICS AND LIFE HISTORY

Food and feeding

No detailed information on the food and feeding of the fish is available. In 40 specimens caught by multiple trolling on the Tinnevelly coast of Gulf of Mannar by Silas (1962b) the stomach in 27.5% was found empty, in 2.5% of them gorged and in the rest the food items were in traces or only one-fourth full. The food components as revealed by the contents were crustaceans, molluscs and fishes. Anchoviella sp., other clupeids , *Trichiurus lepturus* and balistid fish were the major items in the fish components. Molluscs were represented mostly by squids and very few pteropods. Of the crustacean food megalopa larva formed the dominant item. In fish caught in gill nets from Vizhinjam on the west coast of India, Rao, as reported by Jones (1963b), observed the occurrence of cephalopods and carangid fishes among their stomach contents.

In specimens caught by trolling in western Australian waters Serventy (1956b) has observed that the food consisted of variety of organism. No food preferences were indicated from the available data. Clupeids, leather jackets, garfish, mackerel, mullets, flying fish etc. have been met with and crustaceans have been represented by stomatopods and prawn larvae along with cephalopods. Similar food items have also been met with in specimens examined from Northern Australia.

Age and growth

No definite information is available in regard to age and rate of growth of *T. (K.) tonggol.* The largest size measured at Vizhinjam on the west coast of India is 840 mm in length. Specimens in the Gulf of Mannar examined during June to November, 1961, showed modal values shifting from 480 mm to 540 mm.

Based upon the fish caught in 1949 in Northern Australian waters Serventy (1956b) recognized three age groups viz. fish in the second year havng modes at 380 mm weighing 2.2 lbs, those in the third year with a modal length of 580 mm weighing 5.0 lbs and the others in the fourth year measuring 620 mm weighing 8.2 lbs.

The largest specimen trolled from North Australian waters reported by Serventy (1956b) is 105 cm, weighing 34 lbs.

Reproduction

The species is heterosexual. According to Serventy (1956b) the fish in the Australian waters attains sexual maturity in the third year of life, spawning probably taking place in the summer months. It has been observed that all fish which were in the modal length of 51 cm had enlarged maturing or mature gonads.

No information is available in regard to maturity of the gonads of the fish occurring on the Indian coasts. The spawning periodicity has also not been ascertained. However, ripe residual ova, transparent in appearance, with an average diameter of 1.09 mm having an oil globule of 0.33 mm were observed in a specimen of 81.0 cm fork length weighing 7.31 kg landed at Vizhinjam in September 1959 (Rao, 1962).

Larval history of *T. (K.) tonggol* is not known.

XII. EXPLOITATION AND UTILIZATION

The tuna catches of India are mostly obtained from the inshore waters. Excepting in the Minicoy and the Laccadive group of islands where there is a fishery for skipjack, in other regions there is no organized fisheries for tunas. The total annual average for tunas is 4148 tonnes for the period 1957-1968, forming 0.6% in the marine fish landings of India. These catch figures include billfishes also which form an insignificant portion. It is needless to point out at the very outset that the landing figures bear no relation to the available potential resources both in the inshore and oceanic waters, in the seas around India. The Japanese fishing vessels regularly carrying out commercial operation in the Indian Ocean have established beyond any doubt the fact that these waters are abundantly rich for tuna and tuna-like fishes.

From the inshore waters of the mainland tunas are obtained as incidental catches in the types of gear such as seine nets, gill nets, long lines operated for other fishes but in Minicoy in the skipjack fishery shoals are generally 'chummed' by throwing bait fishes into the sea and caught by pole and line fishing. Fairly good quantities of tunas are landed by trolling in Laccadives, Andamans and elsewhere.

Before presenting an account of the exploitation, methods and other details under each of the main tuna species occurring in the Indian waters, it is considered here appropriate to mention some particulars of the small fishes which are used as live-baits in the tuna fishery of the Laccadive island. These fishes are caught from the lagoons which surround the islands and are stored in large floating bait baskets either made of cane or tin and wood until they are taken in the tuna fishing boats. The success of the tuna fishing depends upon the availability of the live-bait for the purpose of chumming the shoals as stated earlier. Some fishes like *Tilapia* and *Panchax* have been introduced into Minicoy and these are also collected and used as bait fish with some success. Jones (1962) listed 45 species of live-bait fishes from Minicoy belonging to 30 genera under 19 families viz. Cyprinodontidae, Albulidae, Clupeidae, Dussumieridae, Polynemidae, Sphyraenidae, Atherinidae, Mugilidae, Carangidae, Mullidae, Apogonidae, Pomacentridae, Cichlidae, Labridae, Kuhliidae, Lutianidae, Emmelichthyidae and Caesiodidae. It is considered that the species belonging to families Pomacentridae, Caesiodidae, Dussumieridae, Apogonidae and Labridae are relatively more important as bait fishes in tuna fishing of Minicoy (Fig. 16 & 17).

