Species Synopsis No. 21
FAO Fisheries Biology Synopsis No. 64
(Distribution restricted)

FIb/S64
SAST - Tuna

SYNOPSIS OF BIOLOGICAL DATA ON SKIPJACK
Katsuwonus pelamis (Linnaeus) 1758 (INDIAN OCEAN)

Exposé synoptique sur la biologie du bonite à ventre rayé
Katsuwonus pelamis (Linnaeus) 1758 (Océan Indien)

Sinopsis sobre la biología del bonito de vientre rayado
Katsuwonus pelamis (Linnaeus) 1758 (Océano Indico)

Prepared by
S. JONES and E. G. SILAS
Central Marine Fisheries Research Institute
Mandapam Camp, India

FISHERIES DIVISION, BIOLOGY BRANCH
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1963

1 IDENTITY

1.1 Taxonomy

1.1.1 Definition

Phylum VERTEBRATA
Subphylum Craniata
Superclass Gnathostomata
Series Pisces
Class Teleostomi
Subclass Actinopterygii
Order Perciformes
Suborder Scombroidei
Family Scombridae
Subfamily Thunninae
Genus Katsuwonus Kishinouye, 1915
Katsuwonus pelamis (Linnaeus), 1758

1.1.2 Description

- Genus Katsuwonus Kishinouye 1915

Body robust, rounded in cross-section, teeth on jaws about 40 in each, absent on vomer and palatine; corselet well defined; hardly any scales visible on rest of body; interspace between first and second dorsal hardly exceeding eye diameter; margin of first dorsal fin strongly concave; lateral line with a decided downward curve below second dorsal; gillrakers number 50 to 63 of which 33 to 42 on lower limb; generally four dark conspicuous longitudinal bands along side of body below lateral line, none above lateral line. Internal characters include long gall-bladder, nearly free from liver running along dorsal side of liver. As in Thunnus and Sarda, a pair of cutaneous arteries branch just behind insertion of pharyngeal muscles, but passing through kidneys, arteries turn outward and forward instead of backwards; epaxial and hypaxial arterial branches running below and above first rib respectively, well-developed; vertebrae 20 + 21 (41).

Katsuwonus pelamis (Linnaeus) 1758

Body proportions expressed as percentages of total length [from tip of snout to fork, latter slightly flexed, Marr and Schaefer (1949)], for ten specimens 283 mm to 458 mm from Laccadive Sea (Minicoy Island) caught by pole and line during January 1960 and November 1961 are as follows:

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 (excluding finlets) 7.4 to 9.1; base of second dorsal including finlets 31.8 to 34.9; 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; greatest width of caudal peduncle at keel 3.5 to 4.5; length of maxilla 10.2 to 11.9; diameter of iris 4.3 to 5.9; longest gill-raker 3.9 to 4.4 and longest gill filament 6.7 to 7.4 percent in total length. (Fig. 1).

The disposition of the different organs of the viscera and the nature of the liver and gall bladder are shown in Fig. 2.

For meristic characters see section 1.3.1.

Color in life is steel blue tinged with lustrous violet along dorsum and decreasing in intensity on sides to level of pectoral base; half of body including abdomen whitish to pale yellow; evanescent vertical light bars seen on sides of body immediately after capture, fading within an hour; so also yellowish tinge on abdomen; conspicuous four to six longitudinal dusky to black stripes below lateral line on each side of body; light greyish tinge on underside of mandible (chin) merging posteriorly with whitish color of lower half of body.

In preservative (formalin) corselet area is light grey, tinged with yellow, upper half of body shining grey; between corselet scale along first dorsal base and along second dorsal base distinct black patches; so also dorsum of head; chin dark grey; lower half of body pale whitish to light grey, but generally four conspicuous longitudinal black stripes present; spine of first dorsal fin dusky, but inter-spinous membrane whitish between anterior spines, but margin tinged dusky between last few spines; second dorsal and dorsal finlets dusky with narrow white margins; so also

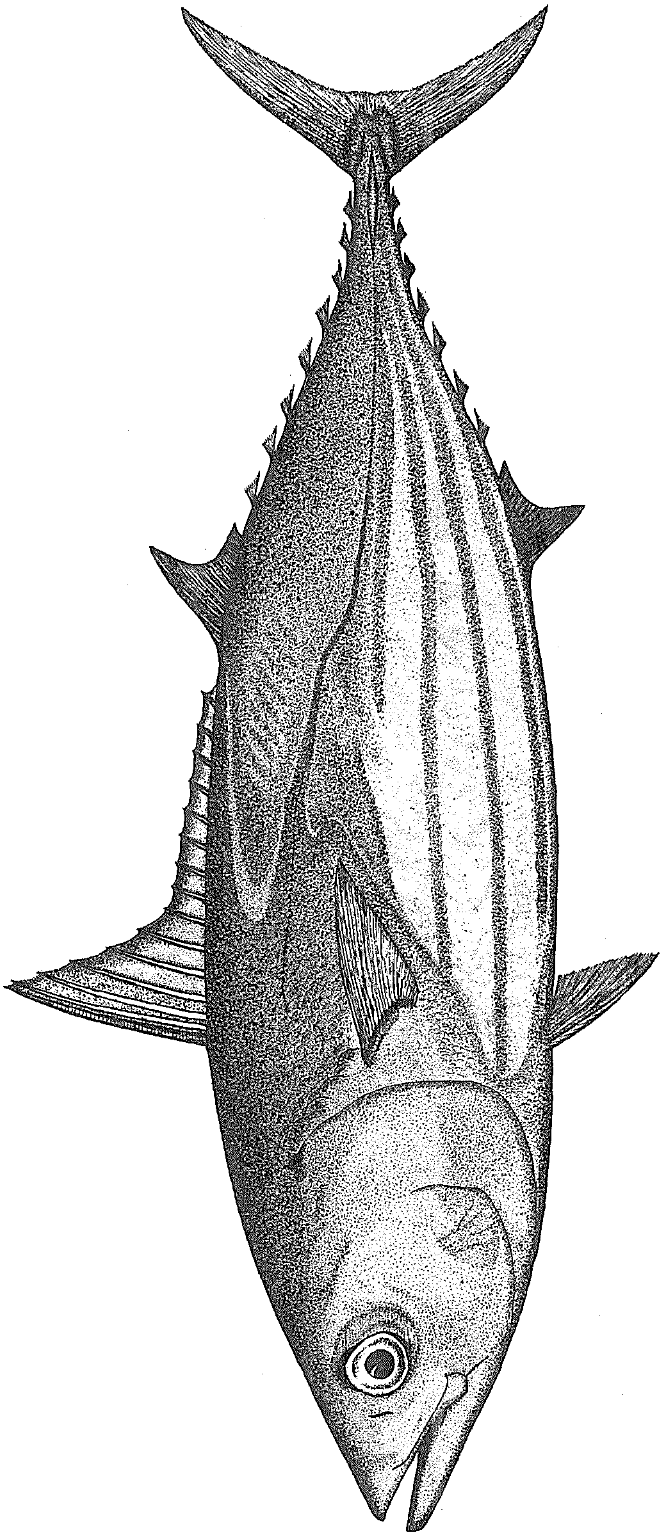


Fig. 1 Katsuwonus pelamis (Linnaeus)

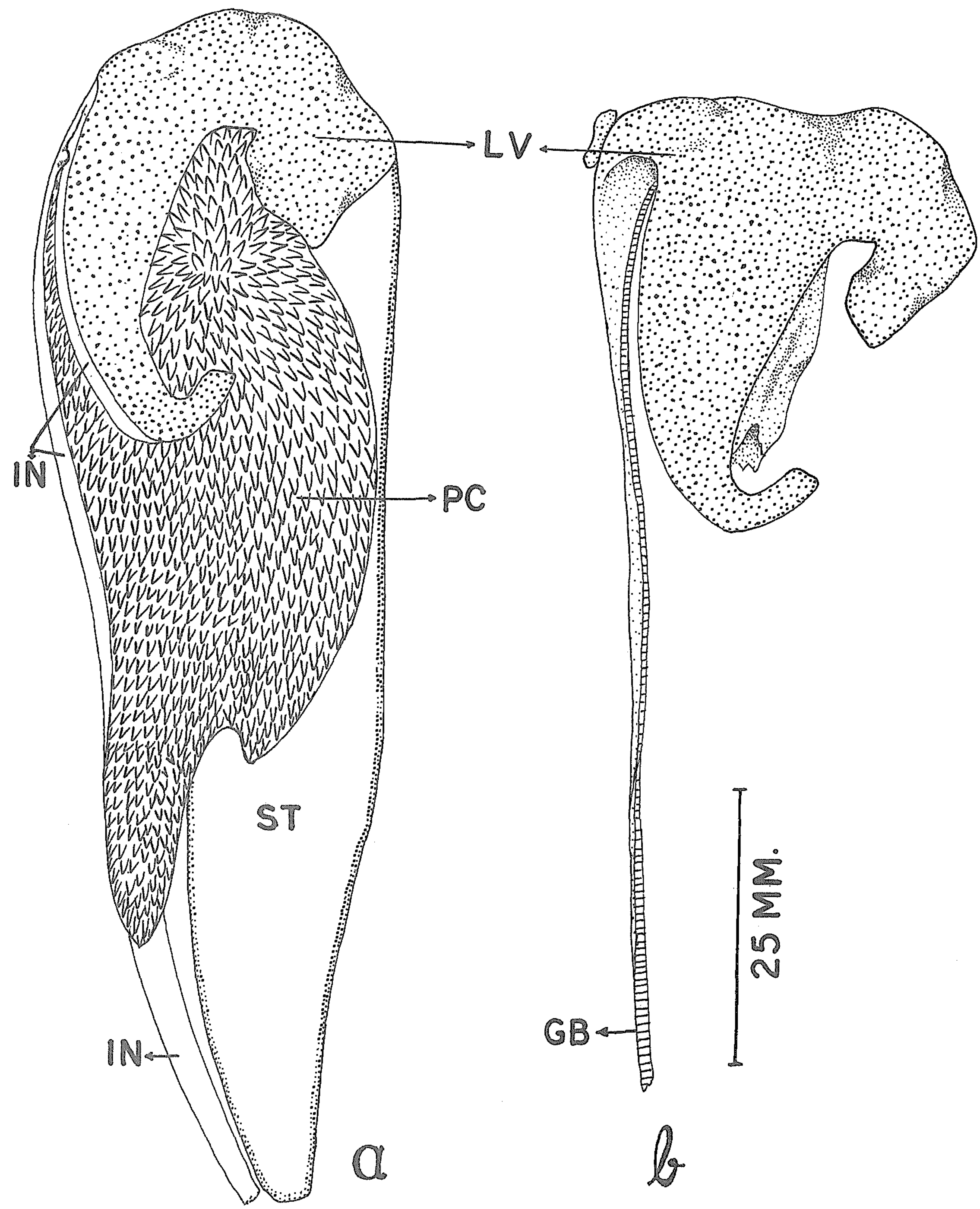


Fig. 2 (a) Disposition of the visceral organs, and
(b) of liver and gall-bladder in Katsuwonus pelamis (Linnaeus)

LV - liver
IN - intestine
PC - pyloric caeca
ST - stomach
GB - gall-bladder

pectorals and pelvics; blackish patch along abdomen for whole length of pelvics; anal and finlets lighter; median caudal peduncular keels blackish with light margin dorsally, but light grey ventrally.

