Species Synopsis No. 29
FAO Fisheries Biology Synopsis No. 72
(Distribution restricted)

FIb/S72
SAST - Tuna

SYNOPSIS OF BIOLOGICAL DATA ON DOUBLE-LINED MACKEREL
Grammatorcynus bicarinatus (Quoy and Gaimard) (INDO-PACIFIC)

Exposé synoptique sur la biologie du Grammatorcynus bicarinatus (Quoy et Gaimard) (Indo-Pacifique)

Sinopsis sobre la biología del Grammatorcynus bicarinatus (Quoy y Gaimard) (Indo-Pacifique)

Prepared by
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 Scombrinae
Genus Grammatorcynus Gill, 1862
Species Grammatorcynus bicarinatus (Quoy and Gaimard) 1824

1.1.2 Description

- Genus Grammatorcynus Gill, 1862

Type: Thynnus bilineatus Rüppell (=Thynnus bicarinatus Quoy and Gaimard); Type locality of T. bicarinatus - Sharks Bay, Western Australia.

(Syn. Nesogrammus Evermann and Seale 1907: type - Nesogrammus piersoni Evermann and Seale)

Body elongate, fusiform; size relatively small, generally not exceeding one meter; body covered with cycloid deciduous scales; cheeks scaled; corselet indistinct; lateral lines, two, first commencing from upper angle of operculum and running along upper half of body to almost commencement of caudal keel, while second branches off from former below vertical from third dorsal spine, descending to lower half of body to join first lateral line in a vertical below penultimate dorsal finlet; caudal peduncular keel on each side not very prominent and covered with a row of pored scales along ridge; pair of lateral keels at base of caudal much smaller; mouth relatively small, maxillary not surpassing vertical below middle of eye; teeth in jaws pointed, villiform on vomer, palatines and upper surface of broad tongue; two dorsal fins more or less contiguous; first dorsal with XI-XII strong spines; dorsal and anal finlets six or seven; pectorals relatively short; interpelvic process short, triangular, not reaching beyond half length of innermost pelvic fin ray (Fig. 1); caudal deeply forked; gill-rakers well developed; gill membranes free; opercle slightly notched at hind margin; vertebrae 31 (13+18).

- Grammatorcynus bicarinatus (Quoy and Gaimard) 1824

Body proportions expressed as percentages of fork length (method as given by Marr and Schaefer 1949) for specimens from the Andaman Sea and Western Marshall Island are given below.

Head 18.1 to 22.3; first predorsal distance 29.2 to 31.3; second predorsal distance 53.3 to 57.0; preanal distance 59.6 to 63.6; prepelvic distance 25.7 to 27.0; greatest depth of body 18.2 to 20.7; length of pectoral 11.7 to 14.3; length of second dorsal 8.1 to 11.4; length of anal 8.0 to 10.1 and diameter of iris 4.3 to 5.9 percent in fork length.

Fig. 2 shows the disposition of the different organs of the viscera in adult male and female.

The stomach is relatively small and heart-shaped. In normal position it is almost entirely covered by the two lateral lobes of the liver. Internally there are about nine irregular ridges at the oesophageal end which gradually peter out towards the middle of the stomach. The stomach region appears to be distensible (Fig. 1). The ridges again appear in the lower third of the stomach and converge prominently at the blind end. The pylorus, which is at the upper lateral side of the stomach, is thick-walled and has about five thick longitudinal folds extending into the short pyloric sac, from which the duodenal part of the intestine abruptly curves down along the postero-lateral side of the stomach, from the end of which the intestine runs as a straight narrow tube to the vent. The pyloric caecae are not so numerous as in some other scombroids (e.g. Thunnus), but are branched and in many clusters, mainly confined to between the upper one-third of the lateral lobes of the liver, covering only a little part of the surface of the stomach. The liver is tri-lobed, the middle lobe being greatly reduced in comparison to the large lateral lobe, of which the right one is the longest. The airbladder is

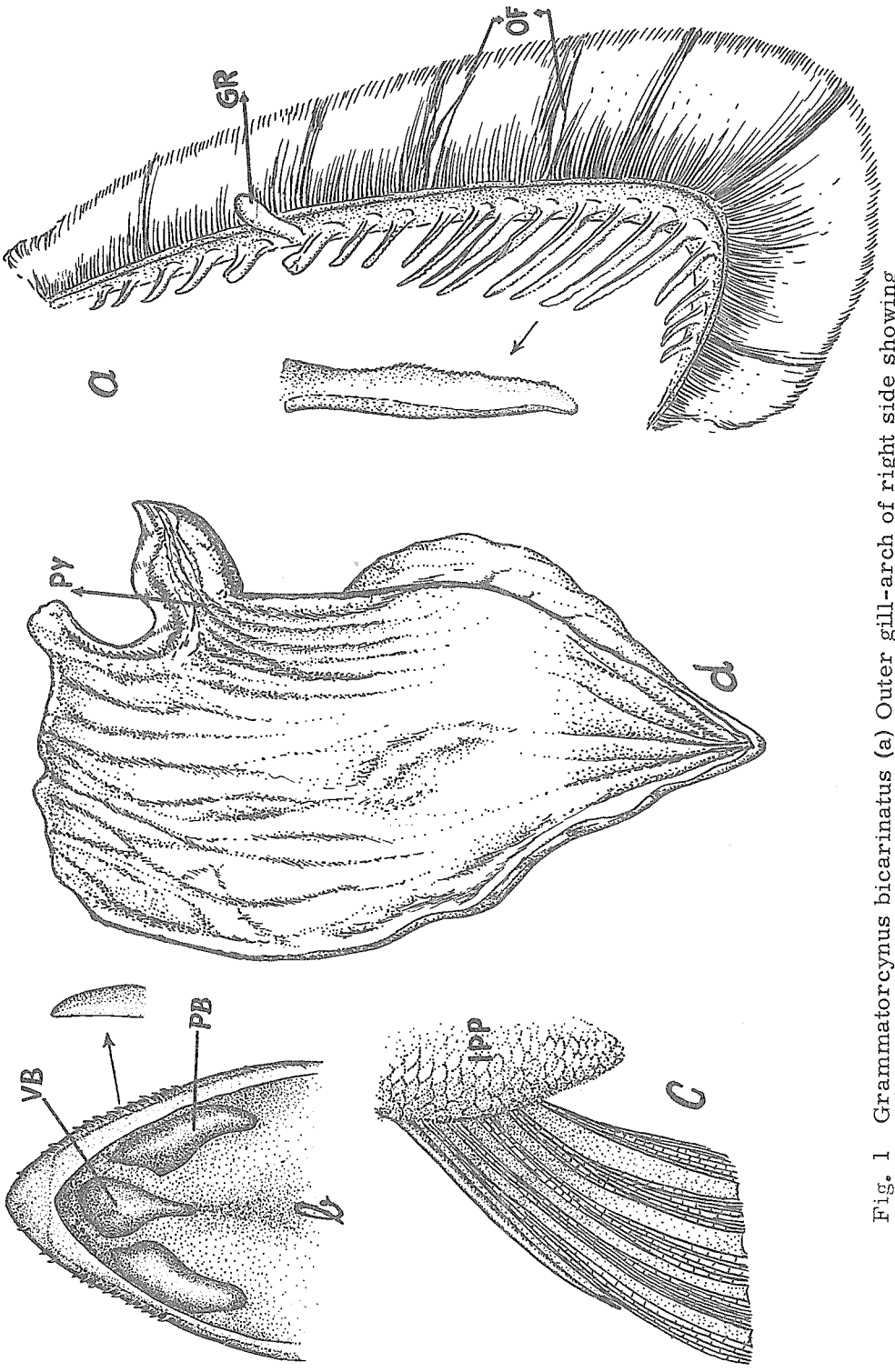

Fig. 1 Grammatorcynus bicarinatus (a) Outer gill-arch of right side showing nature of gill-rakers; (b) Upper jaws and roof of mouth showing conical teeth on jaw and villiforus teeth or vomer and palatines; (c) Inter-pelvic process and pelvic fin on one side; (d) Inner view of stomach showing nature of mucous folds.