Auxis thazard and *Auxis thynnoides*

In India, they are mostly caught in shore-seines, boat-seines, gill nets and hooks and lines. There is no selective gear used for these species. In Laccadives they are obtained along with the skipjack in small numbers which are caught with pole and line and trolling line, when they respond to baits or lures. The juveniles are rarely caught in gill nets. The fishing craft are generally the dugout canoes and catamarans. The fishing areas are mostly within the inshore waters. It is worth pointing out here that in the exploratory fishing operation by drift nets carried out in the offshore and oceanic waters of the south-west coast of India, shoals of *Auxis* of both species were noticed to occur in fair abundance (Silas, 1969). These species are caught along with other fishes from about the close of the southwest monsoon i.e. from August to about December. No statistics are available regarding its landing. Jones (1958) recorded unusual landings of *Auxis thynnoides* by boat seines on two days in October 1956 (4.15 and 6.48 tonnes) at Calicut and Quilandy.

According to Kishinouye (1923) *Auxis thazard* grows to a weight of 6.4 kg in the Japanese waters. The frigate mackerel landing in Nankai region in Japan amount to an annual average of about 13,000 tonnes (Japanese Fisheries Agency, 1961).

In India *A. thynnoides* is caught in length range between 14 and 25 cm. Around Japan, the size range in the commercial catch is from 16 to 50 cm with majority falling between 20 and 32 cm (Yokota *et al.*, 1961).

The frigate mackerels are not considered high quality table fishes. They are usually marketed fresh but when the landings are heavy, they are salt-cured and sun-dried.