Hardly any color difference between smallest and largest adult specimens in the collection.

Juvenile coloration for a specimen 27 mm in total length: "The pigmentation in the specimen is comparatively denser on the dorsal aspect of the head and body. The spinous dorsal has patches of chromatophores on the upper half of the fin membranes between the anterior eight rays. The ventral side of the body is practically devoid of chromatophores except for a few on each side along the base of the anal fin and finlets". (Jones 1959 a).

1.2 Nomenclature

1.2.1 Valid scientific name

Katsuwonus pelamis (Linnaeus) 1758

1.2.2 Synonyms (specially for Indian Ocean area)

(Only taxonomic references are cited here chronologically).

Scomber pelamis Linnaeus 1758
Scomber pelamides Lacépède 1803
Thynnus vagans Lesson 1828
Euthynnus pelamis Deraniyagala 1933; Molteno 1948; Fourmanoir 1957; Smith 1961

Euthynnus (Katsuwonus) pelamis Fraser-Brunner 1950; Deraniyagala 1952; Mendis 1954

Euthynnus (Katsuwonus) pelamys Fourmanoir 1960
Gymnosarda pelamys Barnard 1925
Thynnus pelamys Cuvier and Valenciennes 1831; Günther 1860; Day 1888, 1889; Gilchrist 1902
Katsuwonus pelamis Kishinouye 1915; Serventy 1941; Rosa 1950; Munro 1955, 1958; Jones and Silas 1960, 1962; Talbot 1962; Whitley 1962

1.2.3 Standard common names, vernacular names

(See Table I).

1.3 General variability

1.3.1 Subspecific fragmentation (races, varieties, hybrids)

- Meristic counts

Details of meristic counts for specimen from Indian Ocean is given in Tables II and III.

So far no attempts have been made to distinguish populations, varieties or races, nor do the counts given above throw much light on the subject. Generally XIV - XVI spines are present in the first dorsal and this makes the minimum count of XII given by Smith (1961) exceptionally low.

Natural hybridization is unknown.

Albinism or melanism have not been reported.

However, at Minicoy Island in the Laccadive Sea, among freshly caught skipjack, in a lot of a hundred or so specimens, two or three may be a much lighter color, the lateral bands appearing faded and the dorsum being light dusky, but retaining the basic color pattern. Such occurrences in small numbers are not infrequent, and these specimens can be easily detected in fresh landings.

Table I

Common and vernacular names

Country	Standard Common name	Vernacular Name(s)
Aden, Gulf of		Af Muss; Dabub (Somali dialect); Hargheiba (Alula dialect)
Australia	Striped tuna	Watermelon; Skipjack
Ceylon	Skipjack	Baleya; Alaguduva (Sinhalese dialect); Ocean Bonito; striped tuna
East Africa and Zanzibar	Skipjack	Sehewa (Kiswahili dialect; also refers to Euthynnus sp., Auxis spp.)
India	Oceanic skipjack	Bonito; Kali-phila-mas (Mahal dialect, Laccadives); Vari Choora (Malayalam, Kerala coast) Choora and Metti (Malayalam, Amini Island, Laccadives)
Indonesia	Bonito	Tjakalang; Tjakalang-lelaki; Tjakalang-perempuan; Tjakalang-merah
Madagascar	Bonite	Bonite a ventre raye; Diodary (Sakalawa dialect); M'bassi (Swahili dialect)
Maldive Islands		Kali-phila-mas
Réunion, Mauritius	Bonite	
South Africa	Skipjack	Oceanic Bonito; Lesser tunny; Bonito; Watermelon; Katunkel

Table II

Meristic characters for ten specimens of Katsuwonus pelamis (Linnaeus) from Minicoy Island, Laccadive Sea

Dorsal spine			Dorsal finlets			Anal finlets		Pectoral		
No.	15	16	8	8+1(=9)	9	7	7+1(=8)	26	27	28
F.	2	8	6	2	1	7	3	3	6	1
N = 10 Mean = 15.8			N = 9 Mean = 8.4			N = 10 Mean = 7.3		N = 10 Mean = 26.8		

Gill-rakers

Upper limb							Lower limb								
14	15	16	17	18	19	20	32	33	34	35	36	37	38	39	40
1	3	2	2	2	-	-	-	-	2	-	2	4	1	1	-
N = 10 Mean = 16.1							N = 10 Mean = 36.5								

Total gill-rakers

48	49	50	51	52	53	54	55	56	57	58
-	-	2	1	2	2	1	2	-	-	-
N = 10 Mean = 52.5										

No. = Counts; F = Frequency of occurrence; N = Number of specimens

Table III
Meristic characters as given by various authors for *Katsuwonus pelamis* (Linnaeus) from the Indian Ocean

Charac-ters	Africa			Mada-gascar	Aus-tralia	Indonesia	Ceylon		Laccadives (India)	Total range
	Williams (1962)	Smith (1961)	Talbot (1962)	Fourmanoir (1957)	Munro (1958)	de Beaufort (1951)	Deraniyagala (1952)	Munro (1955)	Jones *et* Silas (1962)	
Dl	XIV-XV	XII-XVI	XIV-XV	XV	XIV-XVI	XV	XV-XVII	XV	XV-XVI	XII-XVI
D_2 + finlets	13-15+ 7-8	12-13+ 8	14-15+ 8	14-16+ 8	14-16+ 7-9	i, 12-14 (=14-16) + 8	3, 12 (=15) + 8	ii, 12-14 (=14-16) + 8	13-14 + 8-9	12-16+ 7-9
Pectoral	-	-	-	-	26-29	ii, 24 (= 26)	27-30	ii, 24 (=26)	26-28	26-29
A + finlets	14-15+ 7	I-III, 12 (=13-15) + 7-8	15+7	14-16+ 7	14-15+ 7-8	iii, 12 (=15)+ 7	3-4 12-13+ 7	iii, 12 (=15)+ 7	13-14 +7-8	13-16+ 7-8
Gill-rakers	15-16+ 38-40 (=53-56)	±35	18-20+ 36-38 (=56)	-	17-21+ 33-42	-	±35-40	±35	14-18+ 34-39 (50-55)	14-21+ 33-42

2 DISTRIBUTION

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

The occurrence of Katsuwonus pelamis has been reported from the following areas in the Indian Ocean:

(a) From the Indian Coast off Bombay, Vizhingam and Tuticorin;

(b) off Ceylon;

(c) Laccadive Sea

(d) Maldives;

(e) Gulf of Aden;

(f) Indian Ocean off Somali Coast; East and South Africa and Mozambic channel;

(g) Madagascar;

(h) Aldabra Island;

(i) Mauritius, Reunion Islands;

(j) Seychelles;

(k) Cocos Island;

(l) Great Australian Bight; South east of Tasmania;

(m) Western Australia;

(n) West of Java and Sumatra; and

(o) Andaman Sea.

The species is rarely encountered in coastal waters where other tunas, such as Euthynnus affinis affinis (Cantor), Kishinoella tonggol (Bleeker), and Auxis spp. may be found. Off South Africa it has not been taken south of 30°S, but captures from the Australian Bight and south of Tasmania would indicate its occurrence in that area as far south as even 43°S. Northward skipjack also occur in the Gulf of Aden, thus, on the whole, covering the tropic and subtropic sections of the Indian Ocean.

In the Laccadive Sea off Minicoy Island where skipjack is caught regularly, the surface temperatures range between 27°C and 30°C during the fishing season extending from November to April (data for 1960 to 1961). However, most frequent temperature readings for the area for the said season is 28°C to 29°C.

Williams (1962) remarks that off East Africa (between 1°30'S and 10°30'S) skipjack are found mainly inside the 100 fathom line. Off Minicoy in the Laccadives, fishing is carried out in waters 800 fathoms or more in depth, but hardly 6 to 10 km from the island as is also practiced in the Maldives. The species is known on rare occasions to enter lagoons, sometimes in pursuit of shoals of Spratelloides, or accidentally during high tides. Skipjack prefers waters of high salinity as would be evident from their non-occurrence in the northern parts of the Bay of Bengal.

Hydrographic work in the Laccadive Sea (Jayaraman et al, 1960) indicates the presence of isothermal water down to 50 m. The discontinuity layer is observed between 75 and 150 m, while a salinity maximum is seen to occur within a tongue of high saline water at about 100 m. From the nature of the density surfaces and the computed geopotential anomalies the authors infer that there are circulatory water movements around the island at practically all levels down to 500 m. The motion is anticyclonic in the upper 100 m, while the reverse below that level, thus helping in maintaining a high productivity level for the waters around the island. Results of carbon-14 experiments carried out in the Laccadive Sea (Prasad and Nair 1962) as well as similar data from adjacent waters collected by the Galathea and Vitiaz expeditions have indicated high productivity, especially in certain localized areas. The waters around Minicoy Island showed the highest production rates with a value of

Ca 300 mg C/m^2/day, and a photosynthetic zone more than 75 m deep.