GR - spatulate gill-raker; IPP - inter pelvic process; OF - "Ossified" gill-filaments; PB - palatine band of villiforus teeth; PY - pyloric opening of stomach; VB - vomerine band of villiforus teeth.

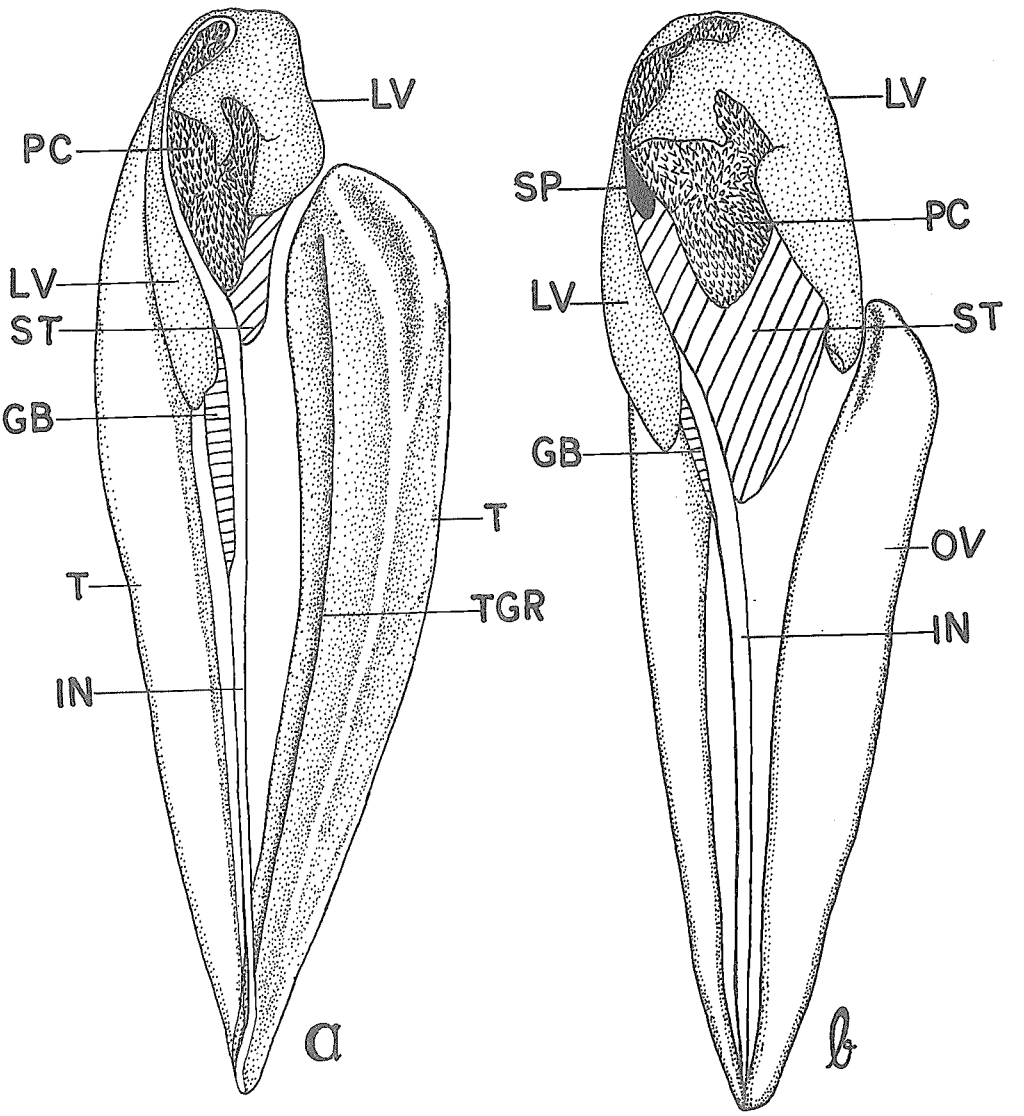

Fig. 2 Grammatorcynus bicarinatus - Disposition of the visceral organs in mature (a) male (431 mm) and (b) female (445 mm). Left testes and left ovary are slightly drawn towards one side.

GB - gall-bladder; IN - intestine; LV - liver; OV - ovary; PC - pyloric caeca; SP - spleen; ST - stomach; T - testes; TGR - longitudinal groove along inner side of testes.

ovate, thin walled and extends to about the posterior end of the visceral cavity.

Color in freshly-caught fish: The upper body, especially the dorsum of the head and the region above the upper lateral line, is bluish green with a metalic lustre. The belly and the underside of the body are silvery-white. The interspinous membranes of the first dorsal and the fins are tinged light blue, while the inner edge, the tips and the inner ray of the caudal fin are tinged yellowish. There is a patch of light red in the region of the chin, below the eye. The iris surrounding the pupil is conspicuously whitish.

On preservation in formalin, the head turns dark grey superiorly. The upper half of the body is greyish with a tinge of yellow. A slightly darker band, about one cm thick passes from the upper angle of the operculum along the mid-lateral side of the body to the base of the caudal. The central rays of the caudal beyond the hypural and the tip of the caudal are whitish. The lower half of the body, including the abdomen, is yellowish-white. The interspinous membrane of the first dorsal is greyish between the first four anterior spines and along the upper half of the remaining rays. The outer margins of the second dorsal and anal fins are tinged dark-greyish along their anterior margins. The pelvics are dusky, and so are the pectorals, which have a basal scaly whitish area. Scattered dark spots are present on the side of the body, especially along the upper half, and there are irregular rows of small greyish blotches on the abdomen between the pelvic and anal fins. Dorsal finlets are greyish basally and lighter along margin.

Scales are small. From the commencement of the lateral line at the upper angle of the operculum to the bifurcation of it there are about 21 to 28 perforated scales; upper lateral line with about 130 to 138 scales from bifurcation to peduncular keel; about 140 to 170 scales on lower lateral line from bifurcation to peduncular keel; about 23 scales present from where the lateral lines meet posteriorly, to hypural along edge of peduncular keel; 12 to 14 rows of scales are present between origin of the first dorsal and lateral line and about 13 rows between origin of the second dorsal and lateral line. The lateral lines are mostly separated below the 8th and 9th dorsal spines, separated by about 28 rows of scales at this point. However, abnormalities in the nature of the lateral line may be seen as shown (Fig. 3 a, b) for two specimens from the Andaman Sea.

Teeth on the upper and lower jaw are uniserially arranged, relatively small, conical, pointed or with slightly blunt tips, there being about 30 in the upper and about 40 in the lower jaw (Fig. 1b). Minute closely set villiform teeth are present in patches on the vomer, palatines and the exposed surface of the tongue.

The longest gill-raker is about as long as the longest gill-filament. The four rakers on the upper limb of the gill arch are shorter than the first seven on the lower limb. On the outer gill-arch of both sides, one or two of the rakers may often be spatulate and directed towards the base of the gill-filaments (Fig. 1a). Between the gill-filaments a few 'ossified' filaments faintly resembling rakers are present, the significance of which is not known.

For meristic characters see section 1.3.1.

1.2 Nomenclature

1.2.1 Valid scientific name

Grammatorcynus bicarinatus (Quoy and Gaimard).

1.2.2 Synonyms

Thynnus bicarinatus Quoy and Gaimard 1824.

Thynnus bilineatus Rüppell 1835; Günther 1860; Klunzinger 1871.

Grammatorcynus bilineatus Gill 1862; Kishinouye 1915, 1923; Hardenberg 1935.

Nesogrammus piersoni Evermann and Seale 1907.

Grammatorcynus bicarinatus McCulloch 1922; Herre 1953; Roxas and Martin 1937.

Grammatorcynus bicarinatus Umali 1950; Warfel 1950; Wade 1951; Sette 1952; Dung and Royce 1953; Ogilby and Marshall 1954; Roux-Estevi and Fourmanoir 1955; Munro 1958 a, b; Schultz 1960; Jones, Silas and Dawson, 1960.

