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ON

LIVING RESOURCES *of* THE SEAS AROUND INDIA

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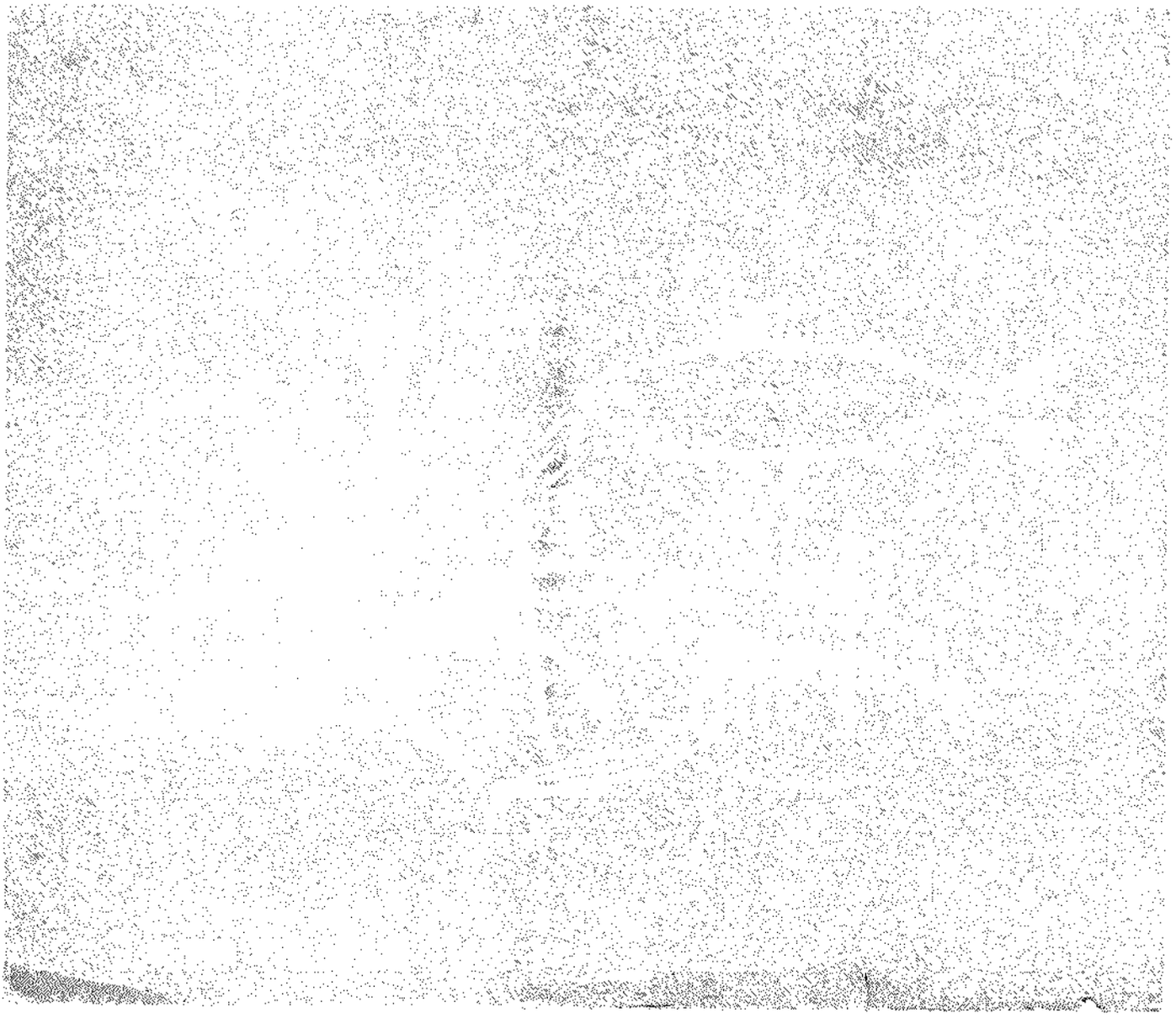

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DEEP-SEA PRAWN RESOURCES OFF THE SOUTH-WEST COAST OF INDIA

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ABSTRACT

Information on the fishery resources of the deeper waters, beyond 100 m off the Indian coast is scanty. The exploratory trawling operations carried out by the Indo-Norwegian Project vessels from 1964 onwards in depths ranging from 120 m to 430 m, covering over 5,000 square kilometres, along the south-west coast of India showed the presence of considerable quantities of deep-sea prawns along with lobsters, crabs and fishes. The analysis of the catch data of over 250 hauls made from these depths has enabled to assess the productivity of these grounds in respect of the newly found prawn resources. Although more than a dozen species of prawns were found in the catches, only seven of them, viz., *Aristeus semidentatus, Heterocarpus wood-masoni, H. gibbosus, Parapandalus spinipes, Plesionika martia, P. ensis* and *Penaeopsis rectacuta* were present in such large quantities as to form sizable portions of the catch. The analysis also indicated that the southern areas (off Quilon and Alleppey) are more productive and that the resources are more concentrated in the depth range 300–375 m.

INTRODUCTION

RECORDS of existence of several species of deep-sea prawns in the Indian seas were available from as early as late 19th century onwards mainly from the surveys of the Royal Indian Marine Ship "Investigator" during the years 1885–1900. The results of the expeditions in the Indian Ocean region in subsequent years have augmented our knowledge about the deep-sea species of prawns. But till now, this knowledge was restricted to the records of the occurrence of some species or other and their systematics only and did not provide any indication regarding the possible commercial concentration of these in any given locality. The rapid development that has taken place in recent years in the prawn processing and export industry of India has not only intensified the exploitation of the inshore prawn resources but also prompted the search for new resources. The occasional hauls made by the research vessels *KALAVA, CONCH* and *VARUNA* from the deeper waters off the south-west coast of India have also showed occurrence of some prawns and lobsters on the continental slope. John and Kurian (1959), Kurian (1964), Mohamed (1967) and George (1967) have reported the possibility of commercial exploitation of some of these deep-sea forms. A concerted effort in finding out the extent of such resources can be said to have commenced only from 1967 when some newly acquired trawlers of the Indo-Norwegian Project started exploratory trawling and charting of the deep-sea grounds lying off the Kerala coast. The present report attempts to examine the extent of these new found resources from the stand point of commercial exploitation based on the operations of the trawlers *KLAUS SUNNANA, VELAMEEN* and *TUNA* from October 1967 to February 1968 and on the occasional trawls of *R. V. VARUNA* from 1965 to 1968 conducted at varying depths beyond 120 metres.

The fishing operations of these vessels being of exploratory nature were not rigorously planned, with the result, the effort spent was not uniformly distributed in all the areas. Nevertheless, the analysis of the results of the operations carried out provides fairly reliable picture of the nature of distribution of the prawn resources in this virgin area.

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Characteristics of the Trawling Grounds

The areas covered by these operations lie between latitudes 8° 00′ N and 14° 00′ N off south-west coast of India and between depths 120 m to 430 m (Fig. 1). These areas are characterised by

