

Proceedings of the
FIRST WORKSHOP ON SCIENTIFIC RESULTS OF
FORV SAGAR SAMPADA

5-7 June, 1989, Cochin

Sponsored by

**DEPARTMENT OF OCEAN DEVELOPMENT
&
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
NEW DELHI**

Organized by

**CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
&
CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY
COCHIN**

OCTOBER, 1990

Published by

Dr. P.S.B.R. JAMES

DIRECTOR

Central Marine Fisheries Research Institute

COCHIN - 682 031

Edited by

Dr. K.J. MATHEW

Central Marine Fisheries Research Institute

COCHIN - 682 031

RESULTS OF AN EXCLUSIVE SURVEY FOR THE DEEP-SEA CRUSTACEANS OFF SOUTHWEST COAST OF INDIA

C. SUSEELAN, M. S. MUTHU*, K. N. RAJAN, G. NANDAKUMAR, M. KATHIRVEL*, N. NEELAKANTA PILLAI**,
N. SURENDRANATHA KURUP AND K. CHELLAPPAN

Central Marine Fisheries Research Institute, Cochin- 682 031

ABSTRACT

Southwest coast of India has great potential for development of deep-sea fishing for crustaceans. Earlier exploratory surveys have revealed the existence of commercially exploitable stocks of deep-sea prawns, lobsters and crabs along the Kerala coast and schemes are under way for their large scale exploitation. FORV *Sagar Sampada*, in her 40th and 42nd cruises, undertook a detailed survey of the resource characteristics of deep-sea crustaceans between Trivandrum and Ponnani during January-February, 1988 and the results are presented in this paper.

In the bottom trawls operated between 60 and 777 m depths, prawns formed sizable portion of the catch from the 'Quilon Bank', with maximum abundance (64-201 kg/hr) between 290 and 370 m depth. The multi-species catch consisted of appreciable quantities of large and medium sized species such as *Aristeus alcocki*, *Heterocarpus woodmasoni*, *H. gibbosus*, *Plesionika spinipes*, *Solenocera hextii* and *Penaeopsis jerryi* suggesting scope for their commercial exploitation and export. The deep-sea spiny lobster *Puerulus sewelli* recorded the highest yield (180 kg/hr) at 235-307 m depth off Trivandrum. Among other crustaceans, the swarming crab *Charybdis (Goniohellenus) smithii* was an important component registering maximum catch at 240-380 m depth off Alleppey. Information on sex ratios, size frequency and mean size distribution, abundance of breeding population etc., from different bathymetric zones have been provided for important species.

INTRODUCTION

The discovery of commercially exploitable stocks of crustaceans beyond the continental shelf off the southwest coast of India in the recent past has offered scope for deep-sea fishing to enhance production of shellfish. The deep-sea prawns and deep-sea lobsters, which have already proved to be sufficiently rich to support large scale exploitation along the coast, can contribute significantly to the seafood export industry of the country. As tapping of the potential resources of our seas has been assigned top priority in the national fishery development programmes, schemes are under way for commercial exploitation of the deep-sea crustaceans from the southwest coast. For judicious exploitation and management of this new resource, a thorough understanding of the population characteristics and biology of the constituent species is an essential prerequisite. Keeping this in view, two cruises of FORV *Sagar Sampada*, namely cruise No. 40 and 42 undertaken during January and February, 1988 were used for an intensive study of the deep-sea crustaceans off the Kerala coast by experimental fishing and the results are presented in this paper. The study was mainly aimed at furnishing details of

the various species of prawns, lobsters and other useful crustaceans occurring on the upper continental slope, their relative abundance, size distribution, sex ratios, breeding population etc. which would serve as baseline information on their unexploited stock.

General accounts on the deep-sea crustacean resources of this coast have been given by Kurian (1965), Suseelan and Mohamed (1968), Silas (1969), Mohamed and Suseelan (1973), Suseelan (1974), Oommen (1980), James (1987) and Kathirvel *et al.* (1989) based on the results of exploratory fishing conducted by the erstwhile Indo-Norwegian Project and other agencies. Recently Suseelan (1985, 1988) has studied the bathymetric distribution and some aspects of the biology of important species of deep-sea prawns from this coast.

DETAILS OF FISHING

The study involved a series of bottom trawling using the High Speed Demersal Trawl (HSDT III) designed by the CIFT, Cochin. During Cruise 40, which extended from 1-1-1988 to 11-1-1988, a total of 20 trawling operations were conducted between 130 and 777 m depth off Cochin to Trivandrum

Present address : * Central Institute of Brackishwater Aquaculture, Madras.

** Regional Centre of CMFRI, Mandapam.

between Lat. $08^{\circ} 35'N$ to $09^{\circ} 32'N$ and Long. $75^{\circ} 33'E$ to $76^{\circ} 15'E$ (Fig. 1). The cod-end mesh size of the net operated during this cruise was 22 mm stretched knot-to-knot. Cruise No. 42, performed during 5-2-1988 to 20-2-1988, covered the area between Lat. $08^{\circ} 30'N$ to $10^{\circ} 39'N$ and Long. $75^{\circ} 25'E$ to $76^{\circ} 37'E$ lying off Ponnani to Trivandrum using a larger mesh size of 40 mm for the cod-end of the net. A total of 25 trawl hauls were taken during this cruise at depths between 60 and 368 m. During both the cruises, the fishing was mainly confined to the 'Quilon Bank' which is considered to be the most productive area of deep-sea crustaceans on this coast.