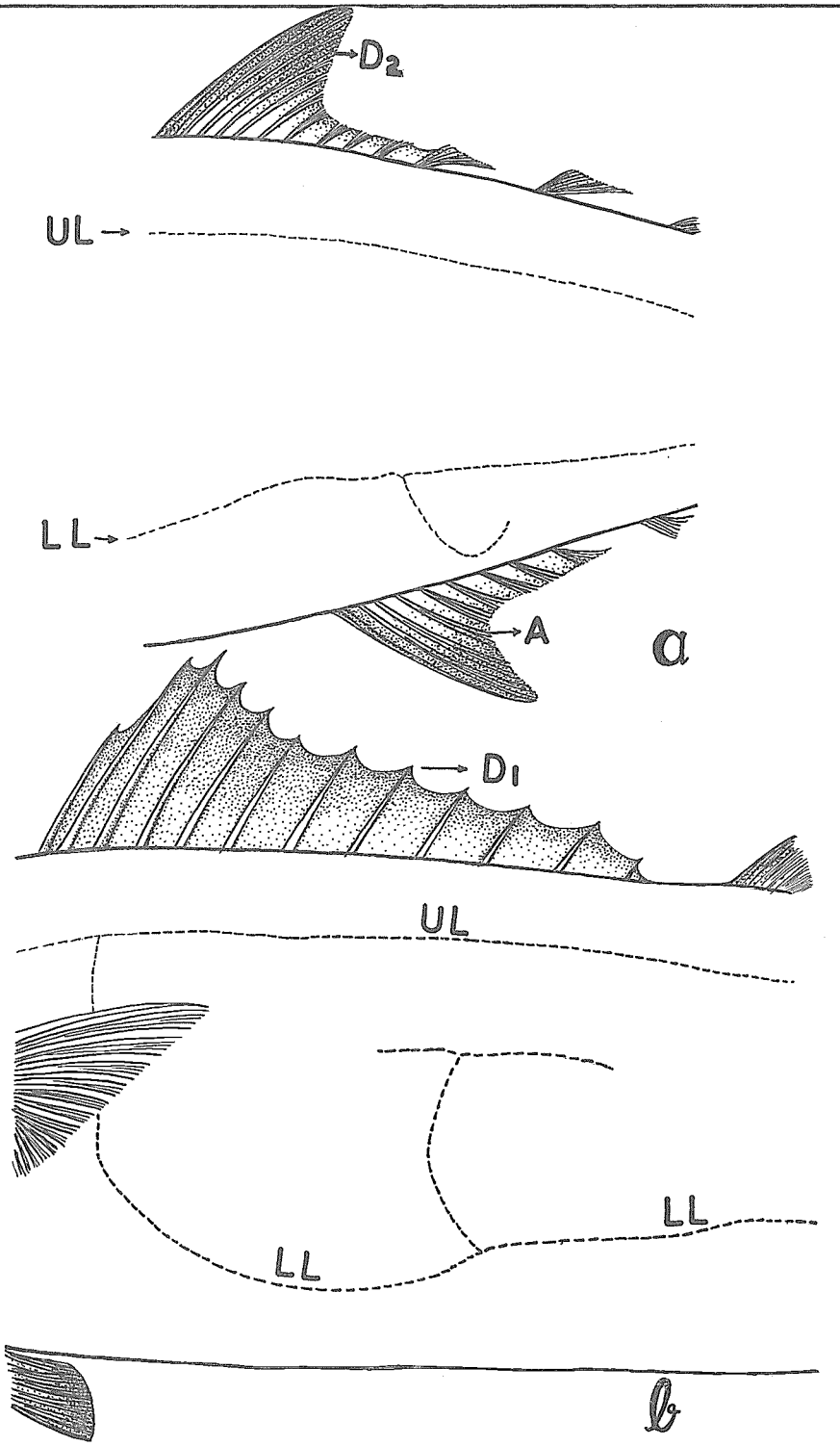

Fig. 3 Grammatorcynus bicarinatus - a and b showing abnormalities in the nature of the lateral line.

A - anal fin; D_1 - first dorsal; D_2 - second dorsal; LL - lower lateral line; UL - upper lateral line.

Grammatorcynus bicarinatus (in part) Fraser-Brunner 1950; de Beaufort 1951.

Nicholls and La Monte (1954) in describing a large Xenogramma from Peru, erroneously considered it to represent the adult of Grammatorcynus and this consequently resulted in Nesogrammus thompsoni Fowler from Hawaii, which is identical with Xenogramma carinatus Waite being treated as a synonymy of Grammatorcynus bicarinatus by Fraser-Brunner (1950), and de Beaufort (1951). Munro (1949) clarified the position relegating Xenogramma carinatus to the synonymy of the little known gempylid Lepidocybium flavobrunneum (Smith).

1.2.3 Standard common names, vernacular names

(See Table I below.)

1.3 General variability

1.3.1 Subspecific fragmentation (races, varieties, hybrids)

- Meristic counts

For 13 specimens ranging in length from 405 to 452 mm from the Andaman Sea the meristic counts are as shown in Table II.

Both Günther (1860) and Kluzinger (1871) have followed Rüppell's (1835) description of Thynnus bilineatus and it is therefore evident that the 17 branched anal rays given by Günther is an error, as the range for this character in the species does not exceed 12.

Wade's mention of 13 dorsal spines is interesting. Perhaps the last dorsal spine seen in the larvae is not exposed being completely covered by the skin in adults.

The range of meristic characters for the species may be stated as:

D_1 XI-XII; D_2+ finlets i-iii, 6-11 + 6-7;

P_1 i-ii, 21-24; P_2I, 5; A + finlets i-iii, 8-11 + 6-7;

Gill-rakers 19-21 (2-4 + 1 + 15-16);

Vertebrae 31 (13 + 18).

Morphometric data given by earlier authors hardly throws any light on variations of specific nature in this species as will be seen from the scant data available presented in Table IV.

- Varieties

There can be hardly any doubt that only a single species is represented in the Indo-Pacific. However, a comparison of the morphometric data for specimens from the Andaman Sea with that given by Dung and Royce (1953) for 15 specimens from Marshall Islands indicates certain trends of variations, as will be evident from Figs. 4, 5 and 6. The data suggest that, size for size, the first predorsal

Table I

Common and vernacular names

Country	Standard common name	Vernacular name
Australia	Double-lined mackerel	Shark mackerel (N. Queensland); Large-scaled tunny (Queensland); Salmon; Salmon mackerel (Moreton Bay); Large scaled tuna
India	Double-lined mackerel	
Japan		Kusarah (Ryukyu)

Table II

Meristic counts for specimens from Andaman Sea

Characters	Dorsal spines	Second dorsal rays (i-ii, 9-10=10-12)	Dorsal finlets	Pectoral rays	Anal rays (i-ii, 10-11=11-12)	Anal finlets	Gill rakers			Total
							Upper limb	Middle	Lower limb	
Range	11 12	10 11 12	6 6+1 1/ 7	23 24 25	11 12	6 6+1 1/ 7	2 3 4	1	15 16	19 20 21
Number of specimens	1 12	1 11 1	7 2 4	1 6 6	2 10	9 1 3	1 5 6	12	2 10	2 5 5
	N = 13	N = 13	N = 13	N = 13	N = 12	N = 13	N = 12	N = 12	N = 12	N = 12
	M = 11.92	M = 11	M = 6.46	M = 24.38	M = 11.83	M = 6.30	M = 3.41	-	M = 15.83	M = 20.25

1/ 6+1 indicates instances where the last ray of the second dorsal and anal fins would appear to be almost completely detached to form finlet. Hence for calculating mean (M) this is treated as 7.