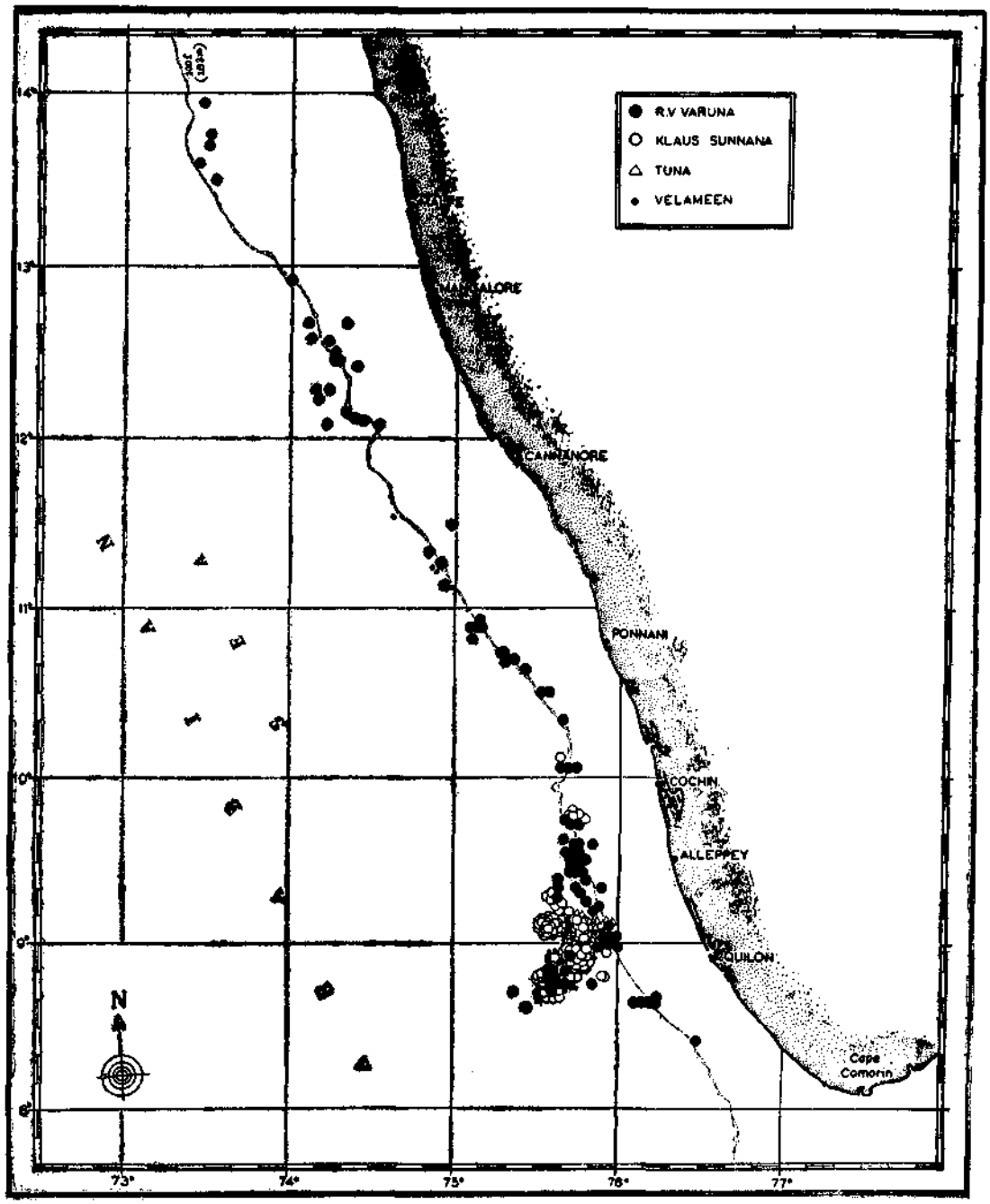

Fig. 1. Area of operation of exploratory trawlers.

certain physical features which are significantly different from the conventional trawling grounds of the inshore regions. Although it is generally considered that the continental shelf here extends upto 100 fathoms (183 m) the downward deflection of the bottom contour of these areas actually commences from about 65 fathoms (120 m). The bottom contour of the continental slope is relatively steep in the upper portion of the bathyal region up to a depth of about 300 m and the bottom here is generally hard with occasional rocky and coral patches. After 300 m the contour is less steep and the bottom more soft. In areas between latitudes 8° N and 9° N the steepness of the bottom slope is interrupted by a flat area between depths 275 m and 375 m. This flat area which is now being referred to as "Quilon Bank" is seen to be most suitable for trawling (Fig. 2). Samples of the bottom deposits incidentally obtained in the trawls were frequently collected and examination of this material showed that the softness of the ground is due to the green mud composed exclusively of foraminiferan shells. Not even a single sand particle could be seen among this material when examined under microscope. Hydrographic conditions of the waters of the

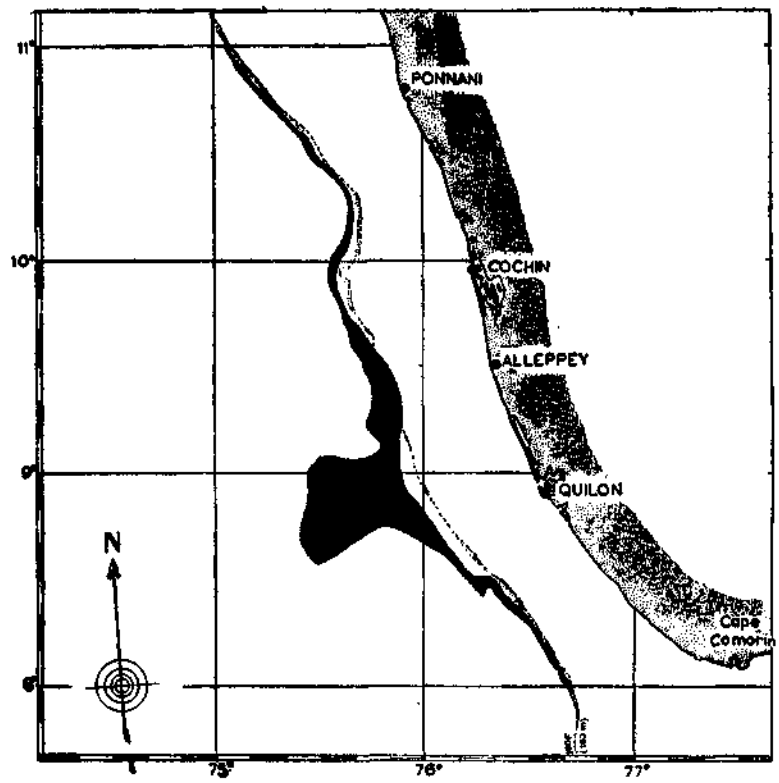

FIG. 2. 'Quilon Bank' and adjacent areas rich in deep-sea prawns.

TABLE I

Hydrographic conditions of the waters of the deep water trawling grounds off Quilon

Depth m	Range of bottom temperature °C	Range of dissolved Oxygen ml/l	Range of salinity ‰
200	13·73–15·43	0·72–1·35	34·75–35·92
300	11·71–12·89	0·65–1·05	35·08–35·30
400	10·94–10·97	0·56–0·97	34·87–34·99

trawling grounds are summarised in Table I. The striking characteristics of this aphotic zone where the prawns abound, therefore, appears to be the relatively cooler waters with very low Oxygen content. Changes in these characters as well as the pressure variation associated with the depth of water would have been the reason for the death of all the animals hauled up. Generally, all the animals hauled up reached the surface in dead or dying condition.

Operations and the Catches

The exploratory trawlers *KLAUS SUNNANA*, *TUNA* and *VELAMEEN* made 190 hauls in 22 cruises at depths ranging from 200 to 395 m mostly off Quilon and Alleppey and the research vessel *R. V. VARUNA* made 96 hauls from depth varying between 124 and 430 m. Details of these operations are given in Table II.

Table II

Details of Operations

Name of vessel and horse-power	Length of head-rope of shrimp trawl used in m	No. of hauls taken	Depth operated in m	Period of operation
R. V. VARUNA (400 h.p.) ..	16	96	124–430	May 1965 to July 1968
KLAUS SUNNANA (220 h.p.) ..	45	128	200–395	October 1967 to February 1968
TUNA (480 h.p.) ..	35	24	do	do
VELAMEEN (480 h.p.) ..	47	38	do	do

Of the 286 hauls, 37 contained no catch whatsoever and in the remaining 249 hauls catch varied from 1 kg to 2,510 kg per haul of approximately one hour duration and amounted to a total yield of 63,928 kg including fish, prawns, lobsters and other crustaceans. The overall catch-rate worked out to 231·62 kg/hr and that of prawns alone to 89·5 kg/hr. The 24,700 kg of prawns landed formed a little over 38% of the total catch. Prawns were obtained in 207 hauls and their catch varied from ½ kg to 930 kg per haul of one hour duration. The percentage composition of the various items in the overall catch is shown in Fig. 3.

The common species of prawns which constituted the deep-sea catches were *Heterocarpus woodmasoni*, *H. gibbosus*, *Parapandalus spinipes*, *Plesionika martia*, *P. ensis*, *Metapenaeopsis andamanensis*, *Penaeopsis rectacuta*, *Aristeus semidentatus*, *Parapenaeus investigatoris*, *Hymenopenaeus aequalis*, *Solenocera hextii* and *Oplophorus gracilirostris*. Among these the first eight species were found to occur in considerable quantities. In addition to these several rare species of prawns and other decapods were also encountered in the catches occasionally. A comprehensive list of the various species of prawns and other decapod crustaceans observed in these exploratory catches is given in Table III, indicating their relative abundance, depth-range of common occurrence and probable economic importance. While one or the other species of prawns showed concentration in a particular area the catches were always of heterogeneous nature and contained several species in varying proportions.