Bogorov and Rass (1961) indicate that a significant correlation exists between congregation of tunas and other pelagic fishes and abundance of plankton in regions of the Indian Ocean. The areas referred to are: the central part of the Arabian Sea from Aden Bay to Bombay; between the Seychelles and Maldive Islands; off Zanzibar and Comoro Islands; to the north east of Madagascar; off Chagos Bank; off Ceylon; to the south from Java; and to the west from Australia. In certain of these areas, the amount of plankton exceeds 15 mg of dry matter per m^3 in the 0 to 100 m layer of water. The tuna species observed by them in these areas of high productivity were Neothunnus macropterus, Katsuwonus pelamis and Auxis thazard.

The wide range of temperature from 17°C to 31°C or more in which skipjack may be encountered indicates either its tolerance to wide fluctuations in water temperature or the existence of distinct populations in different areas of different sets of temperature ranges.

Fourmanoir (1960) reports active and voracious shoals of skipjack off Fort Dauphin (extreme south of Madagascar) in waters with a surface temperature of 22°C, and he further opines that in the Indian Ocean the optimum temperature for skipjack would be 28.5°C.

2.2 Differential distribution

There is only scant information for this area. The skipjack is truly oceanic in habit and as already mentioned is rarely ever encountered in shallow coastal waters or in areas of low salinity. Collections of larvae have also been from offshore areas.

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

- Eggs

Definite identification of spawned skipjack eggs from any part of the Indian Ocean is wanting. However, eggs suspected to be of either skipjack or yellowfin have been collected from the Laccadive Sea by one of the authors during the cruise of R. V. Kalava in February 1958 from station 209 ca 73°20'E and 8°40'N fairly close to Minicoy.

Raju (1960) mentions 0.809 mm as the diameter of the largest transparent intraovarian egg (with a single oil globule) he had observed from a hermaphrodite skipjack from Minicoy. Fully ripe ova up to a diameter of 1.125 mm have been reported for skipjack from the Pacific.

Northwest of Madagascar (Mitsio) two Katsuwonus measuring 62.2 and 63 mm [length up to tail notch (?)] captured on 7 August 1960 had ovaries very near maturity (stage III) with eggs of 0.30 mm and 0.35 mm diameter, some transparent (Fourmanoir 1960). However, the above size is too small for the eggs to be considered ripe, and the so-called transparency should be different from that seen in oozing eggs.

- Larval stages

Correlative evidence from the occurrence of larval skipjack ranging from 2.63 to 7.08 mm and the examination of adult gonads made by Jones (1959a) do indicate the Laccadive Sea, especially around Minicoy and adjacent islands, as one of the spawning grounds of this species (Fig. 3). Further data by Raju (1962a) tend to confirm this.

Jones (1959a) also indicates the presence of several skipjack larvae in the collection of the Danish Dana Expedition of 1928 to 1930 between stations 3905 and 3975 in the Indian Ocean (Fig. 4).

Yabe and Ueyanagi (1961) have shown that in the seas south of Sumatra (ca 100°E, 10°S) numerically large concentrations of skipjack larvae are present from where the maximum numbers were taken in February, while few were collected in June, July and January, the ratio being in the proportion of 14:1:1:1 respectively. This is contrary to their collection of more skipjack larvae during June and July in the Pacific which indicates, among other things, difference in spawning period of the skipjack in both these areas. These authors also infer that tuna larvae (including skipjack larvae) make

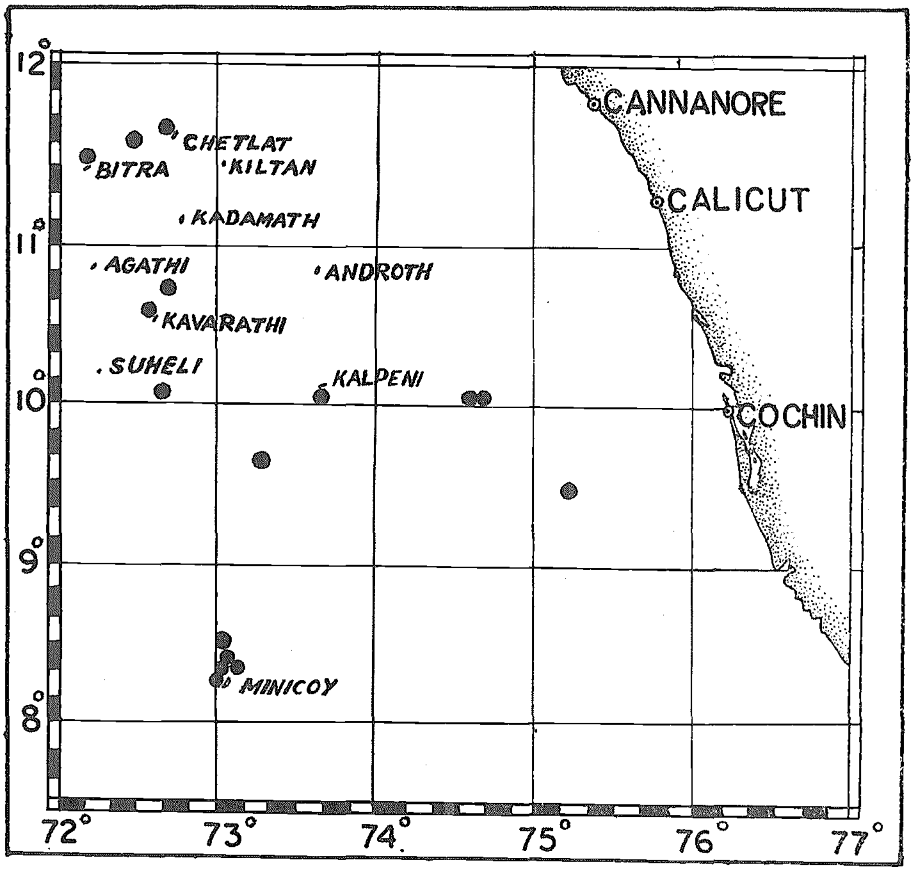


Fig. 3 Centers of collection of larvae of *Katsuwonus pelamis* (Linnaeus) from the Laccadive Sea (after Jones 1959a)

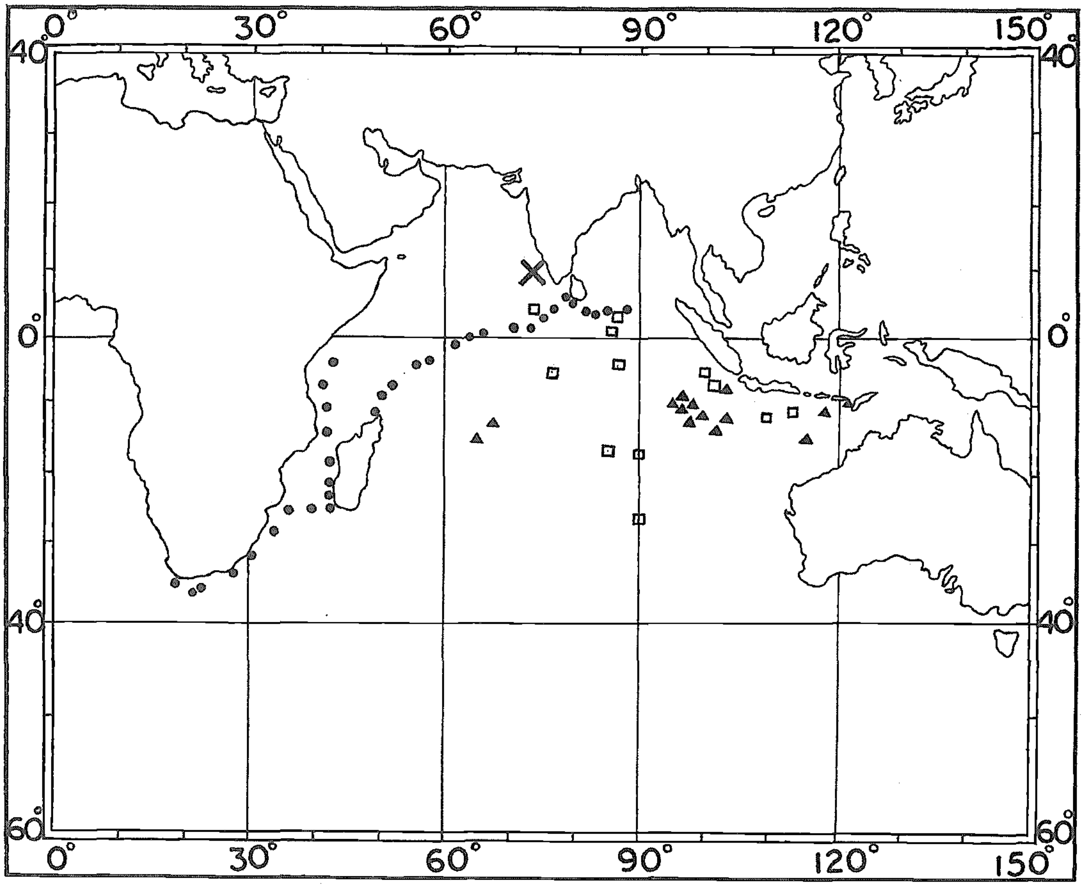


Fig. 4 Distribution of larvae of Katsuwonus pelamis (Linnaeus) in the Indian Ocean based on previous collections:

- X - from the Laccadive Sea (for more details see Fig. 3)
- ● - 1928 to 1930 Danish Dana Expedition Collection stations from where Katsuwonus pelamis larvae have been identified
- ▲ - Japanese collections of Katsuwonus pelamis larvae worked out by Yabe and Ueyanagi (1961); and
- ▢ - Vitiaz collections of tuna larvae including larvae of Katsuwonus pelamis

vertical diurnal migration in the upper 50 m layer, they being rarely encountered in the surface layers to a depth of 20 m during daytime. At night they show a tendency to uniformly distribute in the upper 50 m layer.