Table III

Meristic counts in Grammatorcynus bicarinatus from various parts of the Indo-Pacific

Author	Locality	Vertebrae	D_1	$D_{2+Finlets}$	P_1	P_2	A+finlets	Gill rakers
Günther (1860)	Red Sea	-	XII	i,10+6	-	-	i,17+6	-
Klunzinger (1871)	Red Sea	-	XII	i,10+6	-	-	i,11+6	-
Kishinouye (1923)	Ryukyu Islands and Marshall Islands	31(13+18)	XII	?,9+7	-	-	?,9+7	5+16
Hardenberg (1935)	West Java Seas	-	XII	1,10+7	21	I,5	ii,9+7	-
Warfel (1950)	Philippines	-	XII	?, 9+7	-	-	?,10+7	5+16
Beaufort de (1951)	Java Seas	-	XI-XII	1,9-10+6-7	i,23-24	-	i,ii,11+6	-
Wade (1951)	S. E. Sulu Sea and W. Celebes Sea (Larvae)	31(13+18)	XIII	1,9-10+7	-	-	i,11-12+7	-
Schultz (1960)	Northern Marshall Islands	-	XII	iii,6-8+7	ii,23-24	I,5	iii,8-9+6	4+1+15
Silas (in this synopsis)	Port Blair, Andamans, Andaman Sea	31(13+18)	XI-XII	i,ii,9-11 (=10-12)+6-7		I,5	i-ii,10-11 (=11-12)+6-7	2-4+1+ 15-16

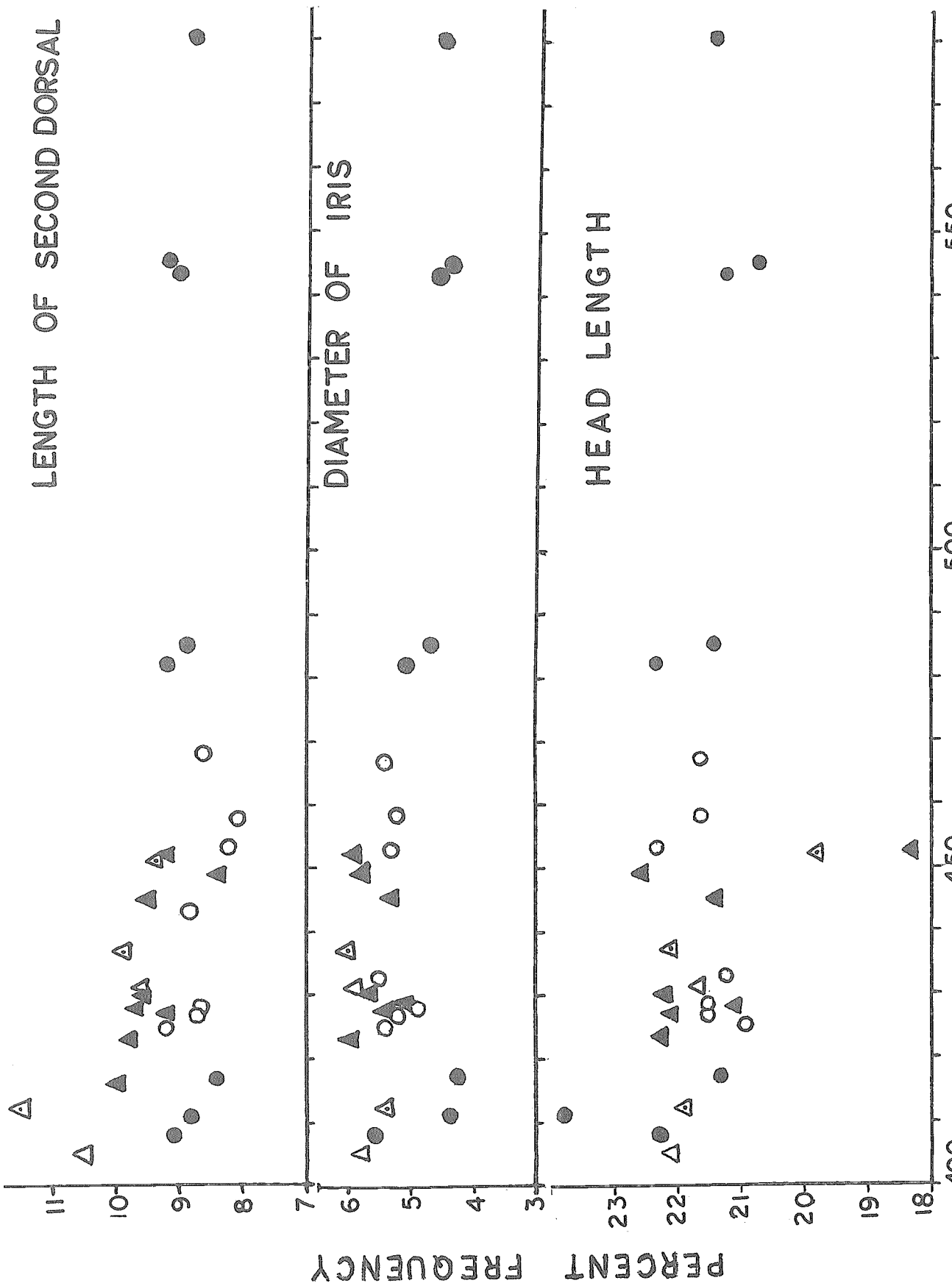

Fig. 4. Morphometric comparison of two samples of Grammatorcynus bicarinatus one from the Andaman Islands (open triangles male; black triangles female; triangles with dot in center - sex indeterminate) and the other from Western Marshall Islands (open circle male; black circles female).