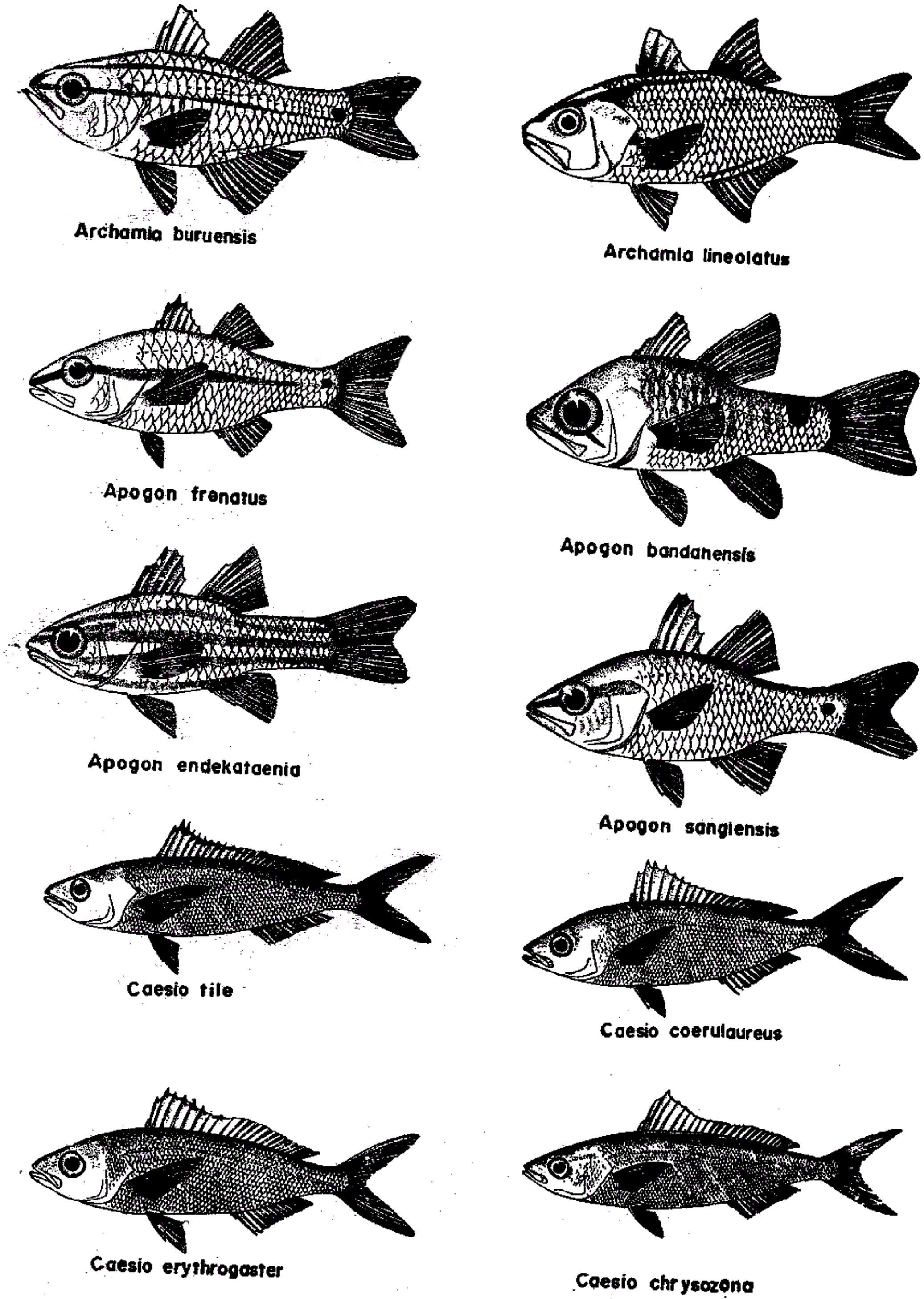


Fig. 16. Bait fishes: Some important species of the families Apogonidae and Caesiodidae.

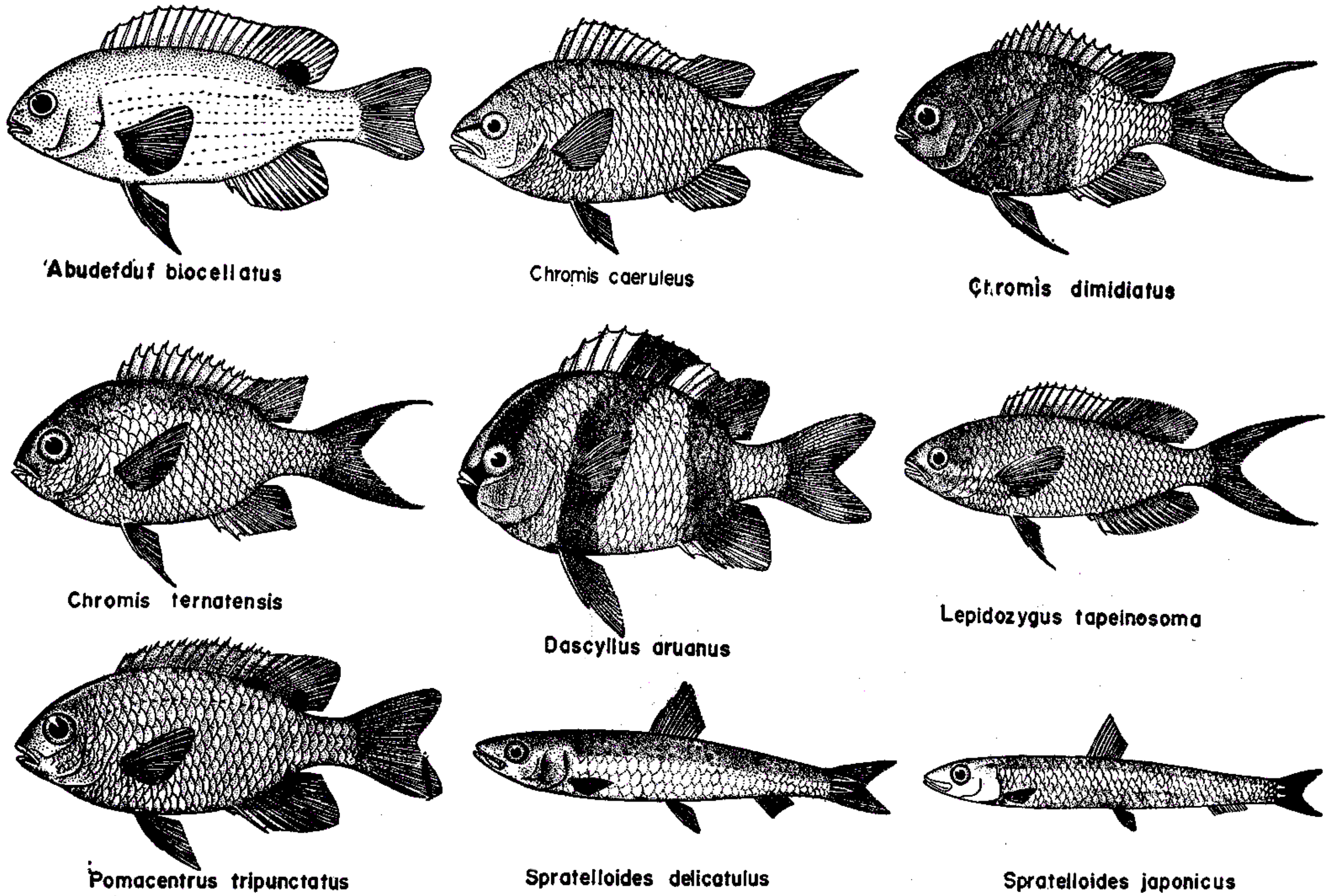


Fig. 17. Bait fishes : Some important species of the families Pomacentridae and Dussumieriidae.

