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SYNOPSIS OF BIOLOGICAL DATA ON THE LONG CORSELETTED FRIGATE MACKEREL Auxis thynnoides Bleeker 1855

Exposé synoptique sur la biologie de l'auxide Auxis thynnoides Bleeker 1855

Sinopsis sobre la biología de la melva Auxis thynnoides Bleeker 1855

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1 IDENTITY

1.1 Taxonomy

1.1.1 Definition

Phylum Vertebrata
Subphylum Craniata
Superclass Gnathostomata
Series Pisces
Class Teleostomi
Subclass Actinopterygii
Order Thunniformes
Family Thunnidae (sensu lato)
Genus Auxis Cuvier, 1829
Species Auxis thynnoides Bleeker 1855

1.1.2 Description

Genus Auxis Cuvier, 1829. Regne Animal Ed. II, 2, 199. (Type: Scomber rochei Risso = Scomber thazard Lacépède, from between 6° and 7° S on the coast of New Guinea)

"Body rounded in cross-section, fusiform, and more elongated than in Katsuwonus and Euthynnus. Caudal portion remarkably short, while the precaudal portion is very long. Snout short, mouth small. Teeth in both jaws only. Fins small, especially the second dorsal, anal and caudal. Posterior portion of the first dorsal has disappeared, and the fin is nearly triangular in shape, and is not continuous to the second dorsal. In the median prolongation of the corselet, we find no indentation at the ventral margin behind the pectorals. Lateral line slightly curved with small undulations. Tongue flat, smooth and silvery.

Basioccipital together with the parasphenoid form paired horn-like processes behind to support the first vertebra above. Exoccipitals fused to one piece of bone, with a prominent dorsal median crest, just below the supraoccipital crest, thus affording a strong hold for the insertion of the lateral muscles. Deep transverse depression along the suture between the prootic and alisphenoid, corresponding to the ventral groove in the optic lobe of the brain. At the anterior border of the depression the alisphenoid is produced to a shelf to partly cover the depression. Pterotic process long and broad horizontally. The sphenotic does not appear in the dorsal side of the skull. Anterosuperior corner of the subopercle produced. One pair of auxiliary intermuscular bones on the coalesced exoccipitals, just above the foramen for the spinal cord. Some intermuscular bones behind that of the 8th vertebra are divided into two portions and are connected by a ligament.

The first vertebra is not closely coalesced to the skull, and the upper posterior zygapophyses are long and large for the attachment of the clavicular ligament. The neural process of the first vertebra is weak and small. In the second vertebra the neural process and the lateral transverse processes are remarkably large. The former is for the attachment of the muscle of the first dorsal, and the latter for the attachment of a pair of strong tendons from the center of paired small cones of myotomes. First three vertebrae have a pair of strong ridges or pillars at the ventral side respectively.

The centrum of the succeeding vertebrae is shaped like an hourglass, as longitudinal ridges are scarcely developed in them. Lateral keels are more or less developed in the majority of the caudal vertebrae, though many of them are not developed along the whole length of the side. In the precaudal vertebrae, ventral processes arise from the anterior end only, and they are united into a median rod, the epihaemal process of some length. At the distal end the rod is separated to parapophyses. The haemal arch and haemal spine are found in caudal vertebrae only. The epihaemal process is turned more or less forward in the caudal region as well, while the haemal processes are turned backward. Both neural and haemal processes from the vertebrae, with the exception of some caudal ones, are laterally compressed. Even in the first caudal vertebra, the epihaemal process is more or less turned forward and the process of that vertebra makes nearly a right angle with the haemal arch. The so-called trellis formed on the ventral side of the vertebral column is scarcely developed in this genus. Spurious interneurals are found between the two dorsals.

Epaxial cutaneous blood-vessels run near the lateral median line, and are united to segmental branches of both epaxial and hypaxial sides. These blood-vessels form sheets of the vascular plexus round the dark red portion of the lateral muscle, as the hypaxial cutaneous blood-vessels are atrophied as in the genus Euthynnus, and take no part in the formation of the plexus.

The rod of the vascular plexus between the parapophyses in the precaudal region and in the haemal canal in the caudal region is thin and much degenerated.

The dark red portion of the lateral muscle, the chiai, is broadest near the vertebral column, as the chief axial blood-vessels are far removed from the latter. A comparatively large portion of the lateral muscle is coloured dark red. Besides a concentric sheath of muscles round the strong tendon from the second vertebra, there is another smaller concentric sheath of muscles round another tendon on the external side of the anterior part of the cutaneous blood vessels.

The dendritic course of the hepatic vein may distinctly be seen on the exterior side of the liver. The right lobe of the liver is exceedingly long, the other lobes are short and rather indistinct. The mass of the pyloric coeca is much shorter than the stomach. Kidneys are elongated. Two ureters are separated and open at the dorsal anterior end of the bladder. Sexual gland when ripened develops backward along both sides of the thick row of interspinous bones of the anal fin. This is due to the narrowness of the abdominal cavity.

The back is dark greenish, it becomes dark bluish after death. Several oblique bands in the scaleless part above the lateral line. Belly silvery, with iridescent reflections. Oval dark spot below each eye" (Kishinouye 1923).

Auxis thynnoides Bleeker 1855

"Body robust, rounded, almost circular in cross-section. Dorsal outline moderately and evenly curved. Ventral outline evenly curved when fresh but flattened abdominally after preservation in formalin". (Jones 1958).

Body proportions expressed as percentages of total length (to fork) for 13 specimens from the southwest coast of India are as follows:

Head 23.7 to 26.8; 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 origins 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 at pectoral base about 16.0 to 18.0 percent of total length.

Mouth moderate, oblique, end of maxillary reaching vertical from anterior margin of eye. Jaws nearly equal, the lower jaw projecting almost imperceptibly beyond the upper. Teeth small, pointed in a single row on both jaws, none on palate. Branchiostegals 7. Gill rakers long and slender, 45 in first gill arch. Two dorsal fins separated by interspace slightly shorter than head length. First dorsal roughly triangular with 10 spines, anterior spine longest. Second dorsal small with 13 rays. Dorsal finlets 8. Anal fin small, with two spines, 11 rays. Anal finlets 7. Pectorals roughly triangular, reaching vertical from the base of first ray of first dorsal. Ventral thoracic, axillary scales equal in length to ventrals. Body naked except for the corselet of scales which taper gradually to 9-10 irregular scale rows at vertical through second dorsal and end as a narrow line at vertical below. Scales large and imbricated above pectoral base. Caudal peduncle slender with feebly developed lateral keels. Lateral line somewhat undulating and without a distinct arch (Jones 1958). Color: "Fresh specimens with an overall bluish iridescence. Color in formalin, almost black dorsally gradually becoming deep brown laterally and light brown ventrally. Wavy bars on the sides above and behind the corselet. A black patch at the postero-ventral border of the eye. Anterior spines of the first dorsal brown. Anal fins and finlets almost colorless with white patch around the base" (Jones 1958) (Fig. 1).

- Internal characters

The dark colored portion of the lateral muscle is nearly equally large in the hypaxial and epaxial portions.