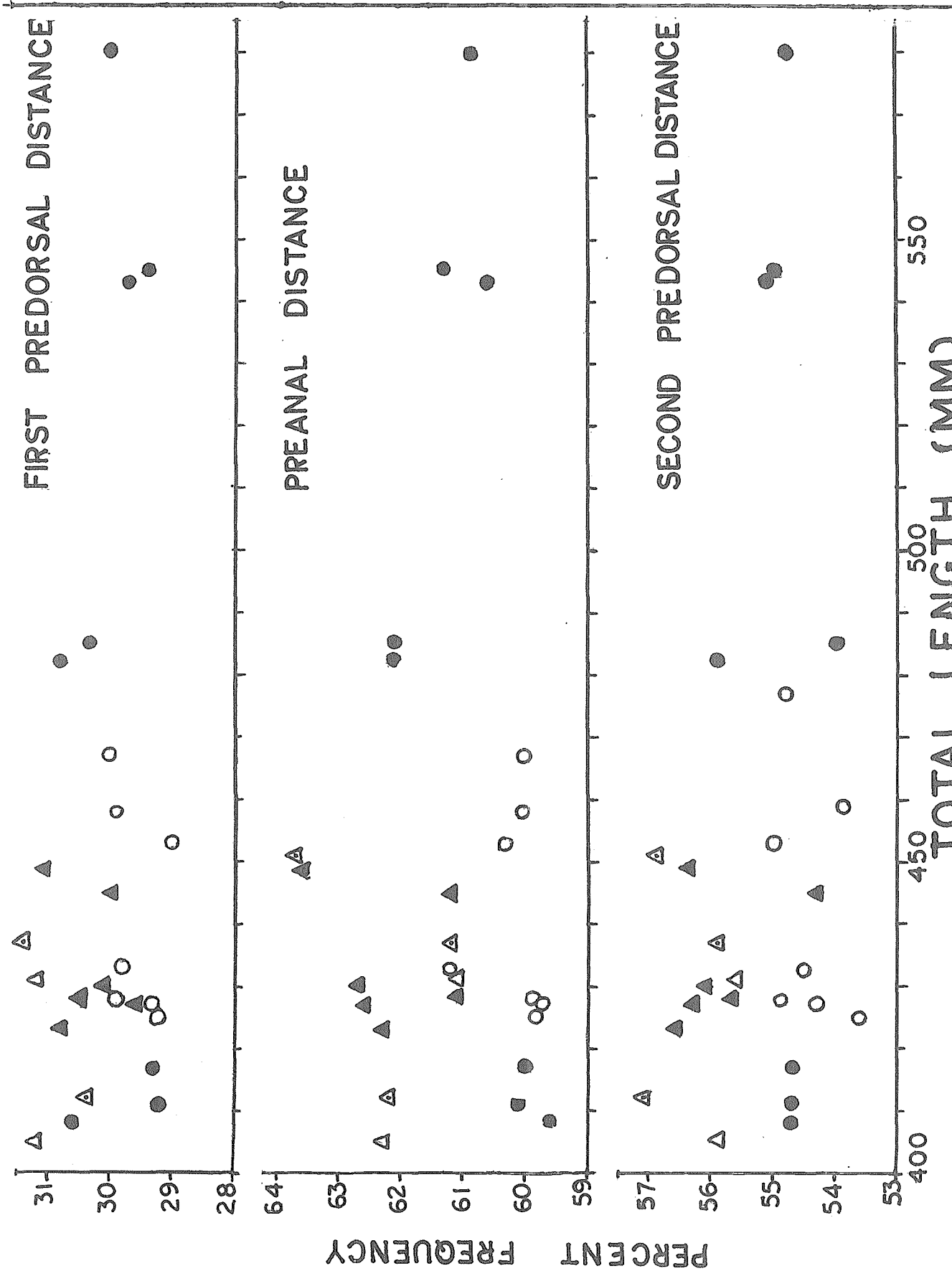

Fig. 5 Morphometric comparison of two samples of Grammatorcynus bicarinatus
For explanation see Fig. 4

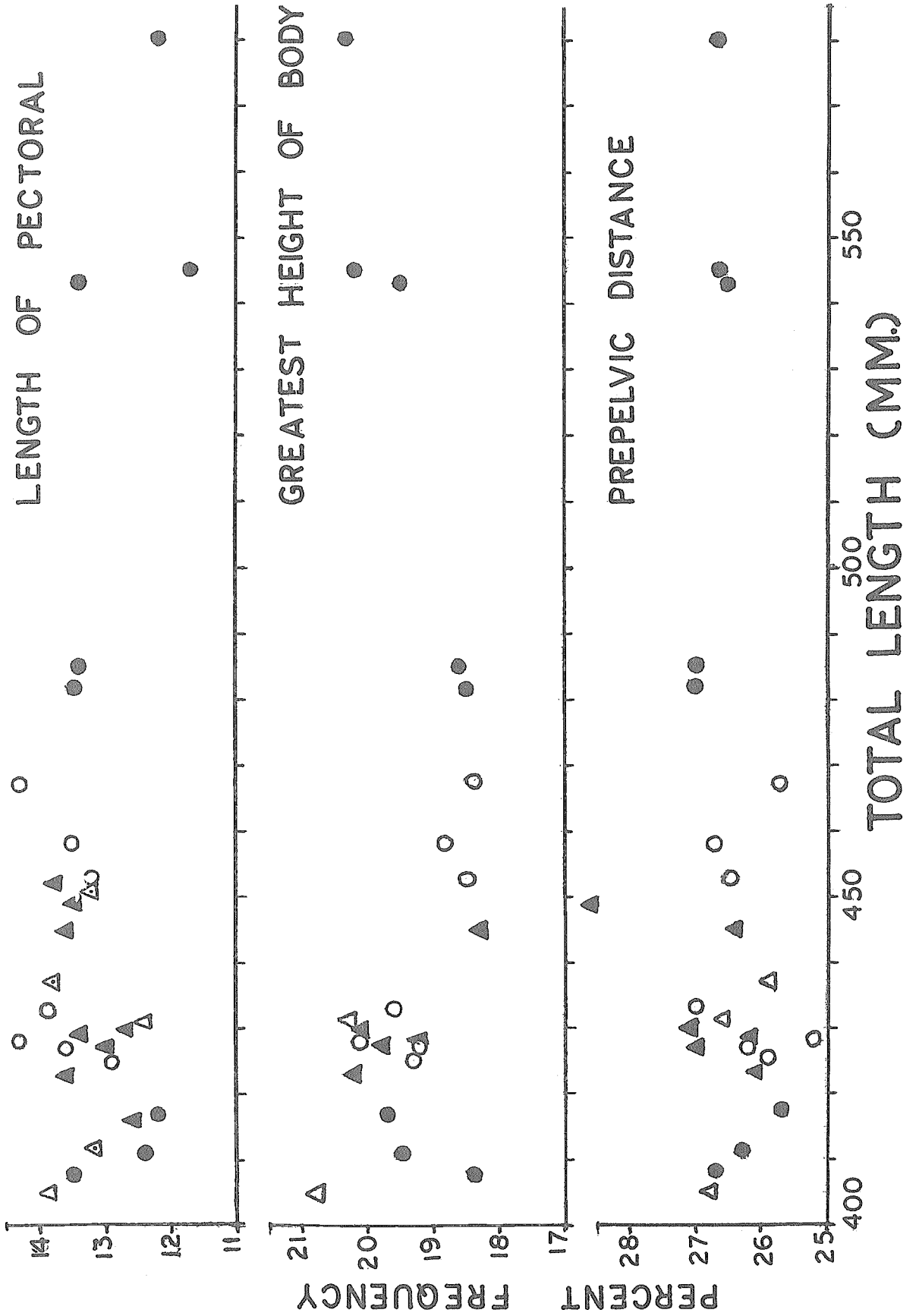

Fig. 6 Morphometric comparison of two samples of Grammatorcynus bicarinatus. For explanation see Fig. 4.

distance, second predorsal distance, preanal distance and length of second dorsal in total length are slightly greater for the specimens from the Andaman Sea. In characters such as head length; prepelvic distance; greatest height of body; length of pectoral fins and diameter of iris, there is considerable overlap. It is not known whether the trends of differences noted reflect the occurrence of distinct breeding populations in the two areas.

It has been found that in specimens from Andamans, irrespective of sex, there is some difference in the decurved position of the second lateral line. In some specimens (Fig. 7a) the pectoral fin hardly reaches the said lateral line, while in others (Fig. 3b) it overlaps the lateral line by about half its length. The latter condition is also seen in specimens from Australia (Fig. 7b).

Albinism, melanism or rubism have not been observed. Nor has natural hybridization ever been noted.