Sarda orientalis

In India *Sarda orientalis* is known to support a minor fishery in the south western region although stray catches occur all along from Ratnagiri to Cape Comorin. The fishing is restricted to inshore waters and the species is caught chiefly by drift nets and to some extent by shore seines. The fishing season is about July to September but stray ones occur also from April to June. Average size of the adults caught in Vizhinjam is about 45 cm.

Along the African coast, the fish a caught by trolling lines and hooking lines. In Japanese waters it is caught in set nets, by trolling, long lines and pole and line. In Philippines, it is captured in traps, set in shallow as well as deep waters upto about 20 fathoms (Silas, 1962a; 1963a). No separate catch statistics are available for the landings of this fish either from India or from other regions, as it supports only a minor fishery.

Gymnosarda unicolor

This species is caught with hand lines at Port Blair, Andamans and is taken in pole and line at Minicoy in the Laccadives. Small numbers of this species are caught with harpoons, hand lines and trolling lines at the Ogasawara and Ryukyu Islands as also from Philippines and Australian waters. It is classified as species of mid-water and surface communities and is found in depths from 20 to 50 fathoms. Off Ogasawara and Ryukyu Islands, according to Kishinouye (1923), it is caught all round the year but the catches are good during its spawning season from May to June. In Andamans they are caught from January to March. This supports only a minor fishery.

Katsuwonus pelamis

Skipjack is caught from the surface waters by using pole and line with barbless lead-coated iron hooks in the Laccadives and the Maldives. Here and elsewhere, when boats return from the fishing grounds, skipjack is occasionally taken by trolling lines. Infrequently it is also caught in the shore seines and drift nets.

In pole and line fishing, it is necessary to collect the bait fishes. The most important among them are the Pomacentridae along with a few other members which occur in large shoals in the lagoons around Minicoy as already stated. When shoals of skipjack are sighted, the boats are steered close to them and the bait fish are thrown into the waters to chum the tuna which actively begin to feed on them. The pole and lines are used when the feeding commences. Water is splashed from the boats over the hooks to hide them. When fishing is good each swing of the rod brings a fish. fishing on one shoal lasts about half an hour. The boats which go for fishing in the morning return by evening, invariably with very good catches (Jones and Kumaran, 1959).

The tuna fishing sail boats at Minicoy are sturdy, stable and durable lasting at least for about 20 years. They have intercompartmental portions in the middle to hold live bait fish.

Around Minicoy Island, the fishing is from September to April with peak season from December to March. The monthly size frequency distribution of the skipjack observed in the pole and line fishery at Minicoy for the period 1958-59 is given in figure 18. The percentage frequency of male and female skipjack observed in the commercial fishery at Minicoy for the same period is shown in figure 19A &B.

During 1960-61 fishing season from November to April over 1000 tonnes of skipjack were landed in Minicoy, with catch per man hour of 0.62 kg (Jones and Silas, 1963b).

Large sized skipjack are caught by trolling lines around Reunion Island, using carangid fishes as bait. In the Japanese long line fishery in the Indian Ocean about 4% of the catch is constituted by skipjack.

In the Japanese waters pole and line catches of skipjack account for 90 to 95% for the period 1955-60 and the rest by the purse seines, other types of inshore seines, set nets, gill nets, hand lines, etc.

In the American fishery skipjack is landed either by pole and line or by purse seines. The major portion of the catch is landed by pole and line fishery. In the Hawaiian fishery also most of the skipjack is caught by pole and line fishing.

The vessels used in pole and line fishing in different countries vary in size and design but all of them have wells for taking the live-baits.