"Depression along the suture between the prootic and the alisphenoid is sharply defined and narrow, and the shelf at the anterior border of the depression is obsolete. Only two intermuscular bones have the middle portion non-ossified. The lateral process of the second vertebra is short and thick. Neural process of some anterior vertebrae is not so broad as in the preceding species. The haemal arch of the first caudal vertebra makes a right angle with the epihaemal spine. From the lower end of the epihaemal spine a pair of short free processes are produced downward and forward in some

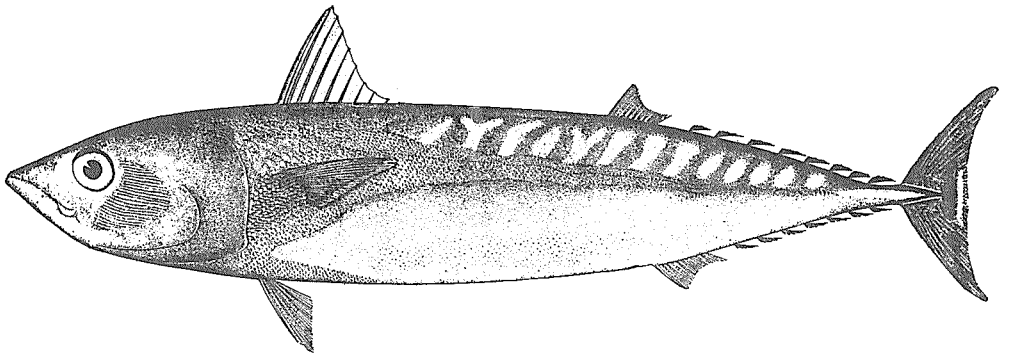

Fig. 1. Auxis thynnoides Bleeker (after Wade 1949).

caudal vertebrae. Free parapophyses from the lower end of the epihaemal process are short, and are but a little separated from each other" (Kishinouye 1923).

"Vertebrae 20 + 19 = 39, including urostyle. First haemal arch on 8th vertebra; first closed haemal arch and first haemal spine on 21st vertebra. Haemal canal borne away from body of vertebra by pedicles (= epihaemal processes)" (Matsumoto 1960).

A comparison of the skeletal structures of Auxis thynnoides (=A. maru) and A. thazard (=A. hira) is given by Godsil (1954).

1.2 Nomenclature

1.2.1 Valid scientific name

Auxis thynnoides Bleeker 1855

1.2.2 Synonyms

Auxis thazard (nec Lacépède)	Jordan and Evermann, 1896
	Walford, 1937
	Fowler, 1938
	Partim de Beaufort, 1951
	Partim Herre, 1934
	Partim Molteno, 1948
	Partim Rosa, 1950
	Partim Fraser-Brunner, 1950
Auxis rochei	Partim Günther, 1860
Auxis maru	Kishinouye, 1915
Auxis tapeinosoma	Herre and Herald, 1951
	Herre, 1953
	Jones, 1958
	Williams, 1960
	Talbot, 1962
	of Japanese workers

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

Meristic counts, shown in Table II, have been given by several authors.

- Gill rakers

See Table III.

While there is considerable overlap in the number of gill rakers on the upper limb of the outer gill arch in both species, the range on the lower limb is low for A. thazard. The total number of rakers also shows a similar trend with the mean for A. thazard being about 40 and for A. thynnoides about 45 (Jones and Silas 1962).

- Corselet scales

Workers from various parts of the Indo-Pacific have recognised two types of Auxis, one a short corseletted form (A. thazard Fig. 3b) and the other a long corseletted form (A. tapeinosoma = A. thynnoides Figs. 2 and 3a). In similar sized juveniles of A. thazard and A. thynnoides to about 300 mm the corselet distinction is very marked. In a few larger adults of A. thazard from the south-west coast of India, it has been found that the corselet, instead of abruptly tapering, gradually narrows somewhat as in A. thynnoides to a vertical, below mid-distance between posterior end of base of first dorsal and second dorsal origin, from where it is narrow with hardly one or two scales on either side. This is shown in Fig. 3c. Such an intermediate condition, as also slight overlap in gill raker counts, could evidently give rise to difficulties in specific determination. However, even in such cases, the gill raker counts are definitely on the lower side, as is typical of A. thazard. Hence in such doubtful cases, this combination of characters should facilitate specific identity (Jones and Silas 1962).

- Varieties

Both Auxis thynnoides and A. thazard occur in the same areas and in mixed schools.

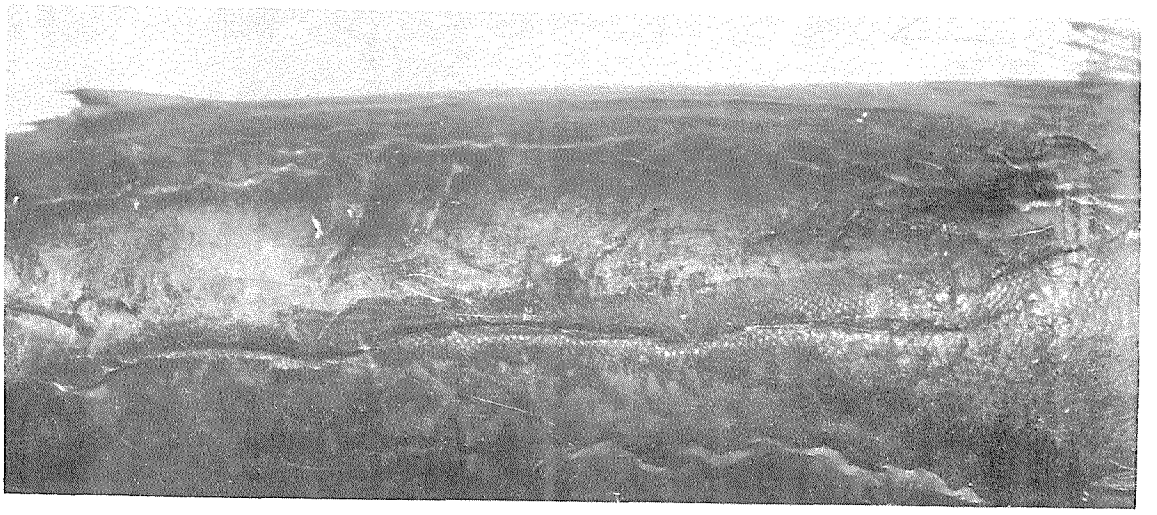

Fig. 2. Photograph of the corselet of a 256 mm specimen of Auxis thynnoides.