Prawns were, by no means, the only catch obtained in these operations. As already stated, fishes accounted for more than half the landed weight of the catches. The common species of fishes among the by-catches were *Chlorophthalmus agassizi*, *C. bicornis*, *Cubiceps natalensis*, *Epinnula*

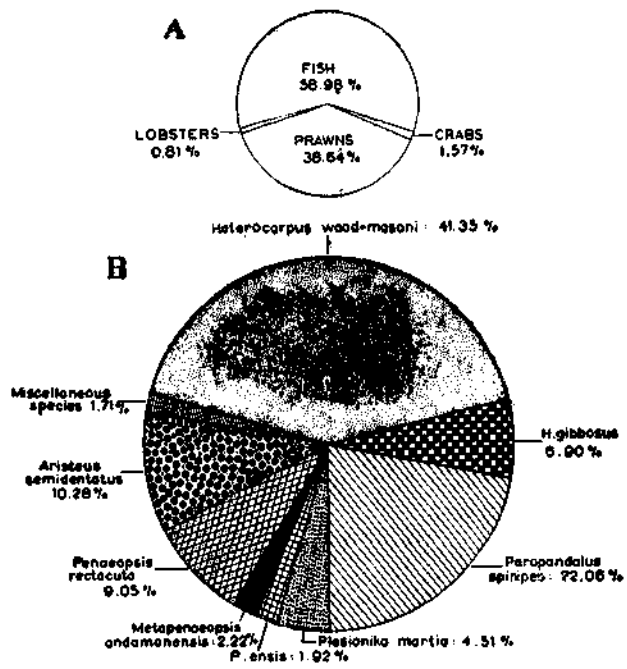

FIG. 3. Species composition: A, Over all catch; B, Prawn catch.

orientalis, *Neoscopeleus macrolepidotus*, *Neobythites steaticus*, *Synagrops japonicus*, *Polymixia nobilis* and *Halieutea stellata*. Tholasilingam *et al.* (1964) have given a detailed list of the bathypelagic fishes occurring in these areas. Although these fishes accounted for the bulk of the catches they were seldom retained on board as they were of very little value in relation to the prawns caught. The Indian deep-sea spiny lobster *Puerulus sewelli* and the crabs *Charybdis* (*Goniohellenus*) *edwardsi* and *Thelxiope megalops* were the other common items in the by-catches.

AREA-WISE CATCH DISTRIBUTION

The analysis of the catch data has been carried out separately for the following depth ranges in areas demarkated by each of the latitudes:

Depth zone 1 .. 101–150 m
Depth zone 2 .. 151–200 m
Depth zone 3 .. 201–250 m
Depth zone 4 .. 251–300 m
Depth zone 5 .. 301–350 m
Depth zone 6 .. 351–400 m
Depth zone 7 .. 401–450 m

8° *N lat. area* (*Table IV*).—78 hauls involving an effort of 87·64 hours of trawling were taken from this area and the prawn catch landed amounted to 5,977 kg forming 31·2% of the total yield form the area. The average catch-rate worked out to 68·2 kg/hr. *Heterocarpus wood-masoni*

TABLE III

List of decapods observed in the deep-sea catches

Name of species	Abundance	Importance	Depth of common occurrence m
PRAWNS			
Solenocera hextii Wood-Mason	*c*	†	250–400
Hymenopenaeus aequalis (Bate)	*c*	‡	310–375
Aristeus semidentatus (Bate)	*b*	†	300–430
A. alcocki Ramadan	*d*	§	338
Aristaeomorpha wood-masoni Calman	*c*	†	320–375
Parapenaeus investigatoris Alcock and Anderson	*c*	‡	275–350
Penaeopsis rectacuta (Bate)	*b*	†	175–300
Metapenaeopsis andamanensis (Wood-Mason)	*b*	†	150–325
Pasiphaea alcocki Wood-Mason	*d*	§	338
Oplophorus gracilirostris A.M.Edw.	*c*	‡	320–375
Acanthephyra sanguinea Wood-Mason	*d*	§	330–375
Plesionika martia (A.M.Edw.)	*b*	†	300–375
P. ensis (A.M.Edw.)	*b*	†	300–375
P. alcocki (A.R.S. Anderson)	*d*	§	300–375
Parapandalus spinipes (Bate)	*a*	†	300–375
Heterocarpus wood-masoni Alcock	*a*	†	300–375
H. gibbosus Bate	*b*	†	300–375
**Pontocaris andamanensis* (Wood-Mason)	*d*	§	300–375
LOBSTERS			
Puerulus sewelli Ramadan	*a*	†	170–200
Palinustus mossambicus Barnard	*d*	‡	250–275
Scyllarus batei batei Holthuis	*d*	§	240–320
S. rubens (Alcock and Anderson)	*d*	§	183
OTHER DECAPODS			
Polycheles typhlops Heller	*d*	§	300–375
Nephropsis carpenteri Wood-Mason	*d*	§	330–375
Eumunida funambulus Gorden	*d*	§	330–375
Munida andamanica Alcock	*d*	§	330–375
**Munida squamosa* var. *prolixa* Alcock	*d*	§	330–375
Munidopsis cylindrophthalmus Alcock	*c*	§	330–375
**M. scobina* Alcock	*d*	§	350–415
**Pleistacantha moseley* (Miers)	*d*	§	338–360
Charibdis (*Goniohellenus*) *edwardsi* Leen and Buitendijk	*b*	‡	200–275
Calappa japonica Ortmann	*c*	§	300–375
Thelxiope megalops (Alcock)	*b*	‡	300–375

* New record to the region; *a*: abundant; *b*: very common; *c*: common; *d*: rare.
† of commercial value; ‡ of minor commercial value; § of academic value only.

accounted for more than half the quantity of prawns landed from this area and its catch rate amounted to 32·25 kg/hr. While most of the species of deep-water prawns of common occurrence (as shown in Table III) have been obtained from this area, *Parapandalus spinipes* (19·12 kg/hr), *Penaeopsis rectacuta* (7·73 kg/hr), *Plesionika martia* (4·12 kg/hr), *P. ensis* (2·08 kg/hr) and *Metapenaeopsis andamanensis* were the other species which contributed to significant portions of the catch.

TABLE IV

Depth-wise catch distribution in areas between Latitudes 08° 00′ N and 09° 00′ N

Depth Zone	1	2	3	4	5	6	7
No. of hauls taken	3	1	1	16	42	15	No operation
Effort in trawling hours	3·67	0·67	0·67	19·90	46·65	16·08	
Catch returns in kg	1550	200	60	2737	8846	5779	
Prawns in kg	2·00	..	..	1095·00	3059·71	1820·00	
% of prawns in total catch	0·13	..	..	40·01	34·59	31·49	
Catch-rate of prawns in kg/hr.	0·54	..	..	55·02	65·59	113·18	
Species composition of prawns	Catch by weight in kg (Catch rate in kg/hr)						
Heterocarpus wood-masoni	..	..	..	405·15 (20·36)	1494·67 (32·04)	925·65 (57·56)	
H. gibbosus	..	..	..	5·37 (0·27)	27·54 (0·59)	7·46 (0·46)	
Parapandalus spinipes	1·20 (0·33)	..	..	239·59 (12·04)	807·76 (17·32)	627·17 (39·00)	
Plesionika martia	0·60 (0·16)	..	..	35·26 (1·77)	205·61 (4·41)	119·57 (7·44)	
P. ensis	..	..	..	15·99 (0·80)	107·70 (2·31)	58·97 (3·67)	
Oplophorus gracilirostris	..	..	..	..	1·53 (0·03)	..	
Metapenaeopsis andamanensis	..	..	..	15·76 (0·79)	115·05 (2·47)	5·28 (0·33)	
Penaeopsis rectacuta	0·15 (0·04)	..	..	367·59 (18·47)	262·52 (5·63)	46·96 (2·92)	
Parapenaeus investigatoris	0·05 (0·01)	..	..	..	1·53 (0·03)	13·65 (0·85)	
Aristeus semidentatus	..	..	..	10·29 (0·52)	34·27 (0·73)	7·46 (0·46)	
Hymenopenaeus aequalis	..	..	..	..	1·53 (0·03)	7·83 (0·49)	
Solenocera hextii	..	..	..	..	..	..	

Analysis of the catch data indicated that the deeper zones gave better catch rate of these prawns and that they were obtained only from depth zones 4, 5 and 6. This tendency was evident in the case of the distribution of all the prawns except *P. rectacuta* which was, however, more abundant in comparatively shallow waters of the area. The highest catch-rate of *H. wood-masoni*, the principal species of this area, was obtained from depth zone 6.