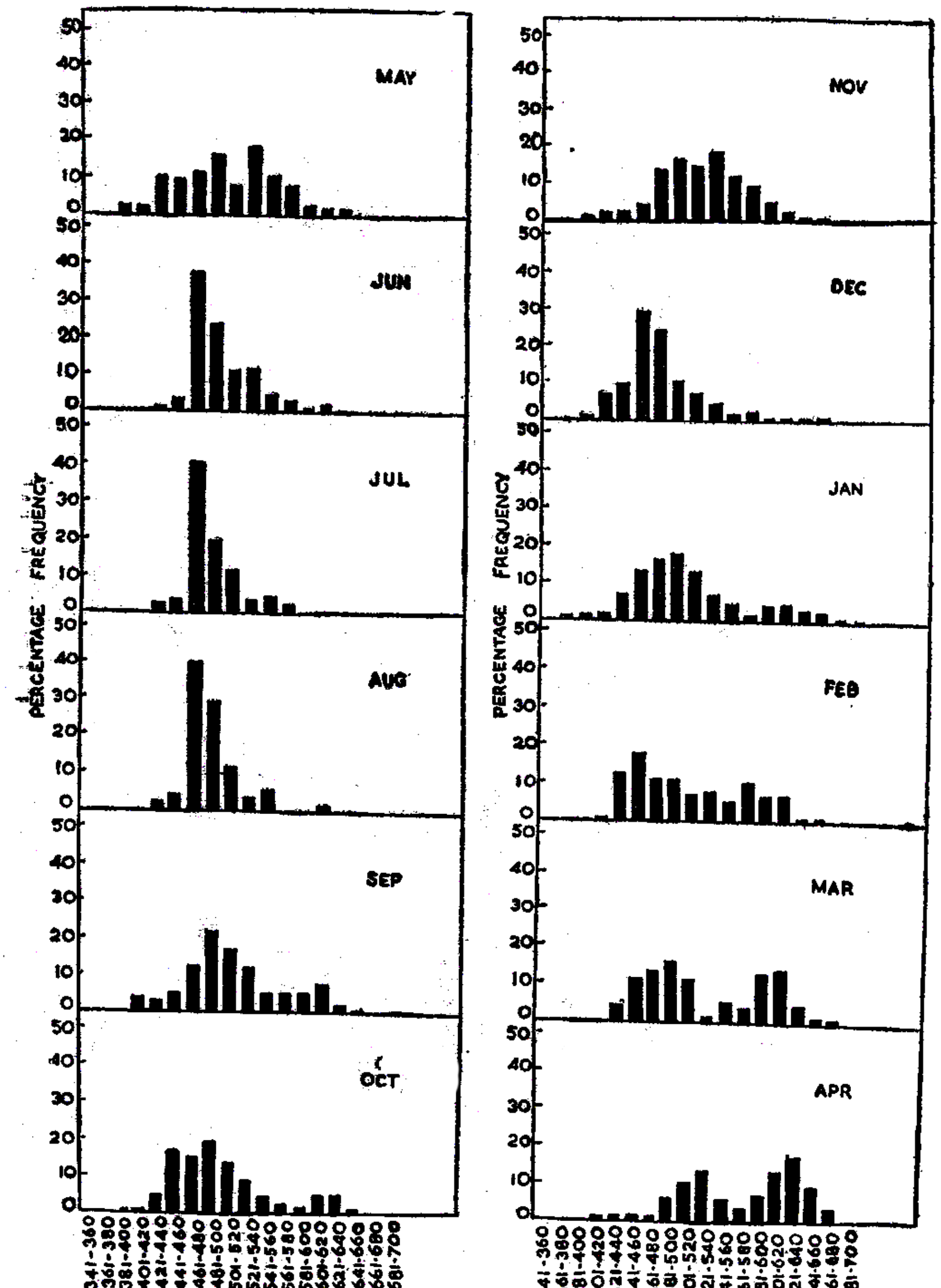
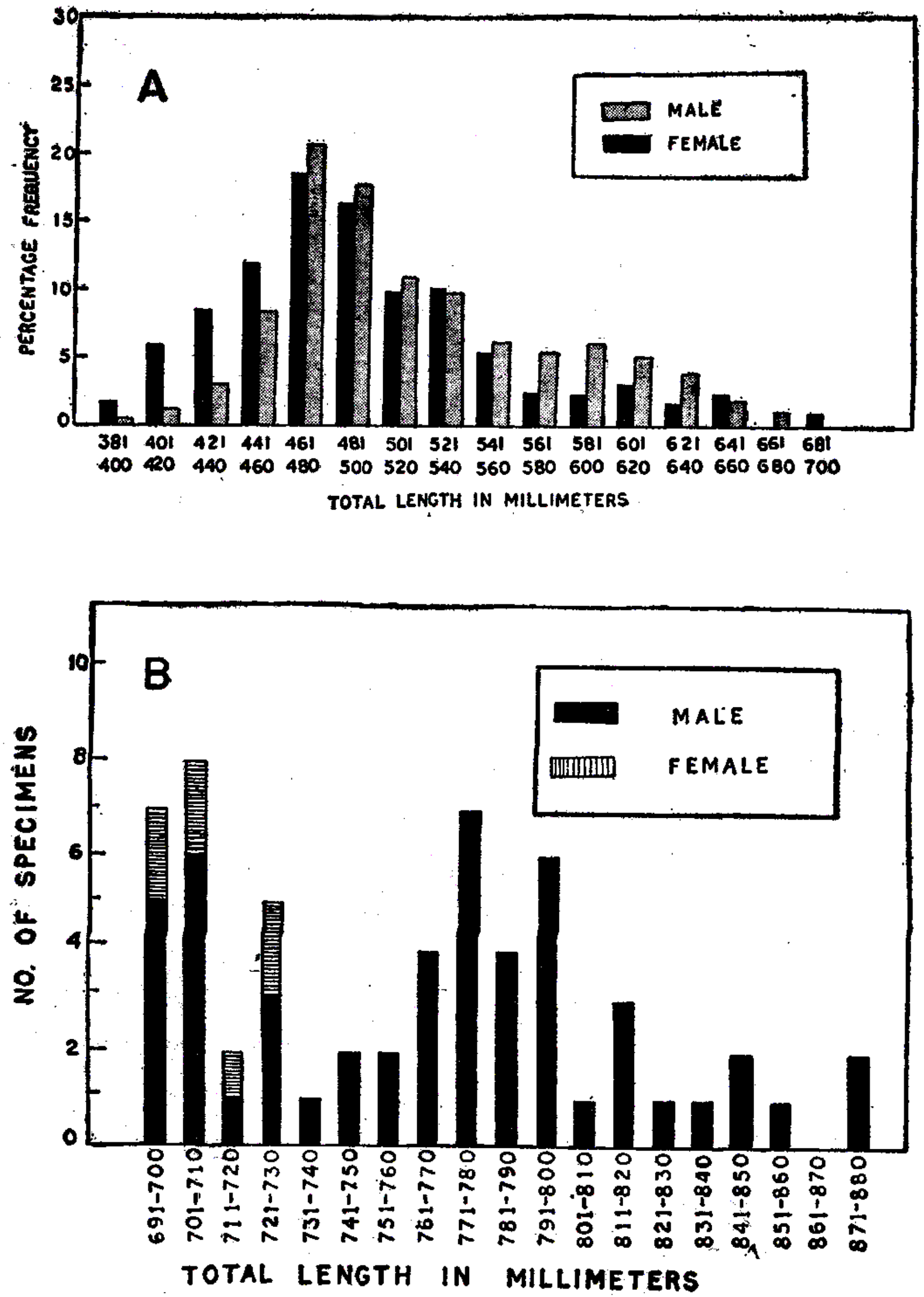