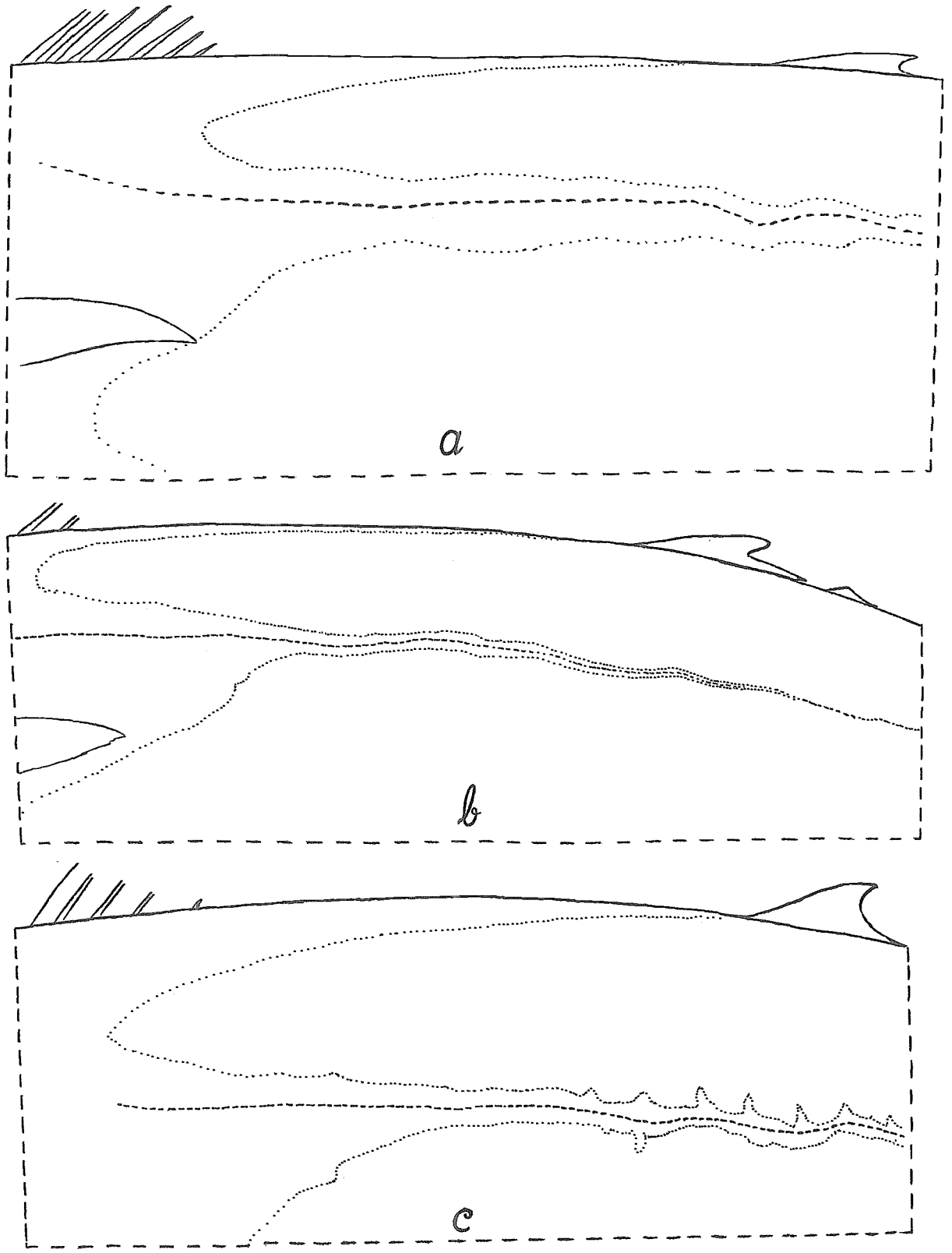

Fig. 3. Outlines of corselets drawn from actual specimens.

a) Auxis thynnoides;

b) Auxis thazard - typical short corseletted condition;

c) Auxis thazard - intermediate condition (pectoral fin left out).

Table I

Common and vernacular names

Country	Standard Common Name	Vernacular Name
Australia	Long corseletted frigate mackerel	Maru frigate mackerel (Munro 1958)
India Malayalam (North)	-	Kuttichoora (means small tuna and generally applied to Auxis thazard and young of Euthynnus affinis also)
Malayalam (South)	-	Urulan-choora (means rounded tuna and applied to Auxis thazard also from which this species is not generally distinguished)
Tamil	-	Eli-choorai (means rat-like tuna) Kutteli-choorai (means small rat-like tuna)
Japan	Frigate mackerel	Marusoda, marumedika, chiboh, diananpo, magatsuwo, manba, mandara, marugatsuwo, nodoguro, rohsoku, subota, uzuwa (Kishinouye 1923).

Table II

Meristic counts of Auxis thynnoides

Organs	Japan Kishinouye (1923)	Philippines Wade (1949)	Indonesia de Beaufort 1/ (1951)	Hawaii Matsumoto (1960)	S. Africa Talbot (1962)	India Jones (1958 and data collected subsequently)
Dorsal fin	9-10 10-12, 8	10-11, 10-12 7-8	10, 11, 6-9	10-11 10-11, 8	10-12, 11, 8	10-11, 13, 8
Anal fin	13, 7	2, 10-12, 7	14, 6-8	12-13, 7	14, 6-7	13, 7
Gill raker	10, 36	10-12, 1, 31-35 = 42-48	--	10-11, 1 32-36 = 43-48	9-10, 32-34	8-12+31-36

1/ According to de Beaufort (1951) his description of Auxis thazard is "made after specimens of Auxis thynnoides of Bleeker's collection in the Leiden Museum". As such the meristic characters given by him are included here.

Table III

Range and mean gill raker counts for specimens of Auxis thazard and A. thynnoides from Indian waters (Jones and Silas 1962)

Species	No. of specimens	Range Mean	Gill rakers		
			Upper limb	lower limb	Total
Auxis thazard	10	R	9 to 10	29 to 32	39 to 42
		M	9.6	30.2	39.8
Auxis thynnoides	13	R	8 to 12	31 to 36	40 to 47
		M	9.5	34.5	44.8

Since only the latter species had been recognised by many workers until recently, it is very likely there would have been confusion of the two species in some early records. Apparent variations in characters in some early descriptions could probably be attributed to this. From available information, it would appear that there is no significant difference in specimens described from different areas of the Indian Ocean.

1.3.2 Genetic data (chromosome number, protein specificity)

Experimenting on the application of paper chromatography for identification purposes by utilizing frozen material, Matsumoto (1960a) found that one-dimensional chromatograms prepared by using butanol and acetic acid with water as the solvent Auxis could be distinguished from other tunas by the smaller number of spots. Using butanol, methylethylketone and ammonia with water as the solvent, the two species could be distinguished from one another by the position of the spots.

2 DISTRIBUTION

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

In the warm waters of the Indian and Pacific Oceans and connected seas (Fig. 4). According to Matsumoto (1959) it also occurs in the Atlantic.

In the Indian Ocean it has been collected from the west coast of India from Malpe near Mangalore (S.Mysore), Calicut and Quilandy (N. Kerala), Vizhingam near Trivandrum (S.Kerala) and Colachel near Cape Comorin (Madras - west coast) (Jones 1958) and from off Cape Peninsula and Mossel Bay in South Africa and from the south coast of Australia (Talbot 1962). Records from the Indian Ocean are rather few and discontinuous, but a careful watch for it might show a wider distribution.

In the Pacific it has a relatively wider distribution in Indonesian waters, Philippines, Ryukyu Islands, South Korea, Ogasawara Islands, South Manchuria, Formosa, Japan, Hawaii, Galapagos, east coast of Australia, New Guinea and west coast of America. It should be found in waters around the Micronesian and Polynesian Islands also from where larvae have been recorded recently (Yabe and Ueyenagi 1961).

According to the above information, the geographical distribution of the species ranges from 20° E to about 80° W and from about 40° N to 34° - 40° S, covering the tropic and sub-tropic sections of the Indian and Pacific Oceans (Fig. 4).

The occurrence of A. thynnoides in the Atlantic is a controversial matter (Matsumoto 1959) and requires further elucidation.

2.2 Differential distribution

Adults have been taken so far only from inshore waters and near islands.

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

Specific identification of eggs, larvae and early juveniles has not been quite successful and most of the material described so far have been identified only up to the genus. There is, therefore, very little information on the pattern of distribution of the early developmental stages of the species (Wade 1951, Matsumoto 1958 and 1959, Jones 1960).

- Larval stages

Compared to other scombroid fishes larvae and young of A. thynnoides appear to be distributed in the highest latitudes (Yabe and Ueyanagi 1961).

Larvae of Auxis are abundant near islands, as observed from the collections made by the POFI (Pacific Oceanic Fishery Investigations) Research ship and the Dana (Matsumoto 1958).

In the Philippine area, Auxis larvae have been collected in plankton hauls made at the surface some distance from shore and their diurnal and nocturnal abundance in surface waters is reported to be approximately the same (Wade 1951).

Larval Auxis collected from the Laccadive Sea were all from the surface hauls of plankton (Jones 1960). The POFI and Dana collections also showed their relative abundance near the surface (Matsumoto 1958). Examination of the Dana collection from the Indian Ocean also has helped to confirm this (Jones and Kumaran 1962).

The present known distribution of the larvae of Auxis thynnoides in the Indo-Pacific is given in Fig. 5. Since some, which have been determined only up to the generic level might belong to this species, they are also included.