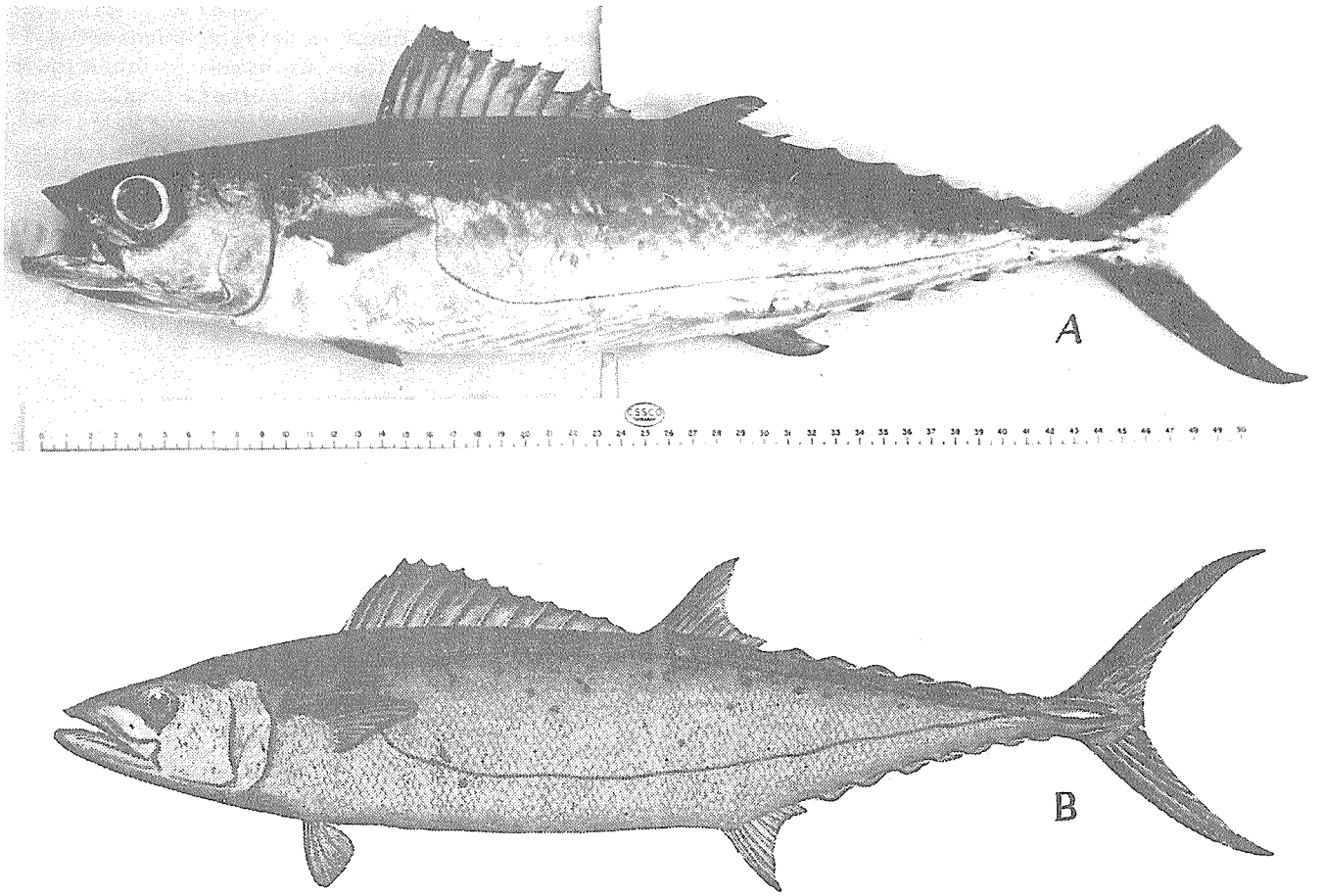

Fig. 7. Grammatorcynus bicarinatus:

A. Female 449 mm from Andamans;

B. Specimen from Eastern Australia (after Ogilby and Marshall 1954).

2 DISTRIBUTION

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

As shown in Fig. 8, the areas of occurrence are:

Red Sea; Andaman Sea; coasts of Australia; Java Sea; New Guinea; North Celebes; Philippines; Marshall Islands; and the Ryukyu Islands south of Japan.

According to this information, geographical distribution ranges from about 40°E to about 170°E, and from 30°N to 37°S. This area covers parts of the tropic and subtropic areas of the Indian and Pacific oceans.

2.2 Differential distribution

The presence of live coral reefs is very characteristic of most of the areas where the species occurs, suggesting its reef-dwelling habit.

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

Exact information is lacking. However, Wade's (1951) collection of larvae from North of Celebes (Sulu Sea) would indicate that it is one spawning area. Gonadial studies of this species from the Andaman Sea (Silas, in this synopsis) suggest that the reefs off central and southern Andamans could be another spawning area. (See section 3.1.7).

- Larval stages

The only available information is that given by Wade (1951) (Fig. 9a). The larvae can be easily distinguished from those of other tunas by the fewer vertebrae (31 instead of 38, or more in the other species) while this low vertebral count is also characteristic of the mackerel genus Rastrelliger, but the latter is typified by only five detached dorsal and anal finlets respectively instead of six or seven seen in Grammatorcynus.

Wade's collections of larval and post-larval G. bicarinatus are from the following areas (Table V).

The 8.5 mm larva (Fig. 9a) shows the following characteristic features: dorsal profile almost horizontal from occiput to posterior third of length; abdominal sac large, somewhat longer than deep; and opening at about mid-length of body; head relatively large, dorsal profile rounded; snout bluntly rounded, three-fourth diameter of eye; mouth slightly oblique, maxillary extending to vertical below middle of eye; eyes large, about 2.5 times in head length; eight or nine teeth on each side of both jaws, short, heavy, bluntly pointed spines, about seven along edge of preoperculum, that at the angle being the largest; an additional small spine present on the faintly-marked crest on surface of preoperculum; vertebrae

Table V
(after Wade, 1951)

Station	Date	Latitude	Longitude	Specimens	
				Number	Size (mm)
B-29	12 October 1947	6°57'N	120°15'E	1	8.6
B-339	1 August 1948	1°N	119°08'E	1	12.9
B-345	3 August 1948	4°05'N	120°59'E	1	8.5
G-65	3 May 1948	6°04.25'N	120°45.5'E	4	10-11.5
G-68	6 May 1948	6°43.6'N	119°12'E	1	17.5

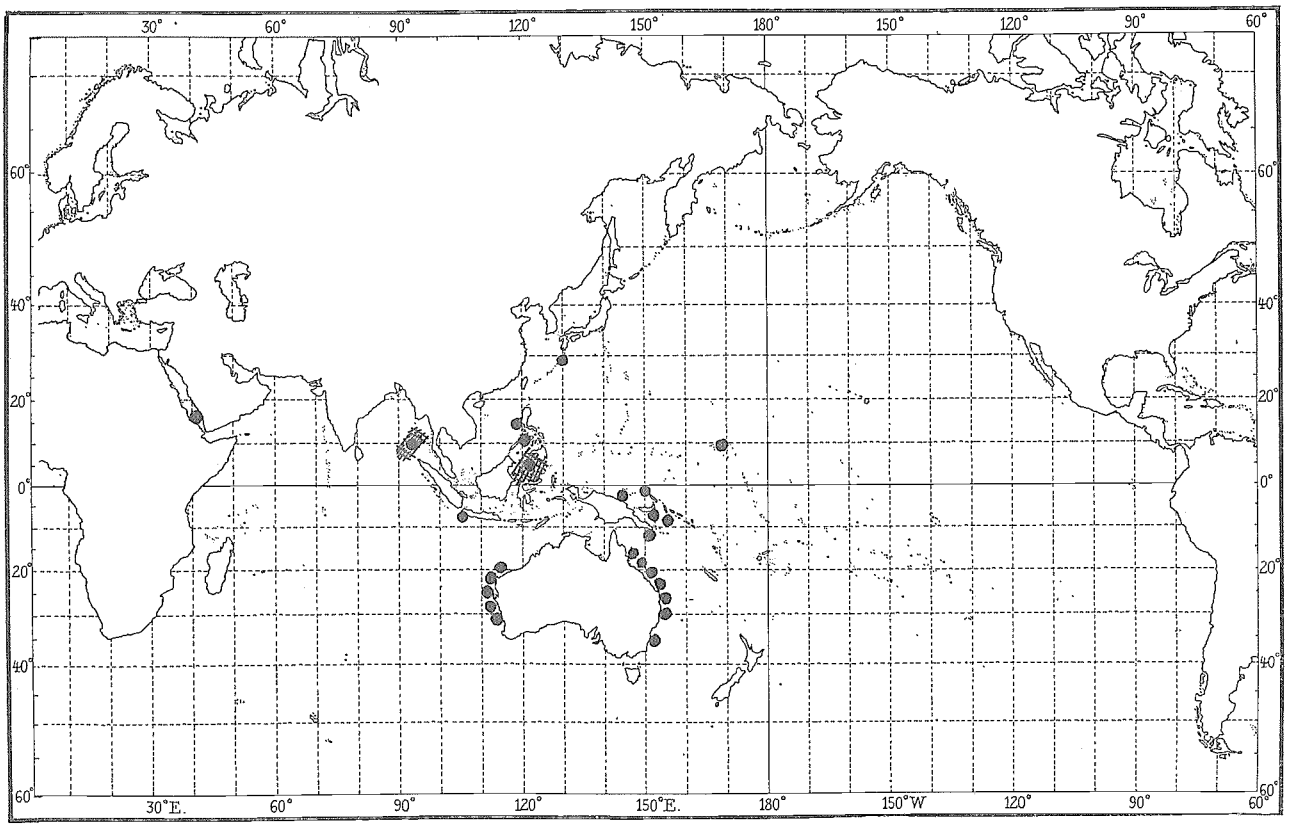

Fig. 8 Geographical distribution of Grammatorcynus bicarinatus in the Indo-Pacific. The black circles indicate locations of collection or reported occurrence; the two square patches indicate likely spawning areas.