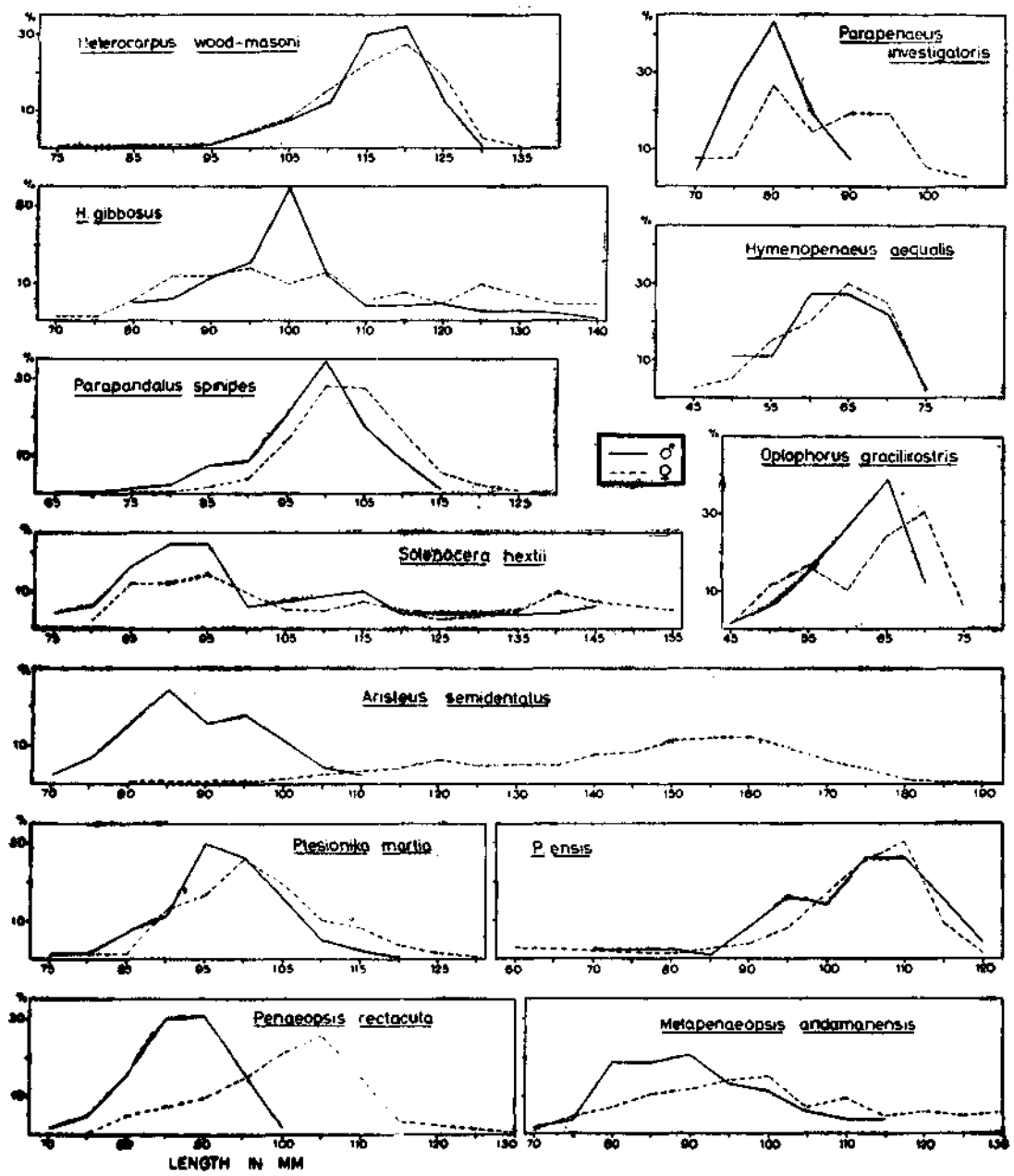

FIG. 4. Size distribution of the deep-sea prawns.

9° *N lat. area* (*Table V*).—This was the the best explored area among the 6 surveyed during these operations and more than half the total number of hauls made during the entire period was taken from here. Altogether 17,964 kg of prawns representing 49·33% of the total catch were obtained from here at an average catch-rate of 120·26 kg/hr. *H. wood-masoni* was by far the predominant species in this area also; its total catch exceeding 7 tonnes and the average catch-rate being 49·46 kg/hr. *P. spinipes* (24·23 kg/hr), *A. semidentatus* (14·76 kg/hr) and *H. gibbosus*

TABLE V

Depth-wise catch distribution in areas between Latitudes 09° 00′ N and 10° 00′ N

Depth zone	1	2	3	4	5	6	7
No. of hauls taken	2	6	11	8	87	43	5
Effort in trawling hours	2·33	5·75	11·58	8·42	79·08	39·38	2·83
Catch returns in kg	550	825	584	1662	20791	11560	243
Prawns in kg	2·00	137·00	83·50	253·00	10864·00	6583·00	35·14
% of prawns in total catch	0·36	16·61	14·30	13·59	52·25	57·00	14·45
Catch rate of prawns in kg/hr	0·86	23·83	7·21	30·04	137·38	167·32	12·42
Species composition of prawns			Catch by weight in kg (Catch rate in kg/hr)				
Heterocarpus wood-masoni	..	..	..	84·00 (9·98)	4746·48 (60·02)	2557·85 (64·95)	..
H. gibbosus	..	..	..	9·36 (1·11)	1071·19 (13·56)	516·58 (13·12)	3·29 (1·16)
Parapandalus spinipes	..	..	31·45 (2·72)	53·38 (6·34)	1929·45 (24·40)	1604·42 (40·74)	..
Plesionika martia	..	..	..	10·12 (1·20)	368·29 (4·66)	360·42 (9·15)	2·39 (0·85)
P. ensis	..	..	..	3·54 (0·42)	160·79 (2·03)	126·51 (3·21)	..
Oplophorus gracilirostris	..	..	..	..	13·04 (0·16)	3·95 (0·10)	..
Metapenaeopsis andamanensis	2·00* (0·86)	5·88 (1·03)	9·22 (0·80)	9·36 (1·11)	236·88 (2·99)	72·48 (1·85)	..
Penaeopsis rectacuta	..	131·12 (22·80)	40·48 (3·49)	63·00 (7·48)	822·40 (10·40)	342·63 (8·70)	0·02 (0·01)
Parapenaeus investigatoris	..	..	..	4·81 (0·57)	13·03 (0·16)	18·45 (0·47)	..
Aristeus semidentatus	..	..	..	5·06 (0·60)	1286·30 (16·27)	890·83 (22·62)	23·22 (8·20)
Hymenopenaeus aequalis	..	..	..	3·03 (0·36)	129·28 (1·63)	25·04 (0·64)	0·58 (0·20)
Solenocera hextii	..	..	2·35 (0·20)	7·34 (0·87)	86·92 (1·10)	69·84 (1·77)	5·64 (2·00)

* *Metapenaeopsis* sp.

(10·71 kg/hr) were the other prawns of importance obtained from the area. In the species composition significant change noticed from that of the previous region was the occurrence of *A. semidentatus*, *H. gibbosus* and *S. hextii*; the former two species being better represented in the catches. *S. hextii* which was totally absent in the previous area was obtained in fair quantities from the deeper zones of this area. All these three species are of commercial importance due to the large size they attain.

The depth-wise distribution of prawns in this area also appear to conform to the pattern observed in 8° N lat. area; the bulk of the catches having been obtained from depth zones 4, 5 and

6. From the overall picture it is clear that the shallow depth zones 1, 2 and 3 and the deepest zone 7 are not productive although some of the prawns were represented in the catches from here. Within the productive depth zones the catch rate for prawns was comparatively high in the deeper ones and this is mostly due to the occurrence of the three species mentioned above. In these cases better catches from still deeper waters seem possible.