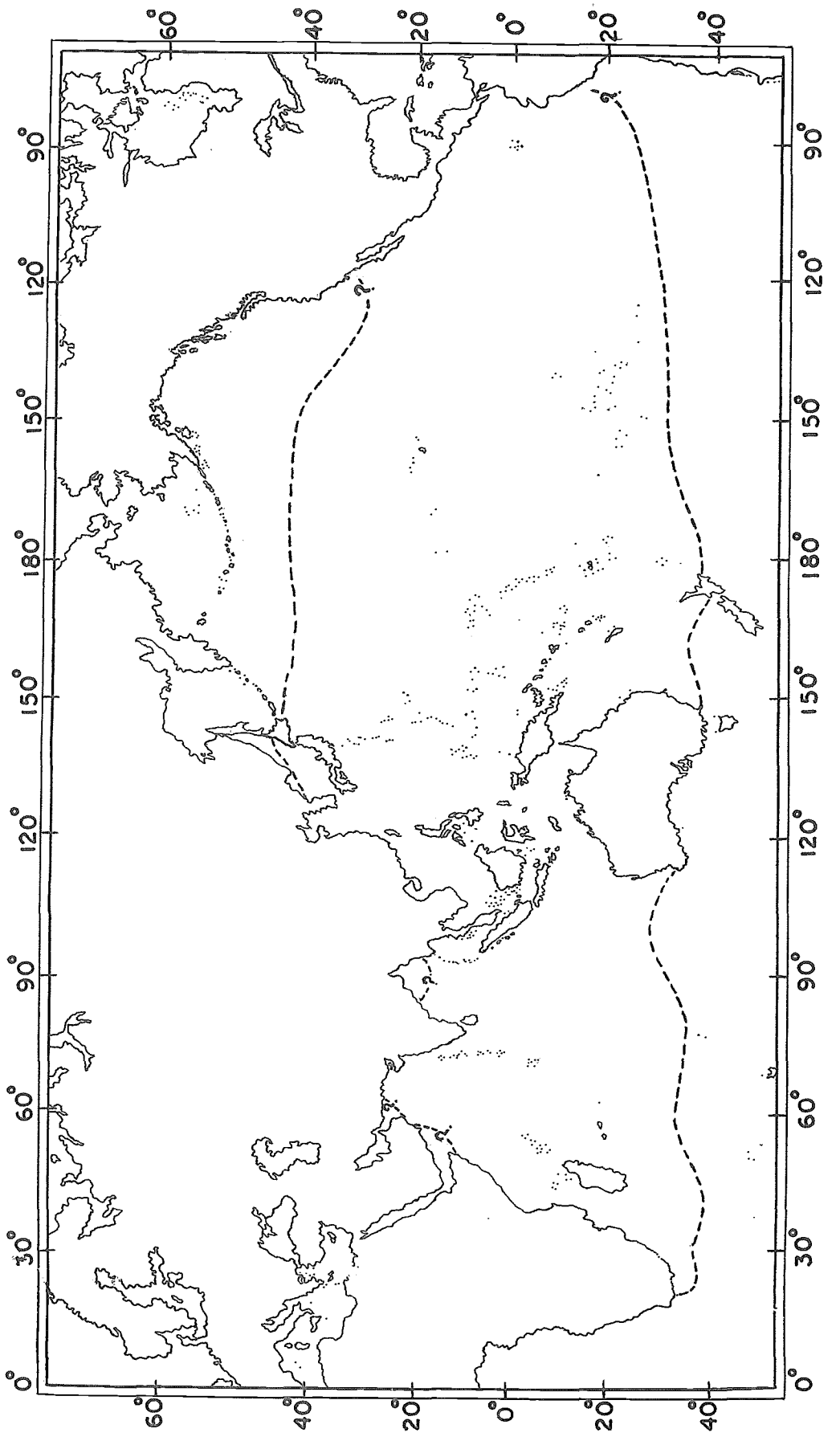

Fig. 4. Distribution of Auxis thynnoides in the Indo-Pacific

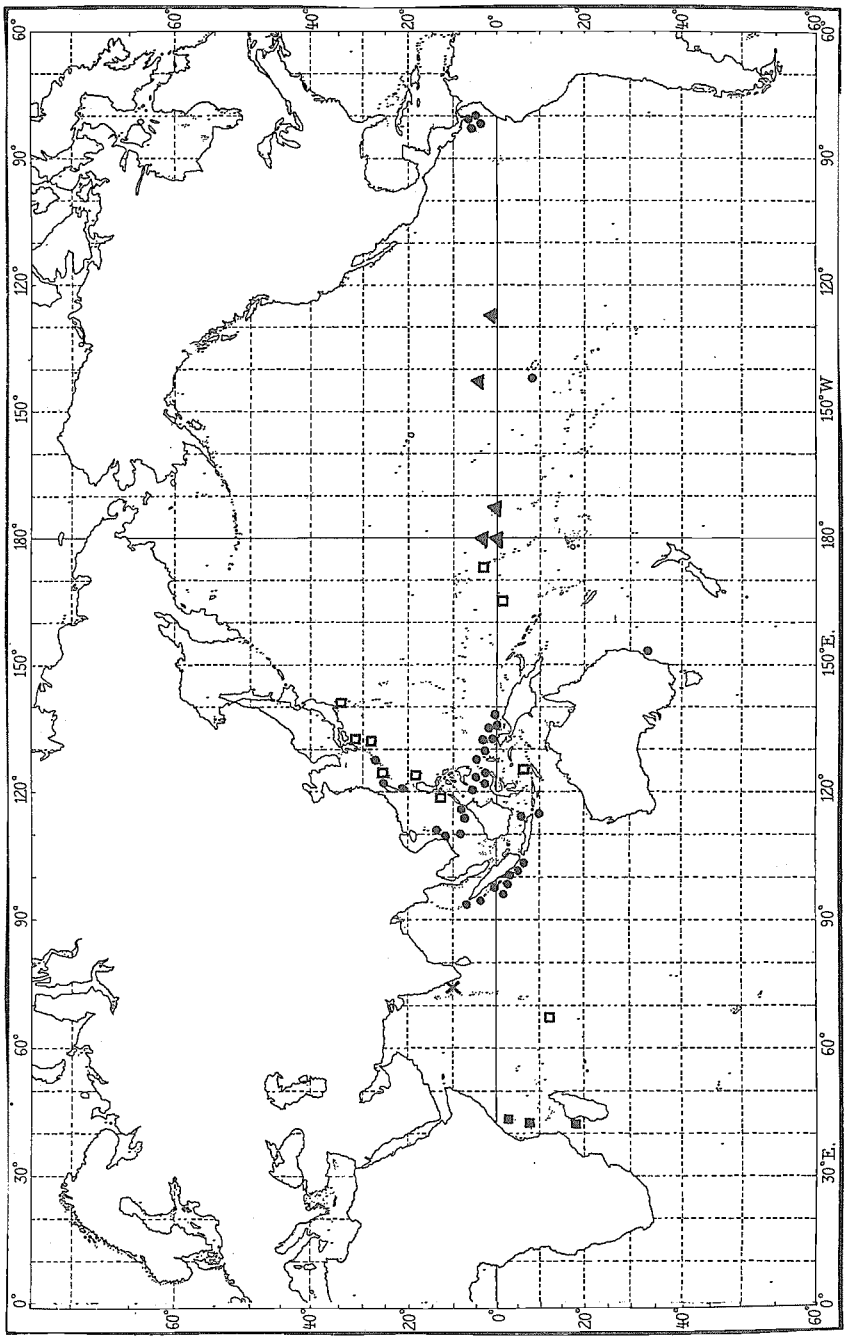

Fig. 5. Places of collection of Auxis thynnoides and Auxis (species indeterminante) larvae in the Indo-Pacific.

✕ Indian collection (Auxis);
□ Japanese collection (Auxis thynnoides);
● Dana collection (Auxis);
■ Dana collection (Auxis thynnoides);
▲ POFI collection (Auxis).

- Young fish

Juveniles of A. thynnoides have been collected from catches landed by shore seines at Vizhingam on the west coast of India (Jones 1960).