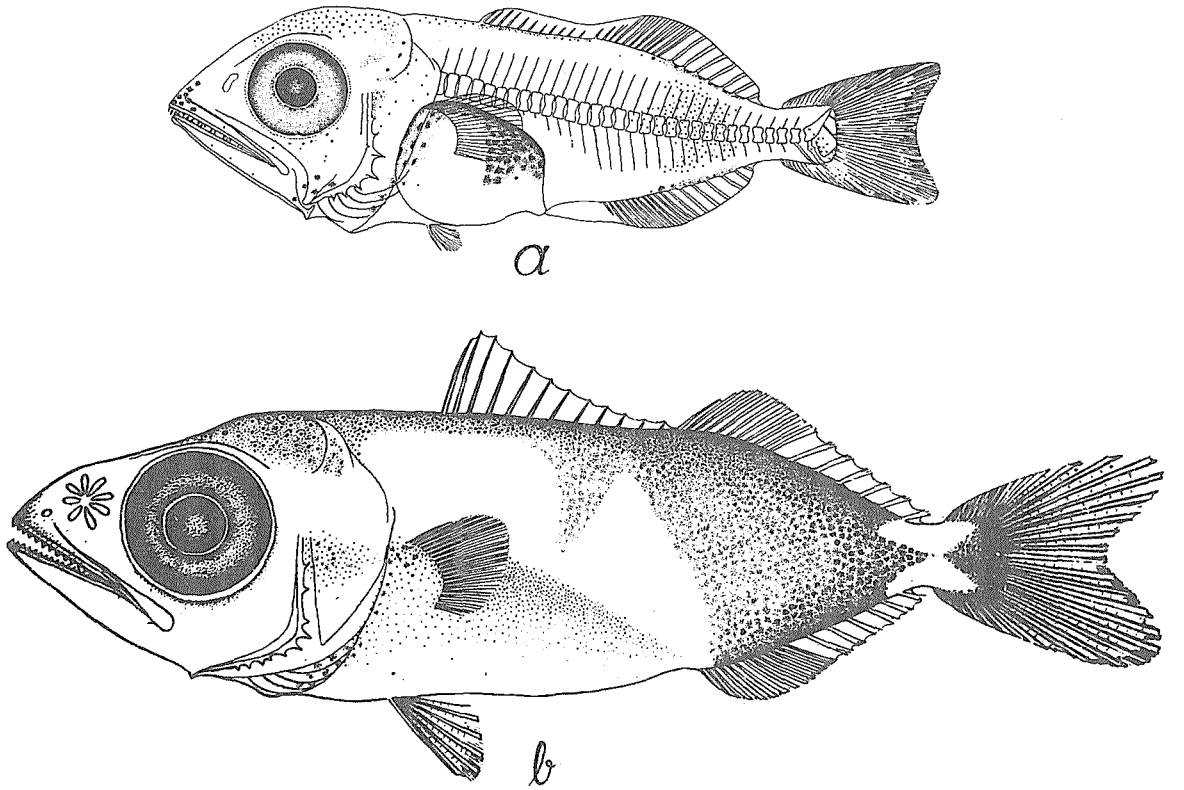

Fig. 9. Grammatorcynus bicarinatus:

a. Larvae 8.5 mm;

b. Post larva 17.5 mm from Sulu Sea of Philippines (after Wade 1951).

31 (13 + 18); first dorsal with 13 spines, short and weakly developed last spine "almost united with first ray of second dorsal". Second dorsal with 9 rays and 7 finlets; anal with 11 rays and 7 finlets (after Wade 1951).

"Preserved specimens are light cream in colour, with a scattered pattern of small black pigment spots. The dorsal aspect of the head from the nape anteriorly to above the eye is slightly pigmented with small black chromatophores; while laterally, below the nape and behind the eye, there are several scattered areas of similar pigment. There is scattered dark pigmentation on the tip of the snout and immediately posterior to the angle of the jaws. The base of the first dorsal and of both dorsal and anal finlets have a narrow line of dark pigment. A lightly pigmented area extends over the side of the body between the dorsal and anal finlets. There are a few scattered pigment spots at the base of the caudal fin. The abdominal sac is darkly and heavily pigmented dorsally and anteriorly, and the colour pattern also extends downward laterally on the posterior portion of the sac" (Wade 1951).

- Postlarvae and juveniles

To this may be referred the 17.5 mm specimen described and figured by Wade (1951) (Fig. 9b). At this stage, as seen in the accompanying figure, a characteristic color pattern is seen. The preopercular spines number 10 and are in the form of short blunt projections, 6 along the horizontal edge, one at the angle and 3 on the vertical edge. The second spine of the first dorsal is the longest. Wade has drawn attention to the error in regard to both dorsal and anal finlets in his drawing of the specimen - (reproduced here as Fig. 9b) - where the last ray of the second dorsal and anal represent the first dorsal and anal finlets respectively, the specimen having a second dorsal fin ray count of 10 rays plus 7 finlets and an anal count of 12 rays plus 7 finlets.

Most of the larvae and postlarvae were collected under a light at night.

- Adults

Capture of adult Grammatorcynus would indicate its occurrence close to reefs in waters 20 fathoms in depth. There is no regular fishing for this species anywhere in its distribution range, but stray catches are made at Port Blair, Andamans (January to March); Philippines (off Zamboanga, Mindanao and Jolo, Sulu Archipelago) and off New South Wales and Queensland, East Australia, while its occurrence in other areas is only sporadic or rare.

Off Port Blair, Andamans, the fish is caught using handlines with Sardinella spp. as chief bait.

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

No definite information except what has already been mentioned under section 2.2.1. Temperature would appear to be a factor limiting the occurrence of the species to areas where coral reefs occur. If so, its non-occurrence in the Central Pacific, in Hawaiian waters, is puzzling.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality (hermaphroditism, heterosexuality, intersexuality).

Grammatorcynus is heterosexual. No externally observable characters are known to distinguish males and females.

3.1.2 Maturity (age and size)

Preliminary observations made here on specimens from Andaman waters would indicate that the fish is mature at about 420 mm. A smaller mature female, 416 mm was found to contain transparent ova while a specimen 449 mm taken in February 1960 had recovering ovaries with a few unshed degenerate eggs of an earlier batch. Two males 405 and 431 mm had well developed testes (Fig. 2a). No information is available about the age of the investigated mature specimens.

3.1.3 Mating (monogamous, polygamous, promiscuous)

Should be polygamous. No information is available about prespawning or spawning behavior.

3.1.4 Fertilization (internal, external)

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

3.1.5 Fecundity

Estimates of the larger maturing ova with diameter of 0.4 mm and more for ovary weight of 34.40 g was found to be about 93, 100. The number of such maturing ova in the right and left lobes of the ovaries per gram was more or less the same.

3.1.6 Spawning

- Spawning season (beginning, end, peak)

The occurrence of mature ovaries with transparent eggs and spent and recovering ovaries from January to March in the Andaman Sea indicates that this period is one spawning period. The data are too meagre to comment on season, extent, peak spawning period, etc. Ova diameter frequency (Fig. 10) indicates two distinct size groups of maturing eggs in the recovering ovary; one with the mode of 9.43 mm and the other with the mode at 0.81 mm.

- Number of spawnings per year, frequency

No definite information for any area. However, from Fig. 10 for specimens from the Andaman Sea it would appear that spawning may be over an extended period and fractional spawning is suggested.

Collateral data from the occurrence of various sizes of larvae ranging between 8.5 mm and 17.5 mm during the months of May, August and October in the Sulu Sea (see section 2.2.1) (Wade 1951) could also suggest intermittent spawning over an extended period.