10° *N lat. area* (*Table VI*).—Only 17 hauls were taken from this area and the 406 kg of prawns obtained from here formed only 12·15% of the landings. The catch-rate of prawns amounted to 28·6 kg/hr. *H. wood-masoni* which was the most predominant species in the adjoining areas

TABLE VI

Depth-wise catch distribution in areas between Latitudes 10° 00′ *N and* 11° 00′ *N*

Depth zone	1	2	3	4	5	6	7
No. of hauls taken	No operations	2	2	4	1	7	1
Effort in trawling hours		1·42	1·59	3·51	0·50	6·66	0·60
Catch returns in kg		618	410	1197	50	1004	60
Prawns in kg		..	..	60·00	0·68	343·89	1·00
% of prawns in total catch		..	..	5·01	1·32	34·25	1·67
Catch rate of prawns in kg/hr		..	..	17·09	1·36	51·64	2·00
Species composition of prawns				Catch by weight in kg (Catch rate in kg/hr)			
Heterocarpus wood-masoni		..	..	..	..	..	..
H. gibbosus		..	..	11·31 (3·22)	0·4 (0·8)	46·29 (6·95)	0·16 (0·26)
Parapandalus spinipes		..	..	20·61 (5·87)	..	..	..
Plesionika martia		..	..	2·02 (0·58)	0·04 (0·08)	7·98 (1·20)	..
P. ensis		..	..	1·01 (0·29)	..	..	..
Oplophorus gracilirostris		..	..	..	0·01 (0·02)	0·96 (0·15)	..
Metapenaeopsis andamanensis		..	..	1·33 (0·38)	..	..	..
Penaeopsis rectacuta		..	..	19·62 (5·59)	..	1·61 (0·25)	..
Parapenaeus investigatoris		..	..	0·92 (0·26)	0·02 (0·04)	1·20 (0·18)	..
Aristeus semidentatus		..	..	0·29 (0·08)	0·29 (0·58)	277·90 (41·72)	0·87 (1·74)
Hymenopenaeus aequalis		..	..	0·17 (0·05)	0·01 (0·02)	1·48 (0·22)	..
Solenocera hextii		..	..	2·72 (0·77)	0·17 (0·34)	6·43 (0·96)	..

was totally absent here, instead the large-sized prawn *A. semidentatus* was the commonest of all the prawns caught and its catch-rate was recorded at 19·7 kg/hr. *H. gibbosus* (4·1 kg/hr was also present in the catches in fair quantities. The proportion of prawns in the catches was very low and they were practically absent in the catches from depth zones 2 and 3. Depth zone 6 alone gave significant quantities of prawns which formed as much as 34·25% of the total catches and the catch-rate amounted to 51·64 kg/hr.

11° *N*, 12° *N and* 13° *N lat. areas* (*Tables VII and VIII*).—These northern areas have been sampled only occasionally during the oceanographic cruises of *R. V. VARUNA* and the 29 hauls taken were made on widely separated occasions. In 11° N and 12° N lat. areas prawns appeared scarce and the catches here were mainly composed of bathypelagic fishes. Some species of prawns which were common in the southern latitudes were not even represented in the catches from here. The average catch-rate of prawns observed in these three areas were respectively 3·43 kg/hr, 15·56

TABLE VII

Depth-wise catch distribution in areas between Latitudes 11° 00′ *N and* 12° 00′ *N*

Depth zone	1	2	3	4	5	6	7
No. of hauls taken ..	2	No operations	1	1	1	No operations	2
Effort in trawling hours ..	1·58	..	0·42	0·25	0·50	..	0·84
Catch returns in kg ..	103	..	..	21	125		50
Prawns in kg ..	..	..	..	6·00	6·00		0·32
% of prawns in total catch ..	..	..	..	28·57	4·80		0·64
Catch rate of prawns in kg/hr ..	..	..	..	24·00	12·00		0·38
Species composition of prawns			Catch by weight in kg (Catch rate in kg/hr)				
Heterocarpus wood-masoni ..	..	..	..	..	..		..
H. gibbosus ..	..	..	..	1·16 (4·64)	1·16 (2·32)		0·04 (0·05)
Parapandalus spinipes ..	..	..	..	1·38 (5·52)	1·38 (2·76)		..
Plesionika martia ..	..	..	..	0·28 (1·12)	0·28 (0·56)		..
P. ensis ..	..	..	..	..	..		..
Oplophorus gracilirostris ..	..	..	..	..	..		..
Metapenaeopsis andamanensis ..	..	..	..	0·05 (0·20)	0·05 (0·10)		..
Penaeopsis rectacuta ..	..	..	..	3·12 (12·48)	3·12 (6·24)		..
Parapenaeus investigatoris ..	..	..	..	0·01 (0·04)	0·01 (0·02)		..
Aristeus semidentatus ..	..	..	..	..	..		0·28 (0·33)
Hymenopenaeus aequalis ..	..	..	..	..	..		..
Solenocera hextii ..	..	..	..	..	..		..

TABLE VIII

Depth-wise catch distribution in areas between Latitudes 12° 00′ N and 13° 00′ N

Depth zone		1	2	3	4	5	6	7
No. of hauls taken	..	7	3	1	2	1	1	2
Effort in trawling hours	..	7·41	2·78	1·00	1·75	0·75	1·00	1·75
Catch returns in kg	..	1135	803	300	2025	100	10	85
Prawns in kg	..	..	..	50·00	200·00	0·72	..	2·00
% of prawns in total catch	..	..	..	16·67	9·88	0·72	..	2·35
Catch rate of prawns in kg/hr	..	..	..	50·00	114·29	0·96	..	1·14
Species composition of prawns				Catch by weight in kg (Catch rate in kg/hr)				
Heterocarpus woodmasoni	..	..	..	..	..	..	..	..
H. giblosus	..	..	..	..	3·83 (2·22)	0·29 (0·39)	..	0·18 (0·10)
Parapandalus spinipes	..	..	..	..	132·12 (75·50)	..	..	..
Plesionika martia	..	..	..	..	..	..	..	..
P. ensis	..	..	..	..	..	..	..	..
Oplophorus gracilirostris	..	..	..	..	..	..	..	..
Metapenaeopsis andamanensis	..	..	..	50·00* (50·00)	2·06 (1·18)	..	..	..
Penaeopsis rectacuta	..	..	..	..	60·90 (34·80)	0·43 (0·57)	..	..
Parapenaeus investigatoris	..	..	..	..	1·04 (0·59)	..	..	0·01 (1·03)
Aristeus semidentatus	..	..	..	..	..	..	..	1·81 (1·03)
Hymenopenaeus aequalis	..	..	..	..	..	..	..	..
Solenocera hextii	..	..	..	..	..	..	..	..

* *Metapenaeopsis* sp.

kg/hr and 17·41 kg/hr. 13° N lat. area was sampled only in the shallow depth zone 1 from where fair quantities of prawns were landed. The highest catch-rate for *M. andamanensis* and *P. rectacuta* were recorded from this area. No other prawns were obtained from here possibly because the sampling was poor and restricted to a single shallow depth zone.

A general appraisal of the distribution of these prawns, made possible by these exploratory work, shows that the species composition and the intensity of their distribution vary from place to place on this portion of the continental slope (Table IX). Operations in the two southern areas, 8° N and 9° N lat., have resulted in landings of large quantities of prawns with considerably high-catch-rate. But in the northern areas the catch as well as the catch-rate were poor and this is most

likely due to the inadequacy of the survey carried out there. It would, therefore, appear that intensive and planned fishing operations might result in better yield of prawns from there too.

TABLE IX

Area-wise catch distribution of prawns

Areas (latitudes)	8°N	9°N	10°N	11°N	12°N	13°N	Total
No. of hauls taken	78	162	17	7	17	5	286
Effort in trawling hours	87·64	1:9·37	14·18	3·59	16·24	5·17	276·19
Catch returns in kg	19172	36415	3339	299	4458	245	63928
Prawns in kg	5977	17964	406	12	253	90	24700
% of prawns in total catch	31·17	49·33	12·15	4·12	5·67	36·73	38·64
Catch rate of prawns in kg/hr	68·20	120·26	28·60	3·43	15·56	17·41	89·43
Species composition of prawns			Catch by weight in kg (Catch rate in kg/hr)				
Heterocarpus wood-masoni	2825·47 (32·25)	7388·33 (49·46)	..	..	..	..	10213·80 (36·98)
H. gibbosus	40·37 (0·46)	1600·42 (10·71)	57·87 (4·08)	2·36 (0·66)	4·35 (0·27)	..	1705·37 (6·17)
Parapandalus spinipes	1675·72 (19·12)	3618·70 (24·23)	20·61 (1·45)	2·76 (0·76)	132·12 (8·14)	..	5449·91 (19·73)
Plesionika martia	361·04 (4·12)	741·22 (4·96)	10·04 (0·71)	0·56 (0·16)	..	..	1112·86 (4·03)
P. ensis	182·66 (2·08)	290·84 (1·95)	1·01 (0·07)	..	..	..	474·51 (1·72)
Oplophorus gracilirostris	1·53 (0·02)	16·99 (0·11)	0·97 (0·07)	..	..	..	19·49 (0·07)
Metapenaeopsis andamanensis	136·09 (1·56)	335·77 (2·25)	1·33 (0·09)	0·10 (0·03)	52·06 (3·21)	22·50 (4·35)	547·85* (1·98)
Penaeopsis rectacuta	677·22 (7·73)	1399·65 (9·37)	21·27 (1·50)	6·24 (1·74)	61·33 (3·77)	67·50 (13·06)	2233·21 (8·09)
Parapenaeus investigatoris	15·23 (0·17)	36·29 (0·25)	2·14 (0·15)	0·02 (0·01)	1·05 (0·06)	..	54·73 (0·20(
Aristeus semidentatus	52·02 (0·59)	2205·41 (14·76)	279·36 (19·70)	0·28 (0·07)	1·81 (0·11)	..	2538·88 (9·19)
Hymenopenaeus aequalis	9·36 (0·11)	157·93 (1·06)	1·66 (0·12)	..	..	..	168·95 (0·61)
Solenocera hextii	..	172·09 (1·15)	9·32 (0·66)	..	..	..	181·41 (0·66)

* Includes 52 kg of *Metapenaeopsis* sp.