In the Philippines, juvenile Auxis are caught in the Batangas and Balyan Bays in fish traps and several types of local nets, both close to the shore and in open water (Wade 1951).

Two specimens, 52 and 54 mm long, evidently A. thynnoides, have been collected at night from the surface under ship's light from 08° 7'30"N, 83° 8'30"W, very close to the southwest coast of Costa Rica (Shaefer and Marr 1948). Yabe et al (1953) record young of this species from the coast seas of south Japan in summer.

It would appear from the above that larvae and young of A. thynnoides are comparatively abundant in coastal waters and near the surface.

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

As other tunas, Auxis thynnoides is a pelagic fish living in clear, warm water and is not known to frequent areas of low salinity. The areas of occurrence are characterized by the presence of ocean currents and proximity of land masses and islands and the limits of its distribution fall within the 20° C isotherm.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality (hermaphroditism heterosexuality, intersexuality)

A. thynnoides is heterosexual. There are no externally observable characters to distinquish males and females.

3.1.2 Maturity (age and size)

Reported to attain a length of 600 mm (Talbot 1962).

- Variations in chemical contents in relation to maturity

Suzuki and Morio (1957) studied the chemical changes that occur in the tissues of fish in different phases of sexual maturity. The contents of iron, copper and zinc in liver, gonads, pyloric appendage and dark muscles and their variations during different stages of maturity were worked out. The molybdenum and nickel contents in the liver, ordinary muscle, dark muscle, gonad, pyloric caeca and heart of the long corseletted frigate mackerel were studied by Morio and Suzuki (1959).

3.1.6 Spawning

- Spawning season (beginning end, peak)

According to Yabe and Ueyenagi (1961) larvae of Auxis thynnoides occur from May to July near Japan and from January to February in the Celebes Sea and the South China Sea.

From the morphological data published by Suzuki and Morio (1957) on specimens used for biochemical studies it is seen that ripening gonads are recorded from April to June, ripe gonads during June and July and spent gonads during July and August.

Yokota et al (1961) report the collection of larval A. thynnoides three to five mm long south of Shikoku and Kyusyu (Japan) from June to August with the maximum in July.

Larval Auxis were collected during January and April from the Laccadive Sea. The only other month when plankton collections were made was February, but Auxis larvae were not present then. There is no information from this area regarding other months.

According to Wade (1951) the greatest catch of Auxis sp (?) larvae in the Philippines was made during January, February and March. Collection during the rest of the year was meagre. "The hourly catches are too meagre to determine the differences, if any, between the abundance of material in day and night tows. A large sample taken at 0600 to 0630 hours has distorted the true picture of the average daytime catches, although the percentage of successful tows is slightly greater during the day than at night. Only 14 of 250 tows (5.6 percent) were successful during the day; nine of 212 tows (4.2 percent) were successful at night. Ignoring the single large sample, the average catch of both day and night tows is about the same; an average of 0.11 specimen during the day and 0.09 during the night. The rather inadequate data indicate that the diurnal and nocturnal abundance of larval Auxis sp (?) at the surface is approximately the same."

The available information indicates an extended spawning period from about November to August with a peak during the first quarter of the year.

3.1.8 Eggs: structure, size, hatching type, parasites and predators

The most common frigate mackerel in Japanese waters appears to be Auxis thynnoides and therefore there is a possibility that the eggs and early larvae described by Mito (1961) could be of this species. Even if not, the general characters of both the species should be very much similar and therefore the figures are reproduced here. (Fig. 6)

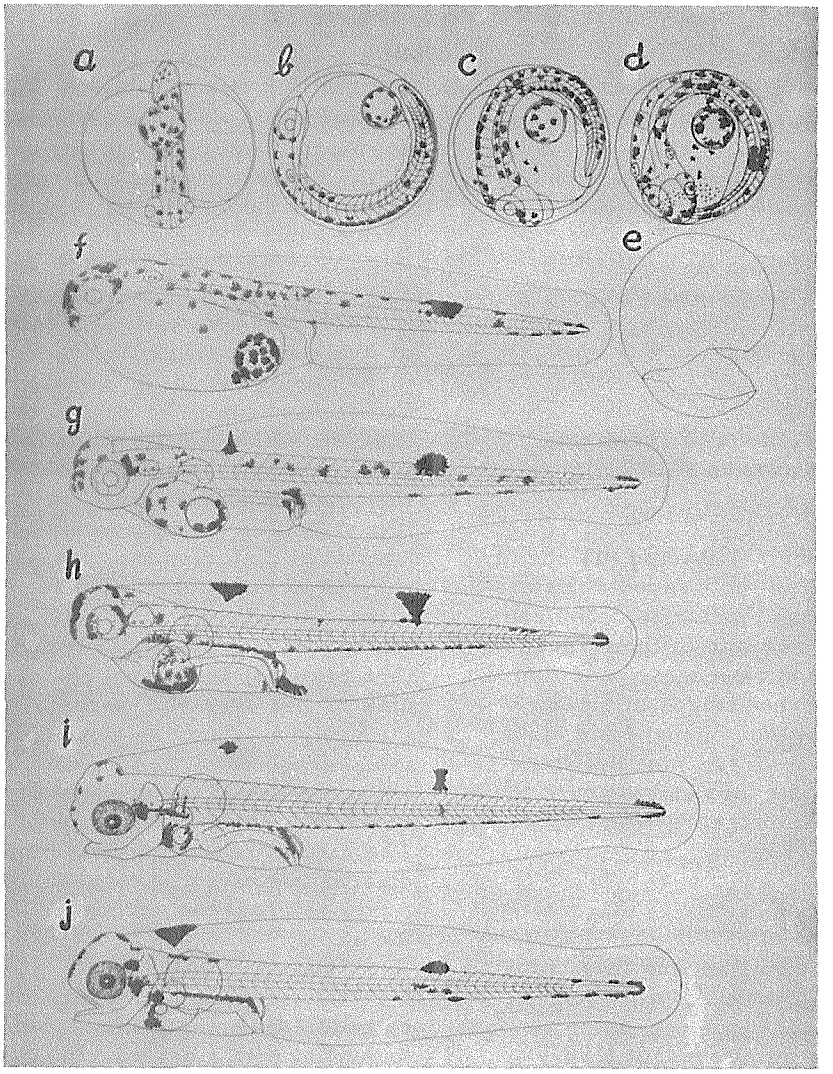

Fig. 6. Embryonic and early larval stages of Auxis sp. (Mito 1961):

a) Pelagic egg, 7h 30m after collecting, 1.04 mm. in diameter, oil globule 0.26 mm.
b) 29-myotome stage, 9h 30m after.
c) 10h 30m after.
d) 14h 30m after, shortly before hatching (24-27°C).
e) Empty egg capsule.
f) Larva just hatched, 2.70 mm. in total length, myotomes 11+32=43.
g) Larva 16h 30m after hatching, 3.68mm. in total length, myotomes 9+31=40.
h) Larva 30h after, 3.58 mm. in total length, myotomes 9+31=40.
i) Larva 42h 30m after, 3.92 mm. in total length, myotomes 9+32=41.
j) Larva 55h after, 3.75 mm. in total length, myotomes 8+31=39.

3.2 Larval history

3.2.1 Account of embryonic and juvenile life (prelarva, larva, postlarva, juveniles)

Fig. 6 shows the yolk sac stages of Auxis sp. as given by Mito (1961). There are striking dissimilarities between the 3.68, 3.58, 3.92 and 3.75 mm larvae in the above and the 3.36 and 4.40 mm stages described by Jones (1960) and 3.5 and 3.75 mm stages described by Matsumoto (1959) and these require explanation.

Yabe and Ueyenagi (1961) succeeded in distinguishing Auxis thynnoides larvae and have figured an 8.1 mm stage (Fig. 7).