Fig. 18. Monthwise percentage frequency distribution of the size groups (total length) of skipjack sampled at random from the pole and line fishery at Minicoy during 1958–1959 (after Raju, 1962b).



Fig, 19. A. Percentage frequency distribution of male and female skipjack in different size groups observed from the landings of the pole and line fishery at Minicoy during 1958-1959;

B. Size frequency and sex distribution of skipjack landed by pole and line fishery at Minicoy during 1958-1959 (after Raju, 1962b).

In Minicoy when the skipjack is landed they are filleted into big chunks of meat. It is quickly washed in sea water and each piece is wound with split coconut leaves, then boiled for about half an hour in lead-coated copper vessels containing seawater and freshwater. The meat is removed and smoked for three to four hours. The fillets, after this treatment and removal of the leaves, are sun-dried and smoked again, the process being repeated about three times until the product looks like the 'Katsuobuchi' of the Japanese. A certain amount of mould grows over the surface imparting the necessary flavour. The resultant product known as 'mas min' is all exported from Minicoy to the mainland and also to Ceylon, Malaya and Singapore (Jones and Kumaran, 1959). The Minicoy fishery has exported annually about 1100 to 5500 bags each weighing 120 lbs of 'mas min' valued between Rs.1.40,000 and Rs. 6,00,000 during the period 1952 to 1960 (Jones and Silas, 1963b)

Euthynnus affinis affinis

The species is caught all along the east and west coasts of India, and also other regions viz. Andamans and Laccadive Islands under the Union Territory. Some detailed information is available regarding the fishing methods and yields of the commercial fishery at Vizhinjam on the west coast of India (Bennet, 1962). The fishing craft are the same as used in the fishery for frigate mackerel. The principal gear employed in the fishery are drift nets of cotton or nylon and hoods and lines, but a certain amount of catch is also obtained in the shore-seines. Fishery is restricted to the inshore regions upto 20 miles from the shore. From July 1960 to October 1961, the landings of *E. a. affinis* at this center amounted to about 317 tonnes, of which 71.4% was obtained by drift nets, 24.3% by hooks and lines and 4.3% by shore seines. The annual landings gradually rose from 85.7 tonnes in 1956 to 205.8 tonnes in 1960. The remarkable increase in the landings is attributed to a large extent to the use of nylon drift nets in the later years. The landings of the little tunny are fairly good during October to May, but with the onset of the monsoon the catches decline in the period from June to September. In the period from July 1960 to October 1961 the size range of the species was from 15 cm to 70 cm, with the major part of the catch being around 53 cm. Small sized fish were abundant in October.

Along the Tinnevelly coast of the Gulf of Mannar, for over 50 years there has been in vogue seasonal fisheries for tunas including *E. a. affinis* by using multiple trolling (Silas, 1962b).

The fish is consumed in fresh and cured condition. India has been exporting a fair quantity of salted and sun-dried little tunny to Ceylon where there is fairly good demand. In West Pakistan and East Africa the fish is considered as valuable food fish. In Somalia and Australia, commercial quantities are successfully canned and marketed. The flesh being dark and coarse, most canneries do not readily accept the little tunny for canning, except when other tunas with light meat are not easily available. It is worth noting here the suggestion made at C.C.T.A. Symposium on Thunnidae held in Dakar, in December 1960, that the "dark meat" of the little tunny be processed as fish sticks or as the Japanese 'Katsuobuchi' for export trade (Williams, 1963b). There appears to be large untapped reserves of the little tunny as pointed out by Morgans (1954) who estimated this species along with *Sarda* to represent about 0.5 percent of all fish in the Indian Ocean.