Bogorov and Rass (1961) have also indicated several localities from where larval tunas have been collected during the thirty-first cruise of the Vitiaz in the Indian Ocean and when the results are analyzed it is likely to throw more light on the more widespread occurrence of skipjack larvae in various parts of the Indian Ocean.

No information is available of the time taken between spawning and hatching; the rate of growth of larvae; their passive dispersal by ocean currents and the distance traversed from spawning ground before attaining shoaling size.

Details of area of occurrence of skipjack larvae in the Indian ocean are shown in Fig. 4.

- Young fish

Practically nothing is known of juvenile skipjack, except for one specimen 27 mm in total length from the Laccadive Sea (Jones 1959a). Young and half-grown are not generally caught at Minicoy although during certain months (February and March) the size group 270 mm to 370 mm may be taken in stray numbers. The smallest we have examined was 283 mm. Thomas (in litt.) reports that between Minicoy and Cannanore on the West Coast of India, usually several schools of young skipjack are encountered which Minicoy fishermen can easily tell apart from other tuna shoals.

- Adult

For spatial distribution see Fig. 5.

Reports of the occurrence of large shoals of skipjack are available from various parts of the Indian Ocean within the areas delimited in Fig. 5.

Adults are caught mainly by pole-and-line, using live-bait (Minicoy and Maldive Islands); sometimes by trailing lures or trolling; occasionally on longlines; and rarely by shore-seine and driftnets when they enter lagoons and coastal waters. For more on fishing see section 5.

Seasonal variations for stages persisting over two or more seasons

Information is very scanty. Size composition data for May 1958 to April 1959 and November 1960 to April 1961 from the Laccadive Sea given by Raju (1962a), and Thomas (1962b) indicate the likelihood of sporadic influx of smaller size groups into the fishery which is mainly dependent on 400-720 mm size group.

Seasonal and annual variations of areas occupied by adults

No information with special reference to skipjack. However, data given by Yamanaka and Anraku (1961) on oceanographic conditions relevant to distribution of tunas give some data on surface temperature and chlorinity in tuna waters from surface layer to 300 m depth.

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

Skipjack is essentially a surface fish and prefers waters where the salinity is 33°/oo or more and, as mentioned under 2.1, the optimum temperature for skipjack waters in the Indian Ocean appears to be 28.5°C.

For details of competitors, predators and parasites, see sections 3.3.3, 3.3.4, and 3.3.5 respectively.

No information is available about vertical migrations of adult skipjack from any part of the Indian Ocean.

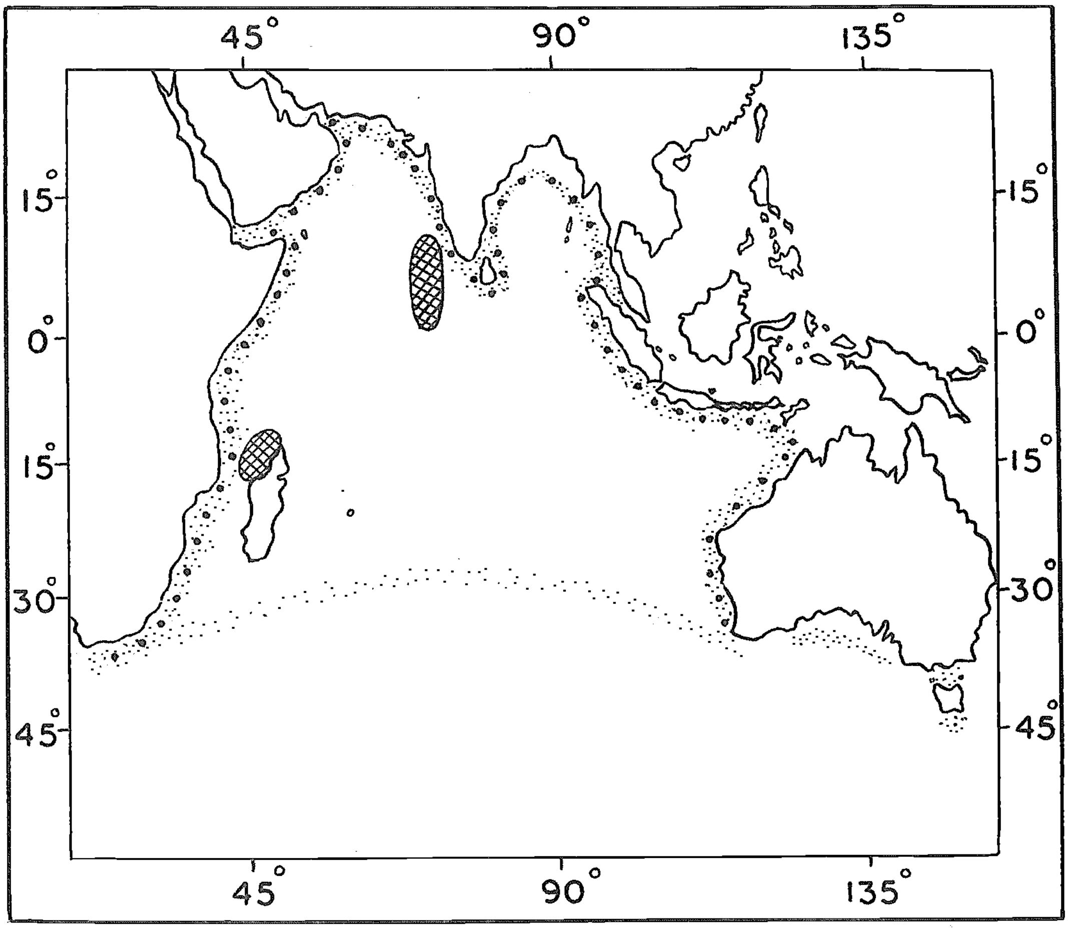


Fig. 5 Distribution of Katsuwonus pelamis (Linnaeus) in the Indian Ocean

Range of regular occurrence

Sporadic occurrence

Fishing areas

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality (hermaphroditism, heterosexuality, intersexuality)

Skipjack is heterosexual. No externally observable characters have been found to easily distinguish males and females.

Raju (1960), and Thomas and Raju (1962) have reported on three instances of hermaphroditism in the skipjack from the Laccadive Sea. Raju (1960) has also described two types of gonadial abnormality in the skipjack from the same area; one in which the right ovary had an anterior lobe completely cut off from the lower portion which was connected to the normal left ovary and the second in which there was an enormous development of the left lobe and the complete destruction of mature ova in it as a result of infection by larval nematodes. In the above instances of gonadial abnormality as well as hermaphroditism the gonads were maturing or mature.

3.1.2 Maturity (age and size)

No definite information on age determinations of skipjack for this area is available, except some preliminary observations in the Laccadive Sea on size composition of the fish caught in certain months from 1958 to 1961 (Raju 1962a and Thomas 1962b). The data is retabulated in Fig. 6, from which it will be noted that the size composition and the catch for the different months at Minicoy do not throw any light on growth trends but probably indicate the constant influx of fresh shoals into the fishing area. Bimodal occurrence is seen for the months from December to April during both periods of observation with few variations.

It is inferred that by February a smaller size-group enters the fishery. There appears to be much in common in the size compositions of skipjack caught by pole-and-line both in the Laccadive Sea as well as the Eastern Tropical Pacific (Schaefer and Marr 1949) for in both areas the fishery depends on one or two age groups of the species which enter the fishery at about 45 to 50 cm and are probably two years old by then, and a larger group with a modal size of 60 to 70 cm. However, in the Laccadive Sea a third group may also occur occasionally for according to Thomas (1962): "The fishing in Minicoy depends on three age groups of Katsuwonus pelamis. The first group is of the size 280 to 450 mm, their age being probably over one year. The second group of fish range in size from 450 to 600 mm and are probably more than two years old. The larger fish ranging in size from 600 to 720 mm are probably three years old. Fishes four years old and older are extremely rare in the catches in Minicoy". This age determination based on size composition may not be in agreement with Aikawa's (1937) findings based on appearance of rings in vertebrae of skipjack in Japanese waters, where the first ring is found when the fish attains 26 cm, the second at 34 cm, the third at 43 cm, and the fourth at 54 cm, indicating that 26 to 34 cm represents one-year class and those above 54 cm the four-year class. The general applicability of this has not been tested.

Fourmanoir (1960), following Aikawa, remarks that small quantities of skipjack caught off Comoros and Madagascar are three to six years old with a body length of 50 to 80 cm (For longevity see section 3.3.1).

The smallest skipjack with mature ovaries observed at Minicoy during the 1958 to 1959 season was 390 mm and 396 mm respectively, while the largest size with immature ova was 481 mm. Generally immature gonads are rare in specimens 450 mm or more in length, but spent ovaries have been encountered in the 400 to 450 mm size group. (Raju 1962a).

3.1.3 Mating (Monogamous, polygamous, promiscuous)

Skipjack is polygamous. However, no information is available for this area on pre-spawning or spawning behavior.