Examination of the Dana collections from the Indian Ocean by Jones and Kumaran (1962) has revealed the presence of one A. thynnoides larva at station No. 3940 (8°24'S, 42°54'E), eighteen larvae at station No.3946 (3°26'S, 4° 58'E) off Mombasa and one larva at station No. 3955 (18°30'S, 42°18'E) off the west coast of Madagascar.

Larval Auxis could be distinguished from other tuna larvae by the presence of chromatophores along the base of the ventral fin fold and above and on the sides of the caudal peduncle. The snout is relatively shorter than in other tuna larvae of comparable size. Presence of 39 myotomes, a large chromatophore at the symphysis of the pectoral girdle and late development of fin rays and lack of chromatophores on the first dorsal are additional characters.

Larvae of A. thynnoides could be distinguished from those of A. thazard by the relatively smaller depth of body and late development of the spinous dorsal. Based on this, it would appear that the larvae described from the Laccadive Sea by Jones (1960) are of the latter species.

The wide gap between the first and second dorsal fins helps to easily distinguish juvenile Auxis from other tunas. Also the body is comparatively more rounded. Herald (1951) refers to the presence of pseudofins on the caudal peduncle of juvenile Auxis. Evidently this is a feature common in both species.

Juveniles of Auxis thynnoides of over 30 mm are known. The presence of a larger complement of gill rakers numbering 34 to 36 in the lower arch in this species distinguishes it from A. thazard, which has only 29 to 31 gill rakers in the corresponding arch.

Juveniles of Auxis thynnoides from 32 to 79 mm have been recorded by Wade (1949) from the Philippines, collected from the market and consisting of specimens caught in traps and by night light operations. Jones (1960) has described some juveniles from Vizhingam (India). Re-examining the latter material, it is seen that the specimens measuring 44 to 132 mm could more correctly be assigned to Auzis thazard, while the juveniles from 181 to 209 mm are unmistakably of A. thynnoides (Jones 1962). Some of the typical juvenile stages are given in Fig. 8.

- Feeding

The only available information relates to the food of larvae of three to five mm by Yokota et al (1961) who studied the food habits of a number of larval fishes found in the sea south of Kyusyu and Shikoku in Japan. They give the body length composition of food animals, size preference of larval fish to copepod larvae, correlation coefficient of total length of larvae and food, feeding density and frequency of group feeding rate. Relevant extracts are given in Table IVa, b and c and Fig. 9.

3.3 Adult history

3.3.3 Competitors

Auxis thazard, Megalaspis cordyla, Stromateus niger and Euthynnus affinis affinis are a few of the common species caught with Auxis thynnoides at Vizhingam (India) in gillnets. A variety of other fishes having more or less the same food habits are generally found in the areas where shore seines and boat seines are operated. Carangids, seerfishes, thunids and perches are caught by hook and line with the frigate mackerel

The following species are caught with Aux thynnoides in Japanese waters according Y et al (1961).

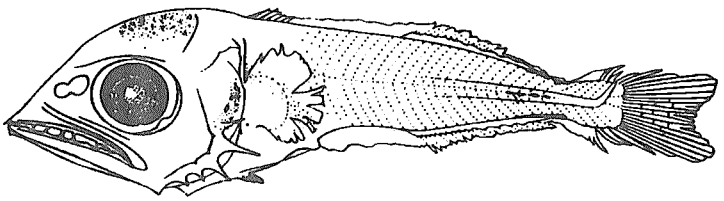

Fig. 7. 8.1 mm stage of Auxis thynnoides (Yabe and Ueyanagi 1961)

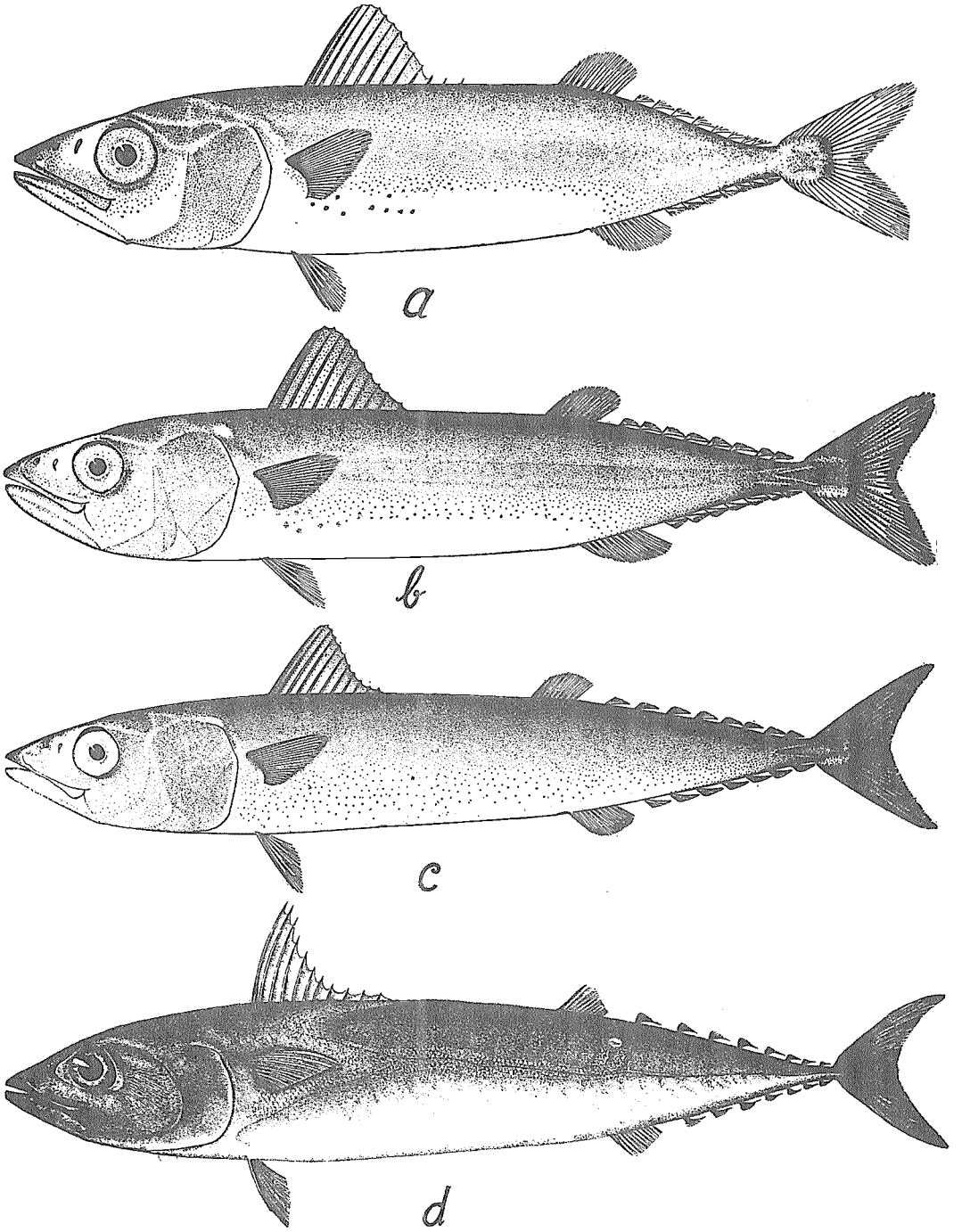

Fig. 8. Juvenile stages of Auxis thynnoides

a) 33 mm
b) 54 mm
c) 79 mm
d) 185.3 mm

(a - c after Wade 1949 and d after Jones 1960)

Table IV a

Body length composition of food animals
(after Yokota et al 1961)

	Nauplius stage				Copepodite stage		Copepoda
B.L. μ	100	150	200	250	300	550	
	2	5	12	1	1	1	

Table IV b

Feeding density P/N
(after Yokota et al 1961)