BIOLOGICAL OBSERVATIONS ON THE COMMON SPECIES

Heterocarpus wood-masoni (*Fig.* 5).—This deep water pandalid prawn has been so far known to science from only 106 specimens (2 from Andaman Sea, Alcock, 1901; 27 from Kei Islands, De Man, 1920; 76 from East Africa, Calman, 1939 and 1 from Arabian sea, George and Rao, 1966) and

this is the first record of the species as a commercial fishery from any part of the world. Rao and Suseelan (1968) described the egg and prezoea of the species. By far the most dominant item in these exploratory catches, the species was caught in all the months when explorations were carried out, but only from depth zones 4–6 of 8° N and 9° N lat. areas. Their size in the catches ranged from 72 to 135 mm in total length but the bulk of the catches was composed of mature prawns of 96 to 125 mm and dominated by 111–120 mm size groups in both the sexes. The size frequency distribution (Fig. 4) showed no remarkable size variation between males and females at any stage of their growth. Males generally predominated in the catches and the sex-ratio of male to female varied from 3 : 2 to 4 : 1 in different catches. Most of the females, with the exception of a few immature ones encountered occasionally, were either berried with eggs in various stages of development or with head-roe and fast developing oostigites in the pleopods. The species, therefore, appears to breed throughout the year. The fertilised eggs on the pleopods and the head-roe are light orange and this colour stands out in contrast with the pink colour of the prawn. The berry, however, becomes greyish in the advanced stages of development.

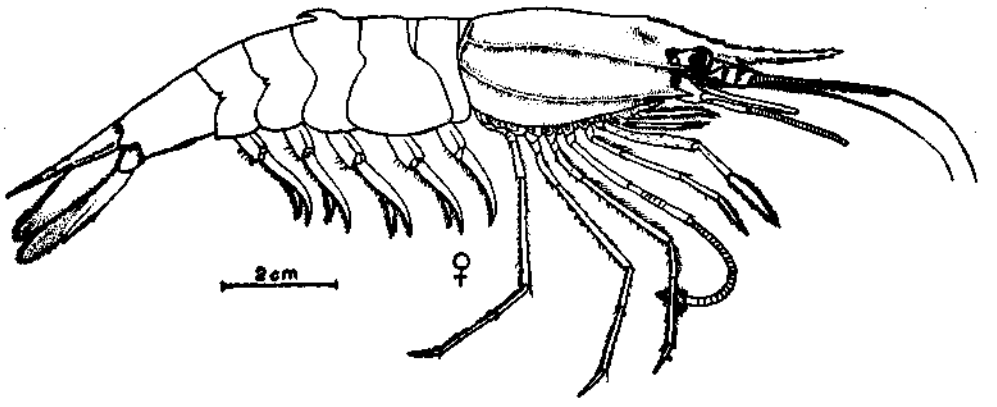

FIG. 5. *Heterocarpus wood-masoni* Alcock.

10,213 kg of this species landed constituted 41% of the overall prawn catch. Being pinkish in colour this prawn is extremely appealing to the consumers and its meat, which is also pinkish, is packed and frozen into an attractive market commodity. The average sized prawns varied from 110–115 numbers head-on per kg. For purposes of freezing their recovery was 48% headless and 32% meat by weight.

Heterocarpus gibbosus (*Fig.* 6).—This species is known to occur in both east and west coast o India and also from the Andaman seas. In the present catches it accounted for nearly 7% of the prawn catches; the majority of which having been obtained from depth zones 5 and 6 of 9° N lat. areas. Unlike *H. wood-masoni*, whose distribution is limited to southern areas only, this species was caught in lesser quantities from the deeper zones of all the areas surveyed. The size of the individual prawn varied from 67 to 140 mm in total length and the catches were represented by all size groups of the females. Males were mostly in 90–100 mm size group (Fig. 4). The size frequency distribution observed indicated that males and females were more or less equally represented at each size-class. However, males which were not represented in very low size-groups were found to predominate at 96–100 mm size-class. That the species is a prolonged breeder is evident from the occurrence of mature and berried females throughout the period of operation. The smallest berried female observed was 105 mm in total length. The colour of the berry is light orange as in *H. wood-masoni* but it turns to dirty grey as the embryo develops. The developing eggs on the berry are not perfectly spherical and they measured 0·640 to 0·784 mm in length and 0·592 to 0·640 mm in width. Immature specimens were found in greater numbers in relatively shallow waters while the bigger prawns seemed to prefer deeper grounds beyond 350 m.

In comparison with *H. wood-masoni* this species is more robust in appearance and the count of average size prawns, head-on, was as low as 75–80 per kg. But due to the excessive bulk of the cephalothorax the recovery of head-less 'tail' and the meat were respectively 43% and 36% by weight.

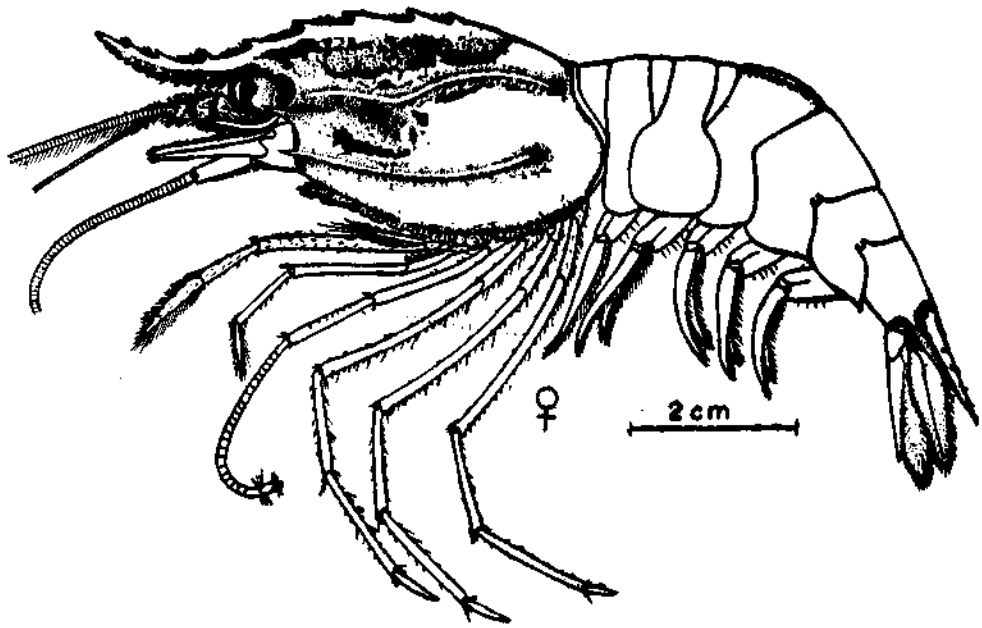

FIG. 6. *Heterocarpus gibbosus* Bate.