3.1.4 Fertilization (internal, external)

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

3.1.5 Fecundity

Estimates of number of eggs in the ovary derived from gonad weight vary considerably from fish to fish. Raju (1962a) observed that

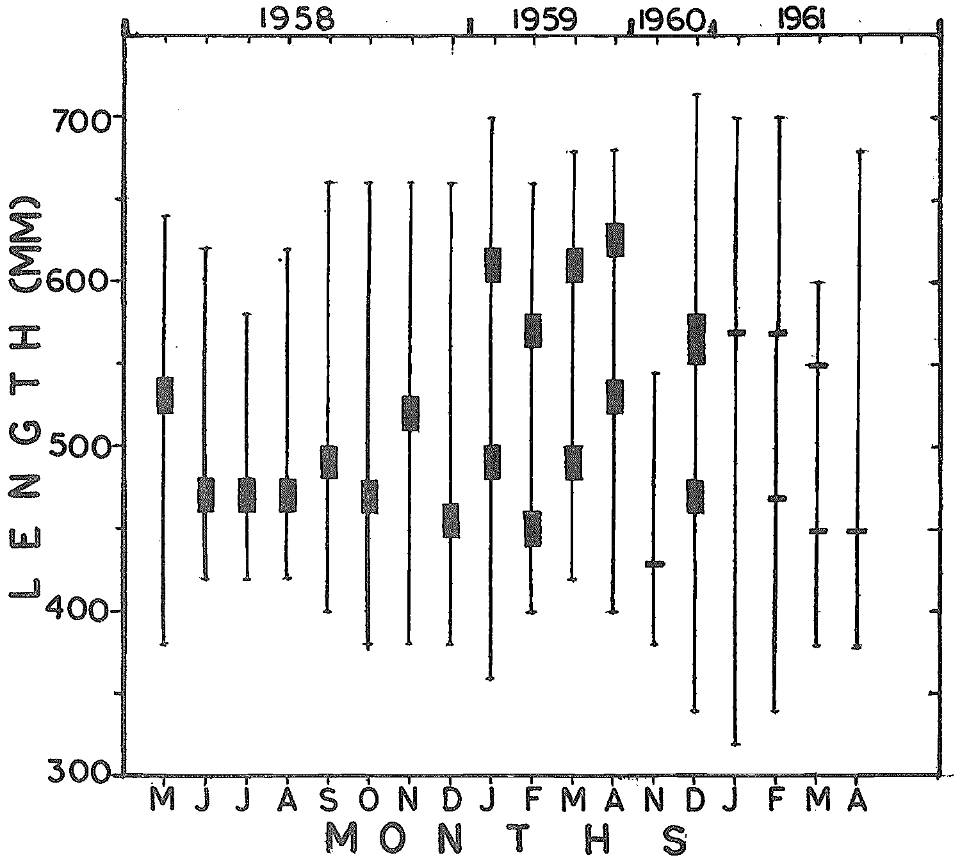


Fig. 6 Size composition of Katsuwonus pelamis (Linnaeus) landed at Minicoy for certain months from May 1958 to April 1961. Horizontal black vertical portion and bars indicate modes, and vertical thin lines the size ranges for the months of observation.

in 63 skipjack from Minicoy, ranging in length from 418 to 703 mm, the total number of ova in the most mature mode ranged from 151.9 to 1,977.9 thousands of ova.

- Relation of gonad size and egg number to body size and to age

No information other than that given under sections 3.1.2 and 3.1.5.

3.1.6 Spawning

- Spawning season (beginning, end, peak)

Definite range of spawning has not been established in any area in the Indian Ocean, although evidence from capture of mature adults, and early larval stages (Table IV) indicates that several spawning areas may be present. However, more information is available from the Laccadive Sea (Jones 1959a; Raju 1962a) around Minicoy and adjacent islands, where spawning is suspected to take place over an extended period from about January to about April and then from June to early September, with the peaks January and June, respectively. This is also deduced from the relatively large number of spent females in the catch during these months.

- Number of spawnings per year, frequency

Data available (Raju 1962a) indicate that during the extended spawning period from about January to April, fractional spawning may take place. Information is not available as to whether the same fish could recoup and have the second spawning season during the June to September period, when skipjack with spent ovaries have been taken at Minicoy.

3.1.7 Spawning grounds

- Coastal (surface, vegetation, shore, shoal, sand, shelter); bottom

Suspected spawning grounds are far from mainland coastal waters. Eggs unknown, but should be pelagic as in other scombroids. No information except what has been given under section 3.1.6.

3.2 Larval history

3.2.1 Account of embryonic and juvenile life (prelarva, larva, post-larva, juvenile)

No information about embryonic life.

No information about prelarva.

Earliest larval stages ever described for the species are 2.63 mm and 2.9 mm (Jones 1959a). They are characterized by the spines of the preoperculum being very inconspicuous; four chromatophores over midbrain (one shown in Fig. 7); a small patch of chromatophores at tip of lower jaw and a conspicuous chromatophore at tip of lower jaw and a conspicuous chromatophore at base of caudal fin just below the tip of the notochord. Two additional chromatophores present mid-ventrally in commencement of posterior third of length; also small chromatophores on dorsal surface of abdominal sac. The 3.60 mm; 5.08 mm and 7.08 mm stages are illustrated in Fig. 7.

The characteristics of a juvenile 27 mm long (Fig. 7) (in formalin) are: "Head is nearly 1/3 of the total length, snout 1/3 and eye 1/4 of the head and the latter 7/10 of the snout length. The maximum width is at the pectoral region and is nearly 1/5 of the total length". "The teeth are distinct and angles of the mouth reach to about a vertical below the middle of the eye. The rudiments of four preopercular spines are still present. The pelvics are as long as the pectorals. The full compliment of spines, rays, and finlets have developed. The finlets on each side are connected together by a thin membrane" (Jones 1959a). For juvenile coloration see section 1.1.2.

The larvae of skipjack could be easily distinguished from those of the yellowfin (Neothunnus macropterus) by the relatively longer snout and maxillary; the presence mid-ventrally of prepeduncular chromatophores and the sparse pigmentation of the first dorsal fin.

3.3 Adult history

3.3.1 Longevity

No definite information is available.

Table IV

Months of collections and size range of skipjack larvae collected from the Laccadive Sea (after Jones 1959a)

Month	Size (mm)	
	1958	1959
January	-	3.85 to 5.71
February	3.60 to 7.08 and 27.0	-
March	3.94 to 6.62	-
April	-	2.63 to 5.82
May	-	-
June	-	-
July	-	-
August	-	-
September	-	-
October	-	-
November	-	-
December	5.08 to 6.85	-

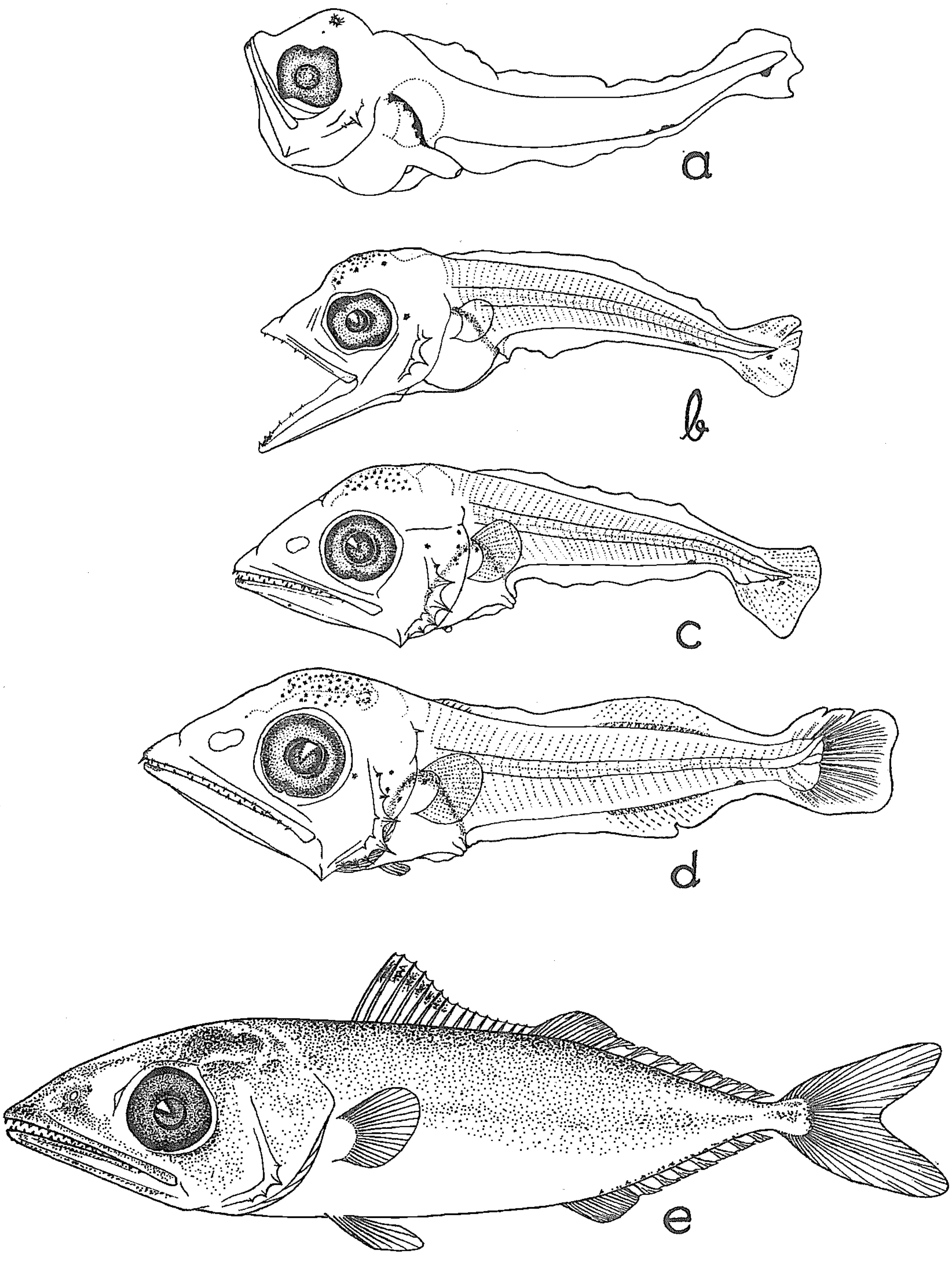


Fig. 7 Stages of larvae and juveniles of skipjack described from Laccadive Sea
(a) 2.97 mm; (b) 3.60 mm; (c) 5.08 mm; (d) 7.08 mm; (e) juvenile 27.0 mm.
(after Jones 1959a)

However, Fourmanoir (1960) remarks that longevity is probably eight or nine years. The maximum weight appears to be 19 kg and the fish attains 95 cm. Larger specimens about a meter long may be caught rarely.

3.3.2 Hardiness

Adaptability to wide range of temperature is quite likely.