	Nauplius stage				Copepodite		Copepoda		Annelida, Mollusca, etc.	
P/N	0	0.5	2.0	3.0	0	0.5	0	4.0	0	1.0
	1	1	1	1	3	1	4	1	3	1

Table IV c

Frequency of group feeding rate
(after Yokota et al 1961)

Group Number	Group Feeding Rate Percentage			
	0	20	40	100
4	25	25	25	25

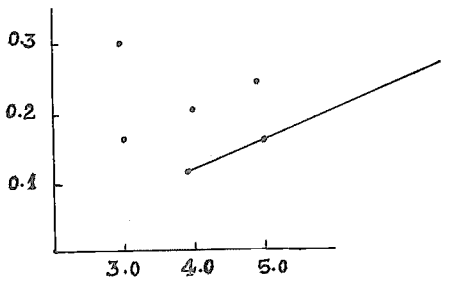

Fig. 9. Size preference of larval fish to copepod larvae
(after Yokota et al 1961)

Pole and line:	Albacore tuna
	Bigeye tuna
	Bluefin tuna
	Skipjack
	Spotted mackerel
	Yellowfin tuna
Longline:	Bluefin tuna
	Sailfish
	Skipjack
	Spotted mackerel
	Striped marlin
	Swordfish
	Yellowfin tuna
Trolling line:	Bigeye tuna
	Bluefin tuna
	Dolphin fish
	Euthynnus affinis yaito
	Sailfish
	Sarda orientalis
	Skipjack
	Spotted mackerel
	Striped mackerel
	Swordfish
	Yellowfin
Set net:	Bigeye tuna
	Bluefin tuna
	E. affinis yaito
	Sarda orientalis
	Scad
	Seriola aureovittata
	Seriola purpurascens
	Skipjack
	Spanish mackerel
	Spotted mackerel

3.3.4 Predators

Auxis thynnoides is an important part of the stomach contents of tunas and marlins caught by longline from Queensland waters and Banda Sea, occurring in greater numbers than A. thazard (Watanabe 1962). The specimens of Auxis recorded from the stomach contents of a sailfish by Jones (1958) when he collected the first specimen of A. thynnoides from Indian waters, could also probably be of the same species. According to Yokota et al (1961) the most important predator of A. thynnoides in the vicinity of Japan is the oceanic skipjack, while the yellowfin, bluefin, bigeye and Auxis thazard also feed on it. The size range of A. thynnoides in the stomach contents of the above fishes is given in Table V. Kishinouye (1917) has recorded juvenile of A. thynnoides from the stomach contents of albacore, bigeye tuna, skipjack and yellowfin tuna.

3.3.6 Greatest size

Said to attain about 600 mm (Talbot 1962) but specimens over 500 mm are rather rare.

3.4 Nutrition and growth

3.4.2 Food (type, volume)

Kumaran (1962) found that A. thynnoides collected from Vizhingam on the west coast of India fed mainly on small fishes and crustaceans and occasionally on squids. Percentage of occurrence and percentage by volume of important items of food are given in Table VI. Anchoviella spp., Leiognathus spp., and clupeids were important constituents. Crustaceans (24.4 percent by volume) formed the second important group of food. Megalopa larvae (21 percent by volume) were encountered in about 38.7 percent of the total number of fish examined. Squids constituted about 22.7 percent of the food consumed and were present only in the stomachs of large fishes. Larval stomatopods of Lucifer formed the major part of the food of some specimens collected by Jones (1958) from Quilandy on the west coast in October 1956.

The stomach contents of Auxis thynnoides caught by trolling line and set net from two fishing grounds in Japan have been studied by Yokota et al (1961). Those caught by trolling had only anchovy as the main food item with other food elements in stray numbers. The specimens caught in set net had jack mackerel as the most dominant item, followed by anchovy. Spotted mackerel and lizard fish were also found in fair numbers, unlike in the stomachs of fish caught by trolling. The tabular statement is reproduced in Table VII.

3.5 Behavior

3.5.1 Migration and local movements

A very large shoal that appeared at Calicut on 17 October 1956 reappeared at Quilandy on 24 October 1956, about 14 miles further north. The surface current in this area during this time was north to south. It is probable that the shoal was migrating for food. As a predaceous pelagic shoaling fish, it has to compete with several other carnivorous species. At the same time it is preyed upon by other fishes. The food demand of large schools should be considerable. Therefore they must be on the move. While this may have its advantages, the large schools are subjected to heavy loss by fishing.

Table V

Body length of Auxis thynnoides in stomach contents
(after Yokota et al 1961)

Region	Tokara to Sakishima								Bashi S. to Sulu Sea						
	'59			'60				'61	'60			'61			
Date	4	5	6	12	1	2	5	1	2	1	2	3	1	3	4
F. L. mm															
-20	0	0	0				2								
20-	4														
30	0									13	93				
40	1	167	3				1			20	178				
50		66	3						1	16					
60		68	4										1		
70		118	9							9			0		
80		27	0							1	7		2		
90		8	4										10		
100		5	13										14		
110			5								1	2	8		
120										1		5	3		
130										2		1	1		
140										2		9	1		
150		3			1			1							1
160						1									
170	1							2							1
180	3				1			1			1				1
190	1			1	0										
200	3	1		7	8			3				1			
210				1	2			5	1					1	1
220				6	3			4	2						
230				2				2							
240	1			3				6							
250								1							

Table VI

Food items of Auxis thynnoides from the west coast of India (after Kumaran 1962)

Food items	Percentage of prevalence	Percentage by volume
Polychaeta	3.2	1.2
Amphipods	16.1	0.9
Mysis stage of prawn	12.9	0.9
Megalopa larvae	38.7	21.0
Alima stage of squilla	12.9	0.9
Unidentified crustaceans	6.4	0.6
Halobates	3.2	0.6
Sagitta spp.	3.2	8.7
Sepioteuthis sp.	16.1	22.7
Sardinella spp.	9.7	3.5
Clupeid larvae	6.4	2.9
Anchoviella commersonii	6.4	2.3
Anchoviella tri	12.9	4.7
Hemirhamphus sp.	6.4	2.7
Sphyraena sp.	3.2	2.3
Caranx sp.	9.7	1.8
Carangid larvae	9.7	2.1
Leiognathus spp.	16.1	5.3
Unidentified fish and larvae	25.5	14.5

Table VII

Stomach contents of Auxis thynnoides
(after Yokota et al 1961)

Date	Fishing ground	Nos.	Mackerels												
			Spotted	Jack	Saury	"NEZUMI" gisu	"KUROTACHI" kamasu	"SAGIFUE"*	Lizard fishes	"HATAAJI"*	*MATOUI SHIMOCHI	*MISHIMA OKOZE	Squids	Anchovy
'58. 12	Kumanonada	187				2	2				1			4
'59. 1	"	137				1	1							36
2	"	175								1		2		38
3	"	105	4		1		2		1					1
'60. 12	"	30												243
'61. 1	"	9						1						
3	"	29											4	2
4	"	17		6	(b) Set net								3	25
'60. 4	Tanegashima	30	37	995					26					459

*SAGIFUE	Macrorhamphosus scolopax (Linne)
HATAAJI	Elephenor macropus (Bellotti)
MATOUISHIMOCHI	Apogonichthys carinatus (C. and V.)
MISHIMAOKOZE	Gnathagnus elongatus (T. and S.)

3.5.2 Schooling

The tendency to school and form large shoals appears very strong in juvenile and adult Auxis thynnoides. Individuals in the same catches are more or less of the same length, indicating that fish of the same size group shoal together. They scatter when disturbed, but soon come together again.

4 POPULATION (STOCK)

4.2 Size and density

4.2.1 Average size

Around Japan the size of the fish caught ranges from 16 to 50 cm but the majority fall between the 20 and 32 cm groups (Yokota et al 1961). The specimens obtained by Wade (1949) from the Philippines ranged in length from 12 to 23 cm. In India the fish caught are generally young and range in length between 14 and 25 cm. Except when shore seines are used, the gear employed is rather selective and the catches cannot give a correct picture of the population structure. The information available is very meagre.