Parapandalus spinipes (*Fig.* 7).—In Indian waters this species is known to occur only in the south-west coast of India. Among the prawns in the trawl catches it occupied second rank in the

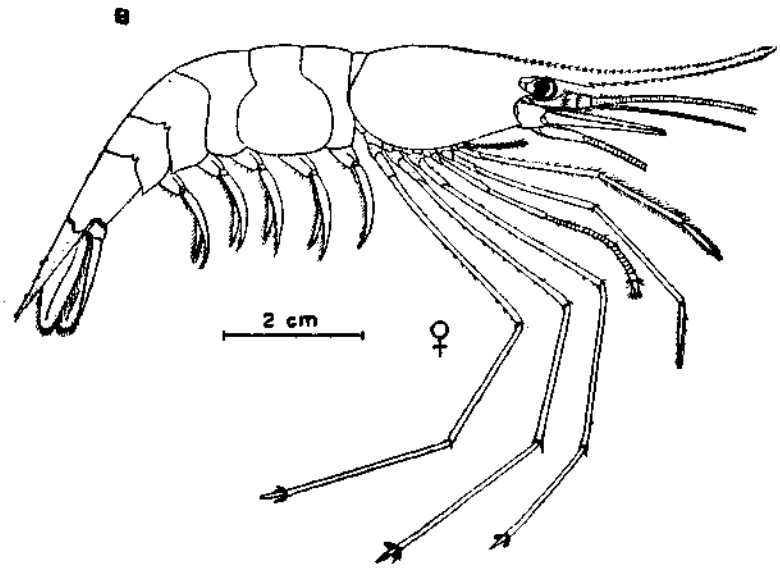

FIG. 7. *Parapandalus spinipes* Bate.

order of abundance and has been collected from all areas between Quilon and Mangalore, mostly from depth zones 4 to 6. A total of 5,450 kg of this species was landed forming 22% of the overall prawn catch. Over 95% of the landings of this species was obtained from the southern areas of 8° N and 9° N lat. at varying catch-rates from 6·34 kg/hr to 40·74 kg/hr. The size of this prawn in the catches ranged from 63 mm to 125 mm but the size groups 95–110 mm in both sexes predominated. The maximum size attained by male was 115 mm while the females were even recorded in the larger size group of 120–125 mm (Fig. 4). The sex-ratio of male to female was 1 : 3 in most of the months. The smallest mature female noticed was 88 mm long and almost all females over this size were seen in berried condition. Although the percentage of ovigerous individuals was found slightly reduced in May and October this species also seem to breed throughout the year. Majority of the females observed were with berry which was greenish-blue in colour. The fertilised eggs were ovoid in shape and their size ranged from 0·752 mm to 0·960 mm in length and 0·592 mm to 0·736 mm in width.

215–225 numbers of average size ' head-on ' prawns weighed 1 kg and the head-less ' tail ' and meat accounted for more than 53% and 41% respectively in relation to total weight.

Plesionika martia (*Fig.* 8).—Although a species of world wide distribution this prawn is also not reported to occur in such large quantities as to support a commercial fishery in any part of the world. However, Holthuis and Rosa (1965) has assigned the species with some importance by including it in the list of species of shrimps and prawns of economic value. During the present trawling operations this species was obtained in fairly good quantities at 250–400 m depth. Though encountered commonly throughout the Kerala coast at these depths, better yield of this species was obtained from off Quilon and Alleppey and the catches were mostly composed of 90–105 mm size groups. The total length varied from 72 mm to 120 mm in males and 80 mm to 128 mm in females (Fig. 4). The smallest mature female measured 85 mm in total length. The females outnumbered the males in most of the catches and almost all mature females were ovigerous throughout the period. The berry is deep blue in colour in the early stages and as the development advances it changes to light grey when well developed eye spots can be seen by the naked eye. The eggs are almost spherical and the diameter varies from 0·5 mm to 0·75 mm. In the overall prawn catch this species alone contributed more than a tonne and the maximum catch-rate of 4·96 kg/hr was recorded from off Alleppey. The count of ' head-on ' individuals of average size varied from 350 to 370 numbers per kg and the ' tail ' alone accounted for over 60% of the total weight.

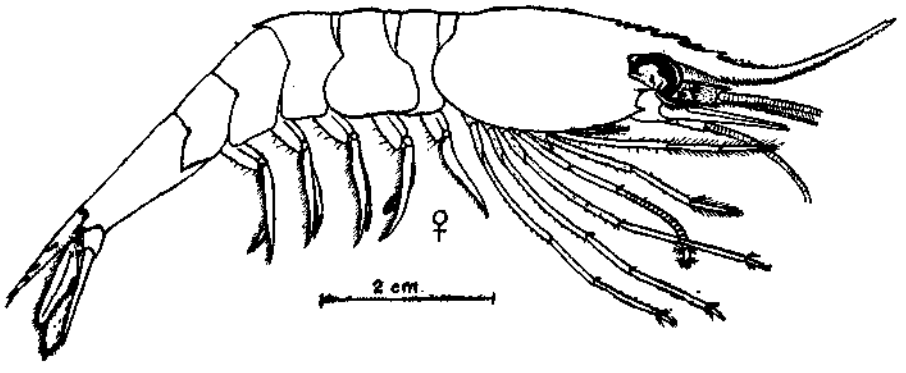

FIG. 8. *Plesionika martia* (A. M. Edw.)

Plesionika ensis (*Fig.* 9).—This is another pandalid prawn which is reported from many parts of the world but its distribution in the Indian Ocean region was hitherto known from only 2 specimens collected by Alcock (1901) from the Andaman Sea. Recently, Suseelan and Mohamed (1969) reported its occurrence in large numbers from these parts and provided a good description of the species. The entire catch of 475 kg landed during the present operations was obtained from

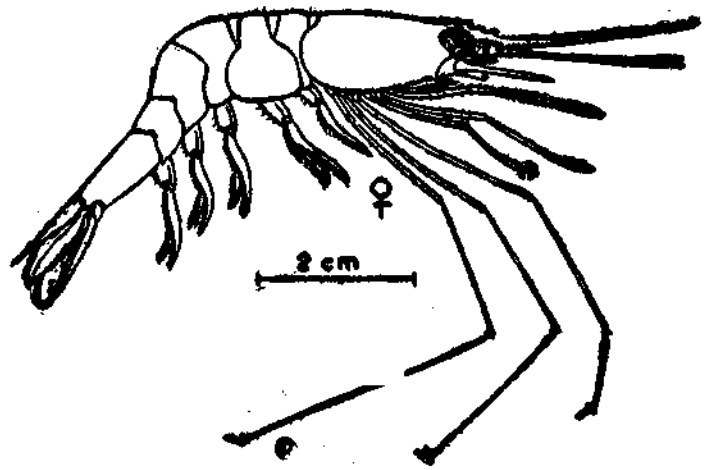

FIG. 9. *Plesionika ensis* (A. M. Edw.)

south of 10° N latitude. The maximum catch-rate was registered from off Quilon and Alleppey as is the case for other pandalids, at depths between 250 and 400 m. The individual size varied from 58 to 120 mm in total length and the the size groups 91–110 mm dominated in the catches (Fig. 4). The smallest berried female collected was 89 mm in total length and 16 mm in carapace length. Females were generally predominant in the catches and the over all sex ratio was 2: 3. Berried females and those with head-roe formed the major portion of the catches throughout the period of observations. The eggs on the pleopods are deep blue but this colour fades gradually as the embryos develop. In advanced stages of development the berry appears whitish. The eggs are oval in shape and they measure 0·640 mm to 0·896 mm in length and 0·560 mm to 0·704 mm in width. The count of average size head-on individuals was 300–330 numbers per kg and the ' tail ' accounted for about half of the total weight.

Metapenaeopsis andamanensis (*Fig.* 10).—A penaeid prawn commonly encountered in the trawl catches at all depth ranges up to 400 m and was obtained from all areas. From the point of view of fishery this species appears to be of significant value as it grows to a maximum size of 130 mm, a size seldom attained by other associated penaeid species except *Aristeus semidentatus.* The total length of males varied from 67 mm to 115 mm and that of females from 68 mm to 130 mm. But the majority of them were in the size groups 80–100 mm for the former and 85 to 110 mm for the later (Fig. 4). Females outnumbered the males in all samples examined indicating sex-wise seggregation in its occurrence. A total of 496 kg of this species was landed forming about 2% of the overall catches.

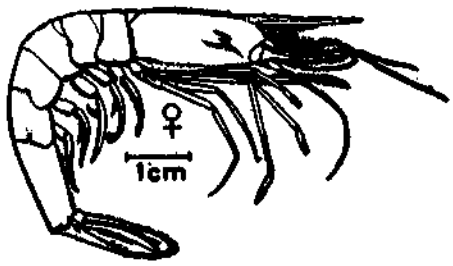

FIG. 10. *Metapenaeopsis andamanensis* (Wood-Mason).

Penaeopsis rectacuta (*Fig.* 11).—Numerically this was the most common of all the penaeid prawns obtained in the deep-sea catches. John and Kurian (1959), Kurian (1964) and George (1966) have reported the occurrence of this species from deeper areas lying off south of Cochin to Calicut. During the present trawling operations this species was obtained from all depth ranges in areas surveyed but it was more common in relatively shallow depth ranges below 300 m. A total quantity of over 2·2 tonnes of this species was landed from all depth ranges at varying catch-rates up to 34·8 kg/hr, the maximum having been recorded from 250–300 m depth range of most of the areas. It formed as much as 9% of the overall prawn catch and ranked fourth in the order of abundance. Unlike many other species obtained in the catches, whose common occurrence to some extent is restricted to only certain areas and depths, this species appears to enjoy a more or less uniform quantitative distribution throughout the south-west coast. The individual sizes ranged from 68 mm to 99 mm in males and 74 mm to 128 mm in females but the the size groups 76–95 mm of the former and 95–110 mm of the later predominated the catches (Fig. 4). The males were always outnumbered by the females and the over all sex ratio was 1 : 3. The count of average size 'head-on' prawns per kg was 250–300 numbers and the recovery of head-less 'tail' and the meat was 71% and 52% respectively of the total weight.