Thunnus* (*Thunnus*) *orientalis and ***Thunnus* (*Thunnus*) *alalunga***

The former has not been caught from the Indian coasts and the latter rarely obtained in long line fishing off Laccadives.

Thunnus* (*Parathunnus*) *obesus sibi and ***Thunnus* (*Neothunnus*) *albacares***

Although growing to very big size and important from the point of view of commercial fisheries in other parts of the world, these species are not frequently caught from the Indian coasts. Stray individuals only have so far been obtained from Minicoy. Of these two species, the latter is more frequently caught in the pole and line fishery. Along with *K. pelamis, T. (N.) albacares* is also made use in the preparation of 'mas min'.

Thunnus* (*Kishinoella*) *tonggol

The fishery of the northern bluefin, *Thunnus (Kishinoella) tonggol* is more regular. It is caught in varied types of fishing gears in the coastal waters. Along the west coast of India, the main catches are from drift nets made of hemp, cotton or nylon, with mesh size of 10 to 12.5 cm. Catches are slightly better during the dark fortnights. In the southern region particularly Kerala and Madras, the fish is caught by hooks and lines (No.4 and 5 size) using sardines and other fishes as baits. Multiple trolling with fast sail boats using 7 to 9 lines is employed in the Gulf of Mannar off Tuticorin (Silas, 1962b). The fishing craft and gear are not of any specialized type but used in common for other fishes also. Fishing is usually done in 10 to 25 fathoms of water. In the Gulf of Mannar trolling lines are operated from June to September. Long lines on the Kerala coast bring better catches from August to April and off Mysore and Maharashtra coast during October to December. Along the north-western coast of India and also in the Andaman Sea, catches are better during the winter months.

General considerations

Laevastu and Rosa (1963) have pointed out the need for ascertaining optimum environmental requirements for each of the tuna species. These show a certain amount of overlapping, but the optimum ranges are almost specific. It may be stated that the yellowfin has a temperature range for distribution between 17^0C and 31^0C, within which the fishery limit is from 20^0C to 28^0C, but the optimum concentration is between 21^0C and 24^0C. In contrast to this, the albacore has the range of distribution from 14^0C to 23^0C, within which the fishery limits are in the zones in the 15^0C to 21^0C with the optimum concentration between 17^0C and 19^0C.The seasonal migrations of some of the species as albacore and bluefin migrate poleward during summer and backward to Equator in winter.

Tunas also show some depth preferences. In general it may be stated that thermocline ridges seem to be preferred places for aggregation, but this again seems to be associated with the presence of more abundant food as direct cause for such aggregations.

Tuna behaviour in relation to current systems indicated that the species aggregate at boundaries of water masses (convergences and divergences). The convergence zones are indicated by the presence of small fish at the surface and divergence by discoloured waters, luminous at night.

These indications are generally used as definite signs for presence of tunas. The optimum current for good tuna fishing has been found by Japanese workers to be 0.5 to 1.0 knots.

Tunas inhabit the waters of optimum transparency which is 25 to 35 m. It has been observed that in lower transparency, the fish has difficulty in finding its prey. It has been observed that the gill nets are more effective for albacore in the turbid waters than in clear waters.

Tunas are found where food for forage is abundant, tuna fishing areas thus coinciding with productive areas in tropics and medium latitudes. Configuration of submarine topography has also an important bearing on the distribution of tunas. The little tunnies are caught close to the coast; further offshore the populations are associated with island groups. Yellowfin and albacore occur mainly in offshore areas. Some meteorological conditions bring about factors conducive for tuna to congregate. Thus when strong southern wind prevails, the yellowfin is found north of Equator; in like manner, congregations occur south of Equator when North-east winds prevail.

The world tuna catch in the five year period of 1964 to 1968 has ranged between 1,200 and 1,400 thousand metric tons. As against this, India's catch of tunas ranged between 3.063 and 5.002 thousand metric tons (Table 2). Unlike in other marine fisheries, the tuna fisheries are constituted mostly by oceanic species like the yellowfin, but a few like the little tunny occur both in the inshore and the offshore waters.India's production of tunas is low for the main reason that there are no well organized tuna fisheries for the oceanic forms. The main catch of the tunas is constituted by a few small species which enter occasionally into the inshore waters.

The world fish catch of the skipjack in 1968 has amounted to 253 thousand m. tons, more than half of which (169.0 thousand m. tons) being caught by the Japanese fishing vessels followed by those of the Pacific coast of the United states (31.2 thousand m. tons). Skipjack fishery in India is negligible although the resources are vast.