3.1.7 Spawning grounds

Unlike skipjack, yellowfin and the albacore, which may migrate over long distances, G. bicarinatus would appear to be more 'sedentary' in habit and as such it will not be surprising if eventually the fish is found to breed near the reefs where they occur. At present, information is available only for two areas: the Andaman Sea, where specimens with ripe ovaries and recovering ovaries have been collected, and the Sulu Sea south of the Philippines, where larvae and postlarvae have been collected (Fig. 8).

3.2 Larval history

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

Only information is that given by Wade (1951). The smallest larva described is 8.5 mm (Fig. 9a) and the largest postlarva 17.5 mm (Fig. 9b).

3.3 Adult history

3.3.6 Greatest size

By far the largest size of G. bicarinatus on record is that from Java Sea given by de Beaufort (1951) as 963 mm. Ogilby and Marshall (1954) remark that in Queensland waters the species attains about 36 inches (914 mm), while Whitley (1962) remarks that it may attain

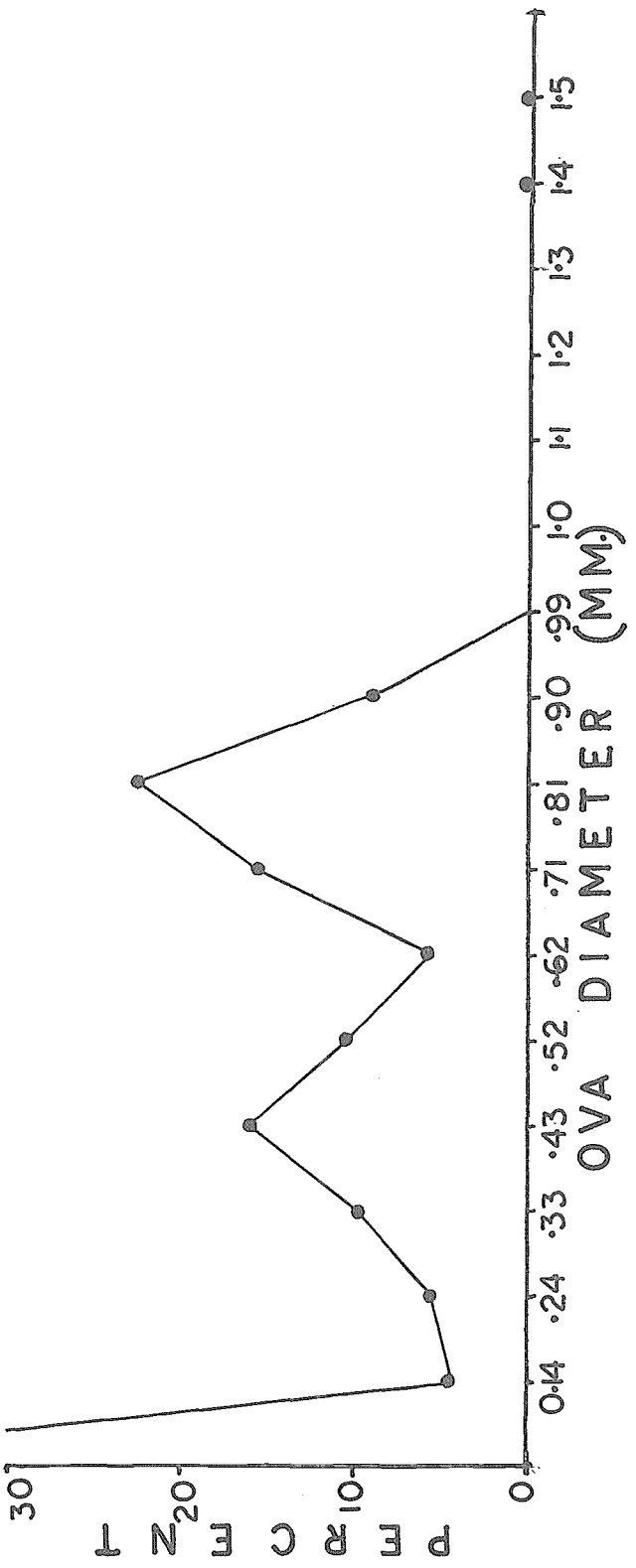

Fig. 10 Frequency polygon of the diameter of the eggs in the ovary of a specimen of Grammatorcynus bicarinatus, 449 mm caught off Port Blair, Andamans, early in March 1960.

48 inches (about 122 cm) and a weight of 25 lb (11.3 kg) in Australian waters. Hardenberg (1935) refers to a 500 mm specimen caught from the reefs off west Java, while Kishinouye (1926) remarks that most specimens caught at Marshall Islands and Ryukyu Islands are about 300 mm in total length. Dung and Royce (1953) have given morphometric data for 8 females ranging from 408 to 580 mm and 7 males ranging from 425 to 467 mm from Western Marshall Islands. Klunzinger (1871) refers to this species attaining about 500 mm in the Red Sea, while the specimens from Port Blair, Andamans are from 405 to 452 mm. Apparently the species may be expected to attain slightly over 100 cm but all indications are that breeding size is attained at much less than half this length, and generally fish between 300 and 600 mm are taken.

3.3.4 Competitors

Observations made at Port Blair, Andamans indicate that among predaceous reef-dwelling species, most prominently Gymnosarda unicolor and Sphyraena spp. are taken from the same habitat as G. bicarinatus. But no information is available about the nature of competition, if any.

3.4 Nutrition and growth

3.4.1 Feeding (time, place, manner, season)

No precise information. However, for food of fish taken on hand lines see section 3.4.2.

3.4.2 Food (type, volume)

Results of examinations of the food of G. bicarinatus caught at Port Blair, Andamans in February 1960 and February to March 1961 shows that crustacean (stomatopod larvae), Squilla sp; Megalopa; Peneid larvae and Mysis, form the most important food of the species while fishes come second in importance. Strangely, no remains of squids of any other organisms were present as food. Fishes in the food have been identified as Sardinella sp., Thrissocles sp., Sphyraena sp., and Balistes sp. The percentage composition of the food items both volume-wise as well as number-wise are given in Table VI.

3.5 Behavior

3.5.2 Schooling

There is nowhere any reference to G. bicarinatus having been encountered in large schools. Its habit may be more akin to that of the dog-tooth tuna Gymnosarda unicolor, which may be seen in small packs, close to reefs, or even solitary.

3.5.3 Reproductive habits

See sections 3.1.5, 3.1.6. It is probable that the spawning period may be an extended one when eggs may be shed in more than one batch. There is no information as to whether there could be two spawning seasons in the same year.

Table VI

Dietary items of Grammatorcynus bicarinatus from Andamans

Food items	Percentage composition by volume	Percentage composition by numbers 1/
Fish	32.7	6.6
Crustacea		
Stomatopoda (Stomatopod larvae, Squilla, etc)	13.0	21.8
Penaeid larvae, Mysis etc.	3.5	30.6
Megalopa	3.0	40.9
Semidigested remains of crustacea	47.8	-

1/ Unrecognisable semidigested remains of crustacea have not been taken into account

4 POPULATION

4.1 Structure

4.1.1 Sex ratio

No definite information. Of 15 specimens listed by Dung and Royce (1953) from Western Marshall Island, 8 were females and 7 males. In 13 specimens the author examined from Andamans 8 were females, 2 males, while the viscera of 3 were too badly damaged to aid in sex determination.

5 EXPLOITATION

5.1 Fishing equipment

5.1.1 Fishing gear

Adult G. bicarinatus are caught off Port Blair, Andamans using hand lines in waters around 20 fathoms or more deep. There is no information about capture methods for other areas.

5.2 Fishing areas

There are no areas in which a specific fishery for this species exists except perhaps off north Queensland, Australia from where "it is received into Brisbane market with the mackerel catch and during the height of the season sometimes reaches as high as ten percent of the mackerel catch landed there" (Ogilby and Marshall 1954).

5.2.1 General geographical distribution

See section 2.1

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

See section 2.1

5.3 Fishing seasons

5.3.1 General pattern of fishing season

In Andamans the fish is caught mainly from January to March. Whitley (1962) remarks that "the fish has been found in February and June in New South Wales, and in winter months in Queensland".