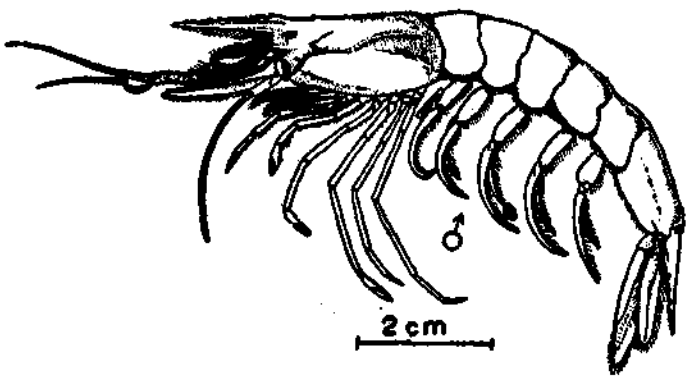

FIG. 11. *Penaeopsis rectacuta* (Bate).

Aristeus semidentatus (*Fig.* 12).—This penaeid prawn, being the largest of all the species obtained in these exploratory catches, is probably the most important item for commercial purposes. The occurrence of it in Indian waters was quite unknown till George (1966) recorded its presence in large numbers at 180–205 fathoms off Alleppey. More than 2·5 tonnes of this species was landed during these exploratory operations and it formed as much as 10% of the total prawn catch. Although represented in the catches from all the three southern areas, most of them were landed from 9° N and 10° N lat. areas. The bathymetric distribution of the species is well evident from Tables IV to VIII. The species was totally absent in the first three depth ranges in all areas and throughout these operations it was obtained only from depths greater than 250 m. The maximum catch-rate of 41·72 kg/hr was recorded from 351–400 m depth range of 10° N latitude area. The catches were mainly composed of females and their size ranged from 78 mm to 188 mm in total length. The size distribution showed unimodal pattern with majority in size groups 146–165 mm (Fig. 4). The males, which were very poorly represented in the catches were relatively smaller in size and their total length varied from 67 mm to 110 mm. The rarity of males in the catches could not have been due to the selection of the gear as in the same hauls prawns of still smaller size belonging to other species were also caught. It would, therefore, appear that the species exhibits extreme sex segregation. Whether this segregated occurrence of females is part of an elaborate spawning movement is a matter to be investigated. Majority of the females observed were mature and a good percentage of them were in impregnated condition throughout the period of observation. The females, therefore, appeared to have congregated in these areas for spawning after having accomplished the mating elsewhere. The count of 'head-on' average-sized female

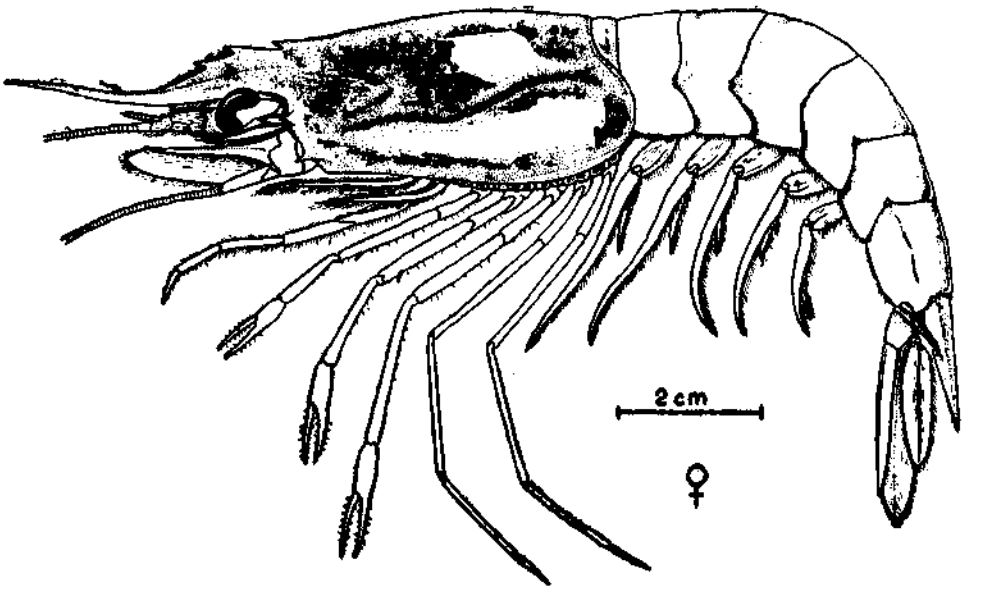

FIG. 12. *Aristeus semidentatus* (Bate).

(145–170 mm) was 60–70 numbers per kg and the head-less 'tail' and the meat accounted for about 58% and 42% respectively in total weight.

Other species.—Most of the other species of prawns as given in Table III were only occasionally met with in the catches. Among these, *Oplophorus gracilirostris*, *Parapenaeus investigatoris*, *Hymenopenaeus aequalis* and *Solenocera hextii*, by their size or nature of occurrence, hold out some commercial importance. The size distribution of these species in the catches is shown in Fig. 4. *S. hextii*, a fairly large-sized penaeid prawn, was represented in the catches from 9° N and 10° N latitude areas. Its total length varied from 71 mm to 155 mm but the majority of them were in 85–95 mm size groups. Relatively small-sized prawns were obtained from shallow areas while larger prawns were collected from deeper grounds.

DISCUSSION

These exploratory trawling operations have established that the upper bathyal regions of the continental slope lying along the south-west coast of India between Quilon and Ponnani is quite suitable for shrimp trawling and that relatively high catch-rate could be expected from here. Although these catches consisted of prawns, lobsters, crabs and fishes only the first two categories have at present emerged as of commercial value. This newly emerged trawling ground, the extent of which is estimated to be about 5,000 sq. km is, no doubt, very small when compared with the conventional inshore trawling grounds. But the high rate of yield, particularly of prawns and lobsters, recorded from here projects it into the lime light in the context of the search for new resources. Applying swept area method an estimate of over 5,300 tonnes have been arrived at as potential resource of these grounds. The average catch-rate of 120·26 kg/hr of prawns obtained from these operations, particularly from 9° N latitude area is of very great importance from the stand point of fishing industry. In comparison with the average catch-rate of 20 to 25 kg/hr of prawns obtained by the mechanised fishing boats working in the inshore areas of this region, this rate of yield appears attractive. Even when due consideration is given to the fact that fishing operations in these areas will require larger and powerful vessels, the high catch returns obtained appear to justify recommendation for deployment of commercial fishing boats to harvest this resource, A word of caution in this context will not be out of place. When exploitation of a new resource

is taking place it is essential that due consideration is given to the sustainability of the population concerned. The present catch-rate may not be a real indication of their abundance since this is only the initial result obtained from a hitherto untapped stock. This catch-rate is bound to come down to an optimum level and it has to be clearly understood and taken stock of before enhancing the fishing effort in order to have a successful commercial fishery.

While our knowledge about this new ground and the animal populations inhabiting it is of a cursory nature at present, certain special characteristics associated with them deserve due consideration. As the various species found in this ground are deep water forms, not apparently associated with the inshore areas, its exploitation will have no effect on the existing inshore fishery. The physical and chemical characteristics of the waters in the upper bathyal region being relatively static and unaffected by monsoon and similar weather conditions, wide seasonal fluctuations in the catch-rates need not be expected. Nevertheless, the biological conditions of the prawns caught indicate that most of them have moved into this ground for spawning and similar life activities. This is clear from the fact that in practically all the species of prawns females were predominant in the catches and that most of them were mature, impregnated or berried. Juvenile stages of these prawns were never met with in these catches and the minimum size observed was about 75 mm in most of the species (Fig. 4). As smaller prawns like *H. aequalis* and *O. gracilirostris* were also caught in the same gear this could not have happened due to gear selection. Therefore, it would appear that the adult prawns get recruited to this ground from elsewhere seemingly for the purpose of spawning. Since the breeding activity of these species is continuous, the recruitment should also follow a continuous pattern. The source from where this recruitment is taking place is not fully known at present. As juveniles of these prawns are not obtained in haul taken from shallower area it is to be assumed that the recruitment is not from inshore grounds.

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