3.3.3 Competitors

No definite information. However, mixed schools of adult yellowfin and skipjack are frequently seen in the Laccadive Sea and food studies of both species have indicated preference to the same major groups of food items, mainly, young of fish, crustaceans (stomatopod larvae, mysids and Megalopa larvae) and cephalopods (Raju 1962 b; Thomas 1962 a). The degree of competition between the two species is not known.

Collection of larval tunas from the Laccadive Sea indicates that along with skipjack larvae, only yellowfin larvae occur, while there appears to be a total absence of larvae of Auxis spp., Euthynnus sp., and other thunnids which are generally known from that area. Different spawning localities for the latter are suspected which may perhaps help in avoiding competition between species in larval and juvenile stages.

Fourmanoir (1960) remarks that the whale shark Rhineodon typus was found several times associated with mixed shoals of Euthynnus alletteratus and Katsuwonus pelamys probably for feeding on a part of the Anchoviella and Spratelloides sought by them. He also mentions a young yellowfin Neothunnus albacora weighing 9 to 11 kg frequently associating with skipjack.

P.T. Thomas (in litt.) informs that on 18 February 1961 at Minicoy 47 specimens of the dolphin, Coryphaena hippurus, ranging from 63 to 103 cm and 639 skipjack 59 to 66 cm and 18 yellowfin 29 to 40 cm were caught in two boats by pole-and-line from mixed schools, this being quite unusual as generally only one or two C. hippurus are taken occasionally along with skipjack.

Unlike in certain parts of the Pacific, off Minicoy, skipjack schools are not reported to be found associated with birds (Sula sp.) or with porpoises.

3.3.4 Predators

Off Minicoy, it is not uncommon to sight skipjack schools accompanied by sharks, although no attempts have been made to identify the latter, nor are they landed during fishing with pole-and-line.

Fourmanoir (1960) mentions that shoals of Katsuwonus observed on the ridge of the continental shelf west of Madagascar are often followed by Carcharinus albimarginatus 2.20 to 2.60 m long, and swimming fast enough to capture skipjack when opportunity arises.

The marlins (Makaira spp.) are also known to prey on skipjack, although no actual data is available for this area.

3.3.5 Parasites and diseases

Several species of helminth parasites and parasitic copepoda have been described from the skipjack (Silas 1962; Silas and Ummerkutty 1962). However, only two records, a monogenetic trematode, Pricea minimae Chauhan (1945), and a caligid copepod, Anuretes branchialis Rangnekar (1951) have been observed on specimens from Indian seas from host said to be Thynnus pelamis (= Katsuwonus pelamis).

Fourmanoir (1960) mentions that besides nematodes and trematodes, the Pleurocercus (Dasyrhynchus) larvae are also very numerous, encysted in the forepart of the liver.

Of thousands of specimens of skipjack caught at Minicoy, none was found to be heavily infected with parasites as to impair its vitality.

3.4 Nutrition and growth

3.4.1 Feeding (time, place, manner and season)

No direct observations are available on time, place and manner of feeding nor the season. However, food of skipjack caught on pole-and-line examined for various months from 1958 to 1961 from Minicoy Island would indicate differences in the predominant natural food components and slight differences in the feed of the different size groups. See section 3.4.2.

3.4.2 Food (type, volume)

Raju (1962b) has shown that the ratio of natural food versus baitfish in skipjack caught by pole-and-line was 1:6.9 to 29.7, the latter varying from month to month. Thomas (1962) arrived at similar conclusions for the period November 1960 to April 1961.

Fourmanoir (1960) mentions that the main food of Katsuwonus are engraulids, clupeids and cephalopods, and also planktonic stomatopods. Off Madagascar, the main components of food are Anchoviella commersoni (adults or very young - 4.7 to 9 cm), and Spratelloides delicatulus. Large Katsuwonus over 70 cm seek small sardines such as Sardinella jussieu or S. melanura and some inclusions of these as food weigh as much as 100 g, while in smaller Katsuwonus 60 to 65 cm long, some stomach inclusions with Anchoviella weigh about 50 g. At Fort Dauphin at the southern extremity of Madagascar another engraulid known only from colder waters has been encountered in the stomach of Katsuwonus.

The observation that fishes constitute the dominant food items of Katsuwonus is more or less in line with the data given by Thomas (1962a) for 280 stomachs examined by him. (Table VI)

When compared with the above data, that given by Raju (1962) indicate notable differences (see Table VII), although the major items of food are the same. These differences in percentage composition of the different food items may as well reflect seasonal fluctuations in the availability of the natural food elements of the skipjack in the environment.

3.4.4 Relation of growth to feeding, to other activities and to environmental factors

Raju (1962b) found that there was an increase in the main food volume of skipjack with the increase of the fork length of the fish, and decrease in the average stomach content per unit of body weight with the increase in body weight, paralleling similar phenomena seen in yellowfin (Reintjes and King, 1953; King and Ikehara 1956).

The data on variations in the composition of food with fish size given by Raju (1962b) for four size groups of skipjack from Minicoy is summarized (Table VIII).

Records of various species of baitfish recovered from the stomach indicate that Lepidozygus tapeinosoma, Dipterygonotus leucogrammicus, Caesio caerulareus, Archamia lineolatus, and Chromis caeruleus constitute the dominant items while Caesio tile, C. chrysozona, Pomacentrus tripunctatus, Apogon aureus, A. septemstriatus, A. sangiensis, A. frenatus are frequent. Occasionally Spratelloides delicatulus, S. japonicus, and species of Panacentrus, Abudefduf, and Apogon are encountered while the remaining species are rare. (Raju 1962b; Thomas 1962a). However, there are seasonal fluctuations in the occurrence of the major species of bait fishes recovered from the stomachs and those occurring in the bait collections (Thomas 1962a).

Of all the baitfishes used at Minicoy, L. tapeinosoma appears to be the most suitable one for chumming tuna, while from experience fishermen know that species of Caesio, (e.g. C. tile) are most effective in this respect. However, availability limits their usage. Most of the live-bait fishes are juveniles. No direct observations is available about the breeding of baitfishes, but data on size composition given by Thomas (1962b) indicate that batches of smaller size groups of these species appear in the bait fishing grounds from time to time.

3.5 Behavior

3.5.1 Migration and local movements

Present knowledge is inadequate to state anything definite on these subjects. No information is available about agencies helping in the spatial dispersal of larvae. Only information available on vertical distribution is given by Yabe and Ueyanagi (1961). (See section 2.2.1)

No tagging experiments have been undertaken in this area for studying the migratory habits of skipjack. The sight records of moving shoals do not throw light as to whether the movements are localized or whether they represent large-scale seasonal movements of an entire stock from one area to another and vice versa to feeding grounds or spawning areas. Size

Table V
Composition of the major items of food of *Katsuwonus pelamis* from the Laccadive Sea

Observer	Period of observation	No. of fish examined	Volumetric percentage Crustacea (A)	Volumetric percentage Fish (B)	Volumetric percentage Squids and Misc. (C)	Frequency of occurrence (A)	Frequency of occurrence (B)	Frequency of occurrence (C)	Numerical percentage (A)	Numerical percentage (B)	Numerical percentage (C)
Raju 1962	May 1958 to April 1959	2, 506	57. 2	18. 7	24. 1	76. 0	15. 1	23. 2	91. 9	6. 4	19. 7
Thomas 1962	Nov. 1960 to April 1961	280	37. 29	58. 78	3. 93	47. 83	77. 71	10. 91	-	-	-

Table VI
Food items of *Katsuwonus* (Thomas 1962 a)

Food item	Size 50 cm and below		Size above 50 cm	
	Volume	Frequency of occurrence	Volume	Frequency of occurrence
Fishes	48. 07%	78. 33%	69. 5%	67. 1%
Crustaceans	46. 69%	46. 66%	27. 89%	49. 0%
Miscellaneous items	5. 2.4%	8. 33%	2. 61%	13. 5%
No. of stomachs examined	99	99	181	181
No. of empty stomachs	39. 4%	39. 4%	54. 7%	54. 7%

Table VII

Dietary items of Katsuwonus pelamis caught on pole-and-line off Minicoy, Laccadive Sea (Natural food only - after Raju 1962 b)

Major groups	Food items	Volumetric percentage (Mean)	Months of occurrence	Highest percentage and month
CRUSTACEA	Stomatopoda (larvae and juveniles) viz., Gonodactylus demani; Squilla (Alima) hyalina; S. (Alima) hieroglyphica; S. wood-masoni; S. fasciata; Lysiosquilla suleirostris	24.7	July, August September October Nov., Dec. January February March, April	57.9 May
	Megalopa	24.2	May, June July, August September Oct., Nov. Dec., Jan. Feb., March April	44.4 June
	Mysids	8.3	June, August Sept., Oct. Nov., Dec. February	38.0 June
	Euphausids	2.16	Feb., Sept. November	3.7 Feb.
	Acetes	1.65	October February	2.5 Feb.
	Phyllosoma	6.95	December March	11.4 March

Table VII (continued)

Major groups	Food items	Volumetric percentage (Mean)	Months of occurrence	Highest percentage and month
MOLLUSCA	Cephalopods *Cavolina* sp. and other pteropods	21.8	May, June August. Sept. Oct. Nov. Dec., Jan. February August	75.1 August
FISHES	Balistidae and Monacanthidae Species: *Odonus niger*; *Sufflamen capistratus* *Balistes stellaris*; *Melichthys ringens*; *Hemibalistes chrysopterus*; *Balistes* spp; *Monacanthus* spp; Syngnathidae: *Halicampus koilomatodon*; *Corythoichthys fasciatus*; *Hippocampus kuda*; Tetraodontidae: *Gastrophysus lunaris* *Chelondon patoca*; *Arothron immaculatus* Miscellaneous fishes	8.7	May, June July, August Sept., Oct. Nov., Dec. Jan., Feb. March, Aug.	30.3 July
OTHER MISCEL LANEOUS ITEMS	Zoea larvae; *Caprella* sp; Ascidian tadpoles; *Salpa* sp; Rubber pieces; Wooden pieces; Bits of sea weeds	1.54	All months	

composition data obtained from pole and line catches at Minicoy tend to indicate the influx of fresh batches of small size groups throughout most months of the year, probably reflecting on the fractional spawning habits of the fish itself.