4.4 Mortality, morbidity

4.4.2 Factors or conditions affecting mortality

Strasburg (1959) has recorded an instance of mass mortality of larval frigate mackerel south of Lanai in the Hawaiian islands. In view of the presence of both species of Auxis in the above area it is presumed that the affected larvae could belong to Auxis thynnoides also and hence included here. In the plankton tows made for sampling larval tuna by the POFI (Pacific Oceanic Fishery Investigations) vessel 'Charles H. Gilbert' in the vicinity of Lanai island, large numbers of frigate mackerel larvae were obtained. Many appeared to have been dead before capture. These had the following characters: "Flesh grey, somewhat translucent; vertebral column invisible; visceral mass often lacking, when present both it and anus flabby; eyes typically absent; lower jaw prognathous; gill arches distorted; body straight. The definitive cause of death could not be determined. There were no signs of predation, disease, or parasitism, but starvation could not be definitely excluded as a factor. It was tentatively hypothesized that the mass death was brought about by passage through an area having marked discontinuities in its surface water temperature" (Strasburg 1959). The larvae collected measured from about 2.25 to about 8.25 mm in total length with the mode between 3 and 5 mm. The rate of mortality increased with size, and larvae about 5 mm were the most affected.

5 EXPLOITATION

5.1 Fishing equipment

5.1.1 Fishing gear

In India adult Auxis thynnoides is caught in shore seines, boat seines, gillnets and by hook and line. Juveniles are caught mostly in shore seines and boat seines, rarely in gillnets. No gear is used exclusively for this species.

In Japan it is caught in pound nets, set nets, driftnets, on trolling lines, longline and pole and line (Kishinouye 1923, Yokota et al 1961). In the Philippines it is caught in fish traps and various types of indigenous nets (Wade 1951). In Hawaii it has been caught by pole and line (Matsumoto 1960) during experimental fishing and in South Africa on trolling lines (Talbot 1962).

5.1.2 Fishing boats

The fishing craft in India where Auxis thynnoides is caught are dugout canoes and catamarans.

5.2 Fishing areas

5.2.1 General geographical distribution

No specific fishery for Auxis thynnoides exists anywhere. It is caught with other fish in Philippines, Japan and along the southwest coast of India. Information about other countries is not available, but it is possible that in many areas its existence in mixed catches with Auxis thazard and juvenile Euthynnus goes unnoticed.

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

In India it is caught within a radius of about ten miles from shore.

5.2.3 Depth ranges

Juveniles and adults are caught in comparatively coastal waters. Occurrence of juveniles in shore seines and traps shows that they frequent shallow waters.

5.3 Fishing seasons

5.3.1 General pattern of fishing season

In India its occurrence in the catches does not appear to be regular. It starts coming in with the close of the southwest Monsoon.

5.3.2 Duration of fishing season

From August to September and November to December in India. Stray specimens have been recorded in April. Wade (1949) has collected the fish from Philippine markets in July and February. Yokota et al (1961) refer to capture in certain areas in Japan during most of the year from January to June, August and September and November and December.

5.3.3 Dates of beginning, peak and end of season

No definite information is available. In India the catches appear to be highest during October and November. Yokata et al (1961) record maximum catches from November to March (Table VIII).

5.4 Fishing operations and results

5.4.2 Selectivity

The gear used is not selective for the species. When nets and traps are used, a variety of other fishes are caught. With pole and line and trolling line other fishes in the vicinity which respond to baits and lures are also caught.

5.4.3 Catches

No statistics are available exclusively for this species, but rarely have very heavy catches been recorded. Jones (1958) refers to landings of 4.15 Tonnes and 6.48 Tonnes of Auxis thynnoides at Calicut and Quilandy in southwest India on 17 and 24 October 1956. "It is not a common fish in the above area and it has been reported that such unusually large catches of this fish have never been recorded in the living memory of the fishermen in these parts." Catches on both occasions were by boat seines.

Table VIII

Size range of catches of Auxis thynnoides from Japanese waters
(after Yokota et al 1961)

Landed	TOTORO		TOSA-SHIMIZU							KUSHIMOTO									TANEGASHIMA			MAKURAZAKI
Year	1958		58	'59			'60			'58	'59		'60			'61			'59		'60	'61
Month	8-9		11	1	3	4	1	2	3	12	1	2	3	12	1	2	3	4	3-4	5-5	4	2-3
F. L. cm		F. L. cm																				
16	5	22	1											3								
7	3	3	1							1				1								
8	7	4	13						1	2			1									
9	13	5	39						0	6		2	4									
20	10	6	5		6				1	15		3	11	1								1
1	5	7	1	4	6		1		2	10	1	11	15	3	1							3
2	3	8		15	9		4	1	11	23	4	15	9	8	0		1	1				14
3	1	9		9	3	3	2	2	7	13	3	22	13	2	3		1	2		2		35
4		30		17	3	3	4	3	33	53	19	45	32	5	3	2	5	3		12		54
5		1		7	8	7	10	12	18	36	39	48	11	2	2		8	7		9		45
		2		5	1	5	4	9	14	12	53	17	4				9	5		6		21
		3		3	2	1	3	2	5	2	13	3	4				4		1	3		7
		4				1	2	1	8		4						1		3	1		2
		5							4										0	4		1
		6																	2	4		0
		7																	5	0		0
		8																	3	0		3
		9																	0	1		4
		40																	7	4		6
		1																	7	2		11
		2																	7	2	2	6
		3																	3	0	2	
		4																	0	1	16	
		5																	1	0	4	
		6																	0	2	0	
		7																	1		1	
		8																			2	
		9																			1	
		50																				

According to Kishinouye (1923) this species, the smallest among the tunas, is more abundant than Auxis thazard around Japan and grows to a weight of 640 g. In the Nankai region in Japan, frigate mackerel landings averaged 13, 275 Tonnes between 1951 and 1955: 14, 088 Tonnes in 1956 and 12, 738 Tonnes in 1957. This was about 13.5 percent, 14.3 percent and 10.5 percent respectively, of the total landings of neritic pelagic fishes during the corresponding period (Japanese Fisheries Agency 1961). Most of the above should be constituted by Auxis thynnoides, since this forms the dominant species in the catches there.

No other catch statistics are available, but the comparative catch size by region as given by Yokota et al (1961) is given below.

In the Philippines the fish in the commercial catches is reported to average 12 ounces (Warfel 1950).

- Utilization of catches

When obtained in stray numbers they are marketed in fresh condition in India, but not considered a prime fish. Large catches are salt-cured in the sun and most of the product is exported to Ceylon.

In Japan it is considered "very poor food-fish, consumed fresh or salted" (Kishinouye 1923).

Table IX

Comparative catch size of frigate mackerels by region
(after Yokota et al 1961)

Year	Hok-kaido	Pacific region			Japan Sea		East C. S.	Seto I. S.
		North	Middle	South	North	West		
1953	0.2	4.9	18.8	61.1	4.6	3.8	6.3	0.3
1954	0.2	1.6	17.1	65.0	7.4	2.9	5.2	0.2
1955	0.2	3.2	19.6	60.0	7.6	1.6	7.5	0.1
1956	0.1	6.6	29.2	54.2	3.2	2.4	3.9	0.1
1957	0.0	2.2	19.1	62.4	5.6	1.4	9.2	0.1
1958	0.2	1.9	14.2	71.4	2.0	2.0	7.8	0.2
1959	0.2	0.5	13.6	69.0	5.1	4.2	6.9	0.2

It would appear from this that the highest catches are from the South Pacific region, followed by the middle Pacific. These two regions account for 80 percent or more of the frigate mackerel catches. (See also Table VIII).