The annual world catches for the period 1964 to 1968 of the main categories of tunas is given in Table2. For all categories of the tunas, the landings by the Japanese are the highest, except in the case of bonito, for which the highest landings are from Peru. Some catch statistics of the Japanese longline fishery for tunas in the Indian Ocean are given in Table 3.

Table 2

World Tuna Catch (in 1000 m. tons)
(Source; FAO (1969a) . Yearbook of Fishery Statistics, vol.26)

		1964	1965	1966	1967	1968
Albacore	..	194	214	190	210	192
Bigeye tuna	..	117	115	112	115	114
Bluefin tuna	..	114	101	99	101	101
Yellowfin tuna	..	252	246	258	230	302
Skipjack	..	230	215	288	288	253
Bonito	..	139	133	158	131	124
Frigate mackerel	..	35	40	37	39	31
Little tunny	..	2	4	3	4	3
Various tuna-like scombriforms	..	138	150	206	244	285
Total		1220	1220	1350	1360	1400
India's tuna catch		5.002	3.698	3.063	3.370	3.309

Table 3

Catch details of Japanes tuna longline fishery in Indian Ocean.
Annual estimates of fishing effort in number of hooks and
Catch in number by species, 1962-1968.

(Source: Fisheries Agency of Japan, 1968)

Year	Hooks	Blue-fin tuna	Southern bluefin tuna	Alba-core	Bigeye tuna	Yellow-fin tuna	Skip-jack
1962	68,416	400		1,004	438	1,394	6
1963	57,309	598		716	273	694	3
1964	68,872	467		1,008	342	620	4
1965	79,852	406		628	395	813	13
1966	89,580	0	366	761	490	1,195	18
1967	126,307	0	734	847	520	913	22
1968	118,565	0	589	621	553	1,756	31

Hooks in 1000; catch in 1000 numbers.

The Japanese tuna longline fishing fleets have been catching nearly all the tuna, comprising mostly of large individuals of the larger species of yellowfin, bigeye, albacore and bluefin from the Indian Ocean upto 1963. Since then Korea and Formosa also entered the longline fishery in a big way in exploiting the tuna resources of the Indian Ocean. The recent declining trends in the catch rates of some of the tuna species in the longline fishery of the Indian Ocean have been examined by a group of FAO experts. They reviewed the available information regarding the tuna resources of the Indian Ocean and the problems relating to management (FAO, 1968; 1969a) and it was concluded that "the longline fishery for tuna in the Indian Ocean was producing tunas at the maximum level which the stocks could support, with the exception perhaps of bigeye, and any further increase in effort would probably not result in increased production". With regard to the bigeye it was stated that "the present level of catch may not be very much below the maximum potential yield", thereby suggesting a possibility of a moderate increase in the catch with increased effort. The estimated approximate maximum sustainable yield for some of the tuna species for the Indian Ocean is given in Table 4.

Table 4

Sustainable yield of large tuna from the Indian Ocean

(Source: FAO Fisheries Reports No. 82, 1969)

Species		Approximate average sustainable yield (in 1000 m. tons)
Yellowfin	..	30-35
Albacore	..	20-25
Bigeye	..	22-28
Southern Bluefin	..	35-40

The catches of the surface fishery of tunas in the Indian Ocean are relatively negligible as compared with the catches of longline fishery. The most dominant species in the surface fisheries are skipjack and bluefin. It has been pointed out that through the development of surface fishery the total production of yellowfin tuna in the Indian Ocean could be increased (FAO, 1969a).

India is located at a very advantageous position in the Indian Ocean.Under the Union Territory, the Andaman Islands and the Laccadive Islands are well situated to function as fishing bases for exploitation of the oceanic resources of the eastern, central and western parts of the Indian Ocean. While other nations situated far away like Japan and U.S.S.R. are exploiting the resources of the Indian Ocean, India is yet to make a beginning in this venture. The few exploratory fishing operation carried out by R.V. 'Varuna', R.V. 'Kalava' and other vessels have shown the immense possibilities of commercial exploitation of the resources. From the Indian Ocean prior to 1952 about 10 thousand metric tons of tuna catch was obtained annually but in recent years the annual catch has gone up to about 150 thousand metric tons, which shows a fifteen-fold increase over a period of less than two decades.

For initiating exploitation of the oceanic resources by this country there is sufficient background information available from the catch statistics of the species-wise tuna occurrence in the Indian Ocean, periodically furnished by the Japanese commercial organizations. India lacks adequately equipped fishing fleet capable of operating in the high seas and also the trained personnel with a knowledge of the highly technical methods of tuna fishing. Much progress has been achieved in fishing with powered vessels on the shelf area in the past two decades. With most of the developmental programmes successfully coming through, we are hopeful that in the not very distant future, India initiates oceanic fishing on commercial lines.

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