Stray instances of skipjack entering lagoons are known. Sometimes they may be in pursuit of prey (Spratelloides spp.) during high tides.

3.5.2 Schooling

Schools around Minicoy Island in the Laccadive Sea are small. Generally the surface agitation caused by the shoal is less than a 100 m wide, as has also been reported for Madagascar waters by Fourmanoir (1960). Within a school, fishes are usually distributed in different layers.

Off Minicoy it is not uncommon to see two or more shoals of skipjack hardly half a kilometer apart. Fourmanoir (1960) remarks that it is frequent to cross over six successive shoals of Katsuwonus less than 300 m apart, especially around the Radama and Mitsio Islands off Madagascar where shoals occur regularly for most of the year in waters 40 to 60 m deep. Occasionally larger shoals of 300 to 400 are seen, but shoals over 500 m wide have not been observed off Madagascar. Along the northwest coast of Madagascar, between St. Sebastian Cape and St. Andrew's Cape, skipjack shoals occurred at the frequency of one shoal every seven miles and one in two shoals was associated with yellowfin tuna measuring 87 to 92 cm. In spite of apparently normal oceanographic conditions between 1955 and 1957, shoals seemed to disappear except in the Mitsio Island area.

P. T. Thomas (in litt.) reports that when stormy weather makes seas choppy, generally skipjack of smaller size groups are caught around Minicoy Island. When the weather clears, shoals of both large-sized and small-sized fish may be encountered. The smaller size group disappears almost completely within a few days.

- General habits

Skipjack is a very alert fish and shoals often sound when approached in a mechanized craft (probably due to the noise of the engine) or when approached by a spearfish (Marlin). During pole-and-line fishing at Minicoy it has been observed when chummed to take any baitfish offered. Instances are not uncommon of hooked fish dropping into the water without the school becoming frightened and disappearing. Indiscriminate feeding, probably at such times is also suggested by stomach contents such as coir fiber, cooked rice, scrapings of paint, pieces of wood, bits of algae etc.

Table VIII

Composition by volume of stomach contents (other than baitfish) of four size groups of skipjack obtained from pole-and-line fishery at Minicoy

	Skipjack size groups			
	(1) Below 400 mm	(2) 401 to 550 mm	(3) 551 to 700 mm	(4) Above 700 mm
Stomatopod larvae	60.5	36.2	9.7	16.2
Mysids and Euphausids	-	19.4	7.7	8.3
Megalopa	14.3	18.0	15.3	7.7
Cephalopods	-	8.8	25.2	37.8
Fishes	12.5	14.2	37.5	27.8
Miscellaneous	12.9	3.4	4.6	2.3

4 POPULATION (STOCK)

4.1 Structure

4.1.1 Sex ratio

Raju (1962a) indicates a disparity in the sex ratio of skipjack in Minicoy waters, with males predominating during most months, a slightly higher percentage of females among the smaller groups and males among the larger size groups.

4.1.3 Size composition

Some data available are given under section 3.1.2.

4.4 Mortality, morbidity

4.4.1 Rates of mortality

No information except suspected mortality of juvenile tuna probably also including skipjack in certain sections of the Indian Ocean (Jones 1962b).

5 EXPLOITATION

5.1 Fishing equipment

5.1.1 Fishing gear

In the Laccadives and Maldives, skipjack is invariably caught near the surface and the gear used is pole-and-line with simple, barbless, lead-coated iron hooks. Strong bambo poles three to four m long are used. The length of the line equals that of the pole. When not in use the hook is kept fixed to the base of the pole. At present nylon has replaced the steel wire used for the distal one third of the line, the rest being of cotton. More details may be had from Jones and Kumaran (1959).

Skipjack has been taken by trolling during experimental fishing operations in East African waters; Madagascar; and off the West Coast of India. In the Laccadives around Minicoy as well as off Tuticorin in the Gulf of Mannar (Silas 1962) boats returning from fishing on rare occasions catch a few skipjack using troll lines. Fourmanoir (1960) mentions that off Madagascar small quantities are also taken by trolling, but due to the brittleness of the mouth of the fish, only one out of eight that take the bait are successfully landed. He added that sport fishermen at Mauritius join "bonate" shoals in small mechanized boats at 10 to 12 knots speed with troll lines and stop as soon as the bait is taken.

Around Reunion Island occasionally large-sized skipjack are caught trolling with Decapterus, and Selar as bait.

Japanese longline catches indicate that less than 4 percent of the tunas caught by them using this method in the Indian Ocean are skipjack.

The infrequent capture of skipjack in shore-seines and driftnets has already been mentioned.

Live-bait fishing is the most effective for catching skipjack and at present in the Indian Ocean it is practiced only around Minicoy Island in the Laccadive Archipelago and around several islands in the Maldives (Fig. 8a and b). Jones and Kumaran (1959) have given details of fishing methods at Minicoy which do not differ from that given for the Maldives by Hornell (1934, 1950) and Jonklaas (1962).

Details of bait fish used are given under section 3.4.5. References to sport fishing for the skipjack from this region are few (Gadsden 1898, 1900).

5.1.2 Fishing boats

In the Maldives as well as at Minicoy Island in the Laccadives, special boats are built for bonito fishing (Figs. 9). These boats are of sturdy construction and have a remarkable degree of stability. At Minicoy as reported by Jones and Kumaran (1959), this type of boat: "is locally built usually with coconut planks fastened with copper nails. Sometimes timber from the local laurel tree (Callophyllum inophyllum) is also used along with coconut planks. The partitions and certain small parts within the hull are made of wood brought from the mainland. The boat is about 12.5 m long and about 3 m broad. It is broadest at the aft which is provided with a slightly raised platform (peelaga) which extends like wings outside the bulwarks. A piece of wood (Kumbukamphi) about 1.25 to 1.5 m in length and 20 cm in breadth is fixed vertically on the platform. This helps to give a supporting hold to the person who steers the rudder, and the aft mast is also kept on this when not in use. The fen-fona-fori or water-splasher is hung on one side. A curved piece of wood (unkanudhuni) about 1 m long, usually colorfully painted is attached to the rudder (unkanu) to facilitate its operation. There are nine compartments in all, of which four in the middle have a series of two to three holes (inguri) at the bottom on each side for access of water from below. The inter-compartmental partitions have small holes for the free flow of water from one compartment to the other. The middle three or four sections (eng-vy) hold live-bait fish, and the water that accummulates at the aft compartment is baled out regularly by a couple of boys with copper balers known as diya-hikka-fe. There is provision for seven to nine oars (phali) on each side. The blade of the oar (phalidu) is of wood about 30 cm long and 20 cm broad, and the handle (thandu) is of coconut timber about 3.5 to 4 m long. There are two masts (kombu) of coconut timber, a longer one about 8 m long in the eighth compartment and a shorter one about 6 m long in the third compartment. The sails are of cloth. Small tuna boats are 8 to 9 m long but these have no platform. Sometimes a wooden raft known as

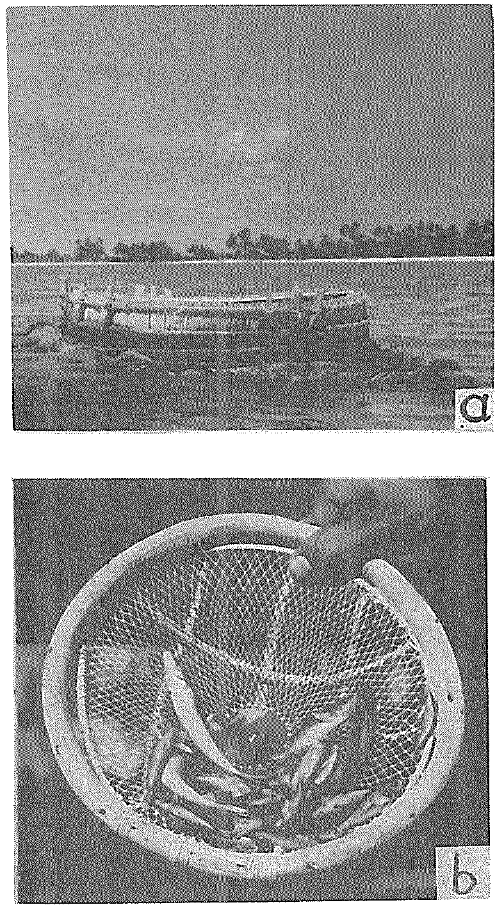
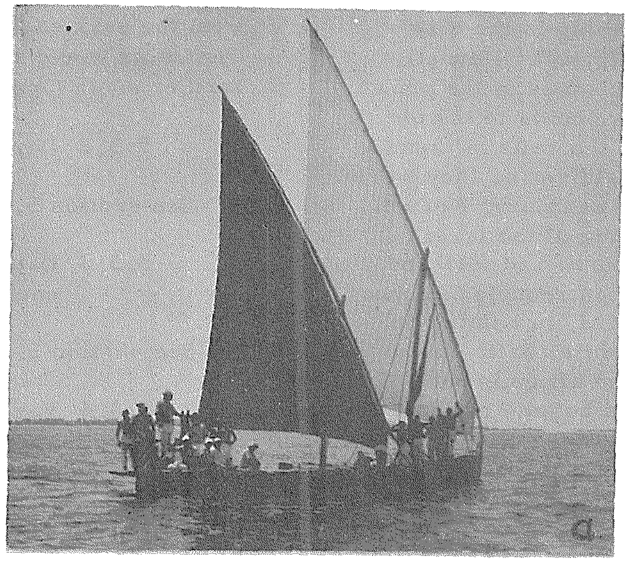


Fig. 8 (a) Live-bait basket anchored in the lagoon at Minicoy;
(b) An "emvery" used for transferring live-bait with some fish inside.



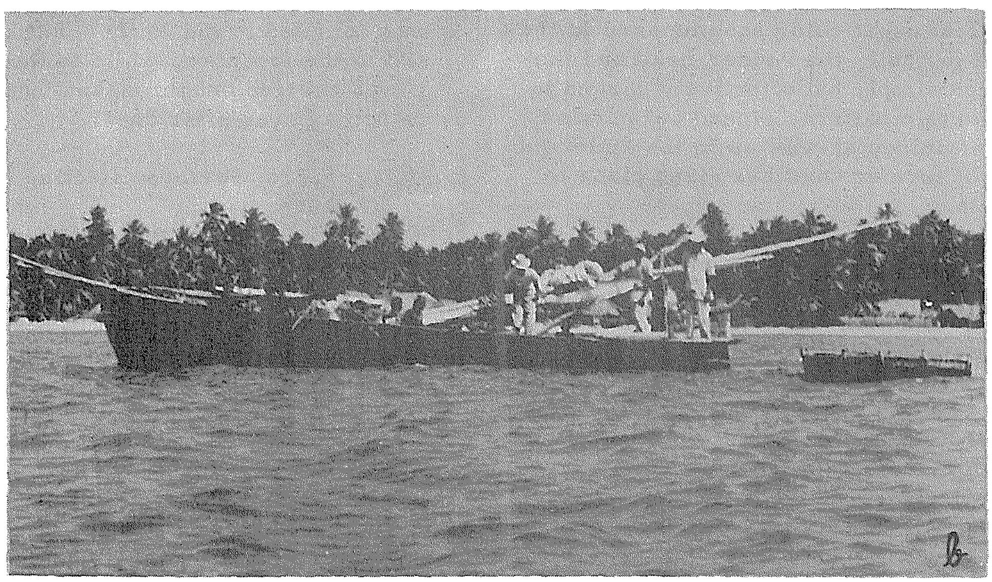


Fig. 9 (a) Tuna fishing boat of Minicoy returning after fishing;
(b) same, proceeding to fishing grounds after collection of bait-fish from the live-bait basket seen on the right side.

kanthu-fathi are used for going to the boat anchored in the lagoon" (Fig. 10). Hornell (1950) mentions the resemblances of the prow and graceful curves of these boats to the old viking ships. Speaking of the sails of these tuna fishing boats in the Maldives as they were during the early part of this century, Hornell (1934) remarks that: "The rig of the larger vessels is a strange combination of fore and aft and square sails. A high rectangular mat sail, the head laced to a yard, is hoisted on the foreside of the mast, while abaft, on the same spar, is set of fore and aft main sail, laced to a gaft but without a boom. Not infrequently this main sail is of thin cotton. The combination of pale brown mat square sail and white cotton main sail is picturesque but to a sailor has a strangely unhandy appearance. In the hands of the islanders the rig works satisfactorily. Considerable taste is shown in all details of painting and carving. While black and yellow form the usual color scheme used in the decoration of the hull, the rudder-head and the tiller are often simply but effectively carved in elegant symmetric pattern, picked out in two colors". In Minicoy as well as in the Maldives the mat sail of former days has given place to the cotton sail.

At Minicoy every Thursday evening the tuna boats are hauled ashore for cleaning, painting and minor repair work, and are launched on Saturday morning for regular fishing. The boats are hardy and durable and most of them last at least 20 to 25 years. The present day cost of constructing a tuna boat at Minicoy is about Rs. 5000/-. Except for the copper nails, keel and bent frames, indigenous timber is used.

5.2 Fishing areas

5.2.1 General geographic distribution

See section 2.2.1.

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

See section 2.2.1

5.3 Fishing seasons

5.3.1 General pattern of fishing seasons

Around Minicoy Island in the Laccadives the fishery is operative from September to April, with the peak season from December to March. The same would apply also to the Maldives further south (Jonklaas 1962).

5.3.2 Duration of fishing season

See section 5.3.1.

5.3.3 Dates of beginning, peak and end of season

See section 5.3.1.

5.3.4 Variation in time or duration of fishing season

During two periods of observation, from May 1958 to April 1959 (Raju, in litt) and November 1960 to April 1961 (Thomas, in litt), the time of fishing varied in relation to the availability. In the former period, fishing was confined to the early hours of the morning and to the forenoon, while in the second period it was carried out throughout the day, the boats returning even after dusk.

5.3.5 Factors affecting fishing season

Around Minicoy the main factors affecting fishing are:

(i) the non-availability of bait fish in sufficient quantities;

(ii) very rough weather during the monsoon period;

(iii) skipjack schools occasionally not responding to bait;

(iv) though the boats are inefficient, as they have to depend on wind and oars, the time taken to get to sighted shoals is greater, with the chance of the shoal disappearing. Due to the same reason more time is taken up in scouting for shoals and fishing is restricted to within a few kilometers from the Island.

5.4 Fishing operations and results

5.4.1 Effort and intensity

For the seasons November 1960 to April 1961 when more than 1,000 metric tons of skipjack were landed in Minicoy, the catch per man hour of effort for the whole season has been calculated to be 0.62 kg (Thomas 1962b).

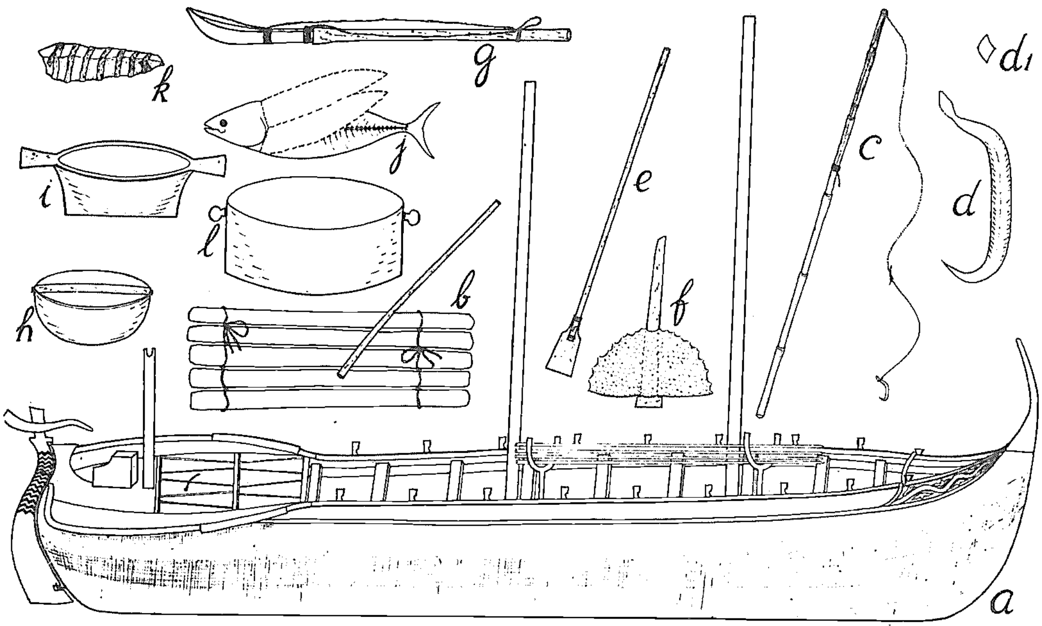


Fig. 10 (a) Tuna fishing boat, (b) raft used in ferrying persons to boat anchored in lagoon or to bait baskets; (c) pole-and-line used for tuna fishing; (d) tuna fishing hook; (d_1) cross section of same; (e) oar used in fishing boats; (f) coral stone anchor;. (g) water-splasher; (h) water-baler; (i) wooden trough used for carrying tuna; (j) method of filleting tuna for préparation of mas (semidiagrammatic); (k) a piece of mas (semidiagrammatic) with split coconut leaf; (l) copper vessel used for boiling tuna meat (after Jones and Kumaran 1959).

5.4.2 Selectivity

The absence of smaller size groups of skipjack below about 300 mm and larger fish above 720 mm in the catches at Minicoy remains to be explained. It is not known whether it may be due to the selective nature of the gear (the hook used is of a standard size) or for some other reason. Fishermen prefer skipjack over yellowfin, which also occur in fair abundance in those waters, since the dried product (mas-min) obtained from skipjack is considered superior in quality.

5.4.3 Catches

For Minicoy for the period November 1960 to April 1961 - see section 5.4.2. The export figures for the smoked product are given in Table IX. The ratio between the fresh and the smoked product is 4:1.

Export figures to Ceylon from Maldive Islands in 1951 (Anonymous 1954) were 2,151 tons of "Maldive fish" (about half the prewar figure), which would mean that the annual prewar landings of fresh skipjack at the Maldives could have been around 16,000 tons.

Fourmanoir (1960) gives the skipjack landing figure for Madagascar as about two tons a year, in La Reunion 5 tons and Comoro Islands 1.5 tons.

5.4.4 Past and present factors of effect on operations and results

It is assumed that only a very small percentage of the available stock of skipjack is tapped at present in this region. Fourmanoir (1960) comments on the considerable scope for improving skipjack fishery in the Malagasy waters and the same should be applicable for other areas also. At Minicoy, the catch per man effort is very low but continuous data is not available to study fluctuations.

5.5 Fisheries management and regulations

In India, the Central Marine Fisheries Research Institute, Mandapam Camp has been collecting data on skipjack biology and fishery; bait fish resources, etc. from the Laccadive Sea for the past few years.

The East African Marine Fisheries Research Organization has been conducting experimental troll fishing and there are indications that good fishing grounds for skipjack exist off East Africa and Zanzibar.

In Madagascar, work carried out at the Office de la Recherche Scientifique et Technique, Outre-Mer (ORSTOM) indicates considerable scope for developing skipjack fishery in that area.

In Australia, the Commonwealth Scientific and Industrial Research Organization (CSIRO) has been carrying out active experimental fishing for tunas which has revealed the occurrence of skipjack around Tasmania, Great Australian Bight and Western Australia in the Indian Ocean.

Table IX
Export figures for smoked skipjack

Year	Number of bags (120 lb each)	Approximate value in Rupees
1952	1,570	1,57,785
1953	2,221.5	2,44,365
1954	1,921	2,30,520
1955	1,191	1,39,283
1956	3,110	3,34,150
1957	5,544	6,04,931
1958	3,406	3,92,254
1960	Ca 1,112	Ca 1,77,920