Haul-wise details of trawling operation and total catch recorded for the two cruises are given in Tables 1 and 2.

OBSERVATIONS

Catch and catch rates of crustaceans

During Cruise- 40, a total of 16 tonnes of catch was recorded of which crustaceans accounted 1,663 kg (10.3 %), fish 14,430 kg (89.4 %) and cuttlefish 45 kg (0.3 %). The total catch obtained during Cruise-

42 amounted to 36 tonnes, of which only 548 kg (2 %) was constituted by crustaceans and the rest 35,067 kg (98 %) by fish items. Tables 3 and 4 give details of catch and catch rates of the different crustacean groups for each of the hauls taken during the two cruises.

Prawns

They formed the common element of crustaceans caught during both the cruises. In Cruise- 40, prawns were represented in all the hauls except haul No. 3 and 17 operated within and on the edge of the continental shelf (130-203 m) and haul No. 14 operated in the deep sea at 731-777 m depth. With a total catch of 776 kg of prawns for the entire cruise forming 47 % of the total crustacean catch, the catch rates varied considerably in different areas operated. The maximum catch rate of 201 kg/ hr was recorded at station 12 at 299 m depth. Appreciable quantities of prawns, ranging from 130 to 150 kg/ hr of trawling were also obtained at stations 1, 4 and 10 lying in the Quilon Bank. In general, comparatively higher production rates were noticed between 290 and 360 m depth.

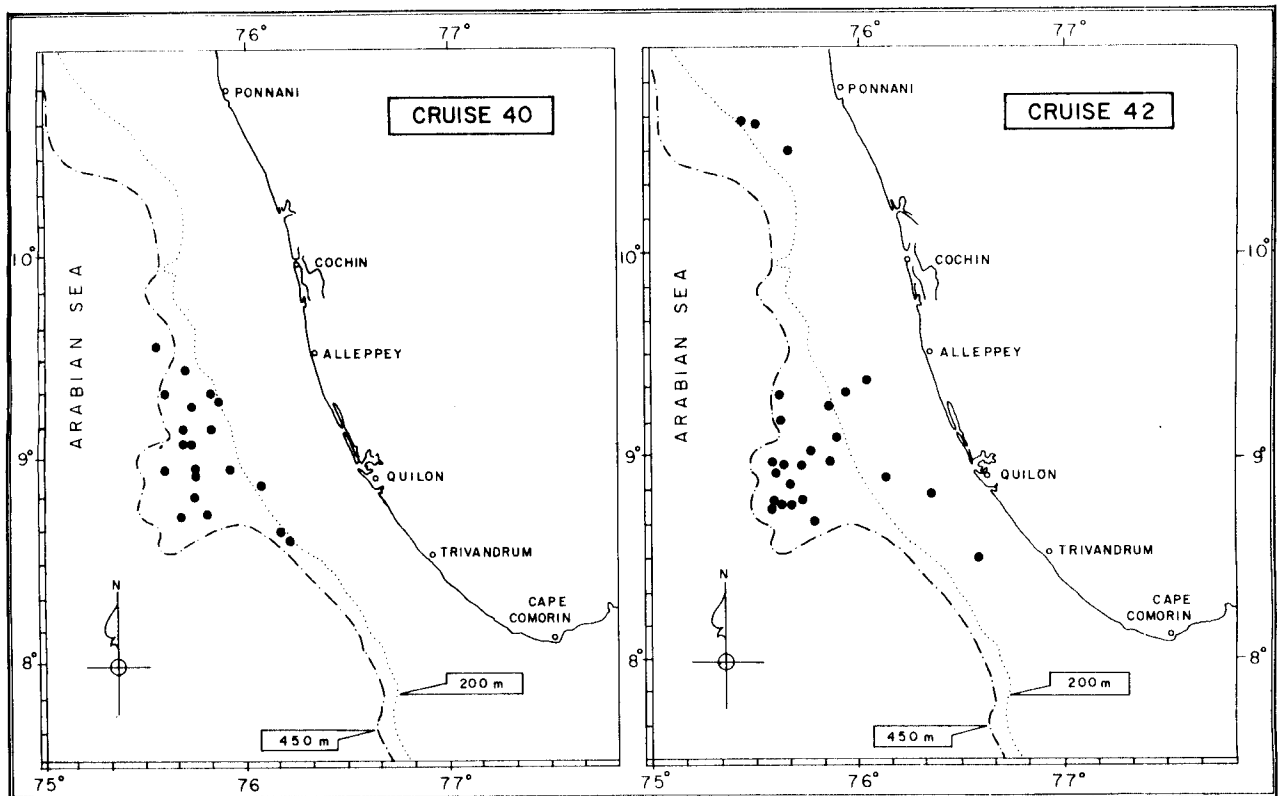


Fig. 1. Study area. Black rounds indicate trawling stations.

TABLE 1. Trawling details of Cruise No. 40

Stn. No.	Date	Position Lat. /Long.	Depth (m)	Time (hrs)	Duration of hauls (minutes)	Total catch (kg)
1	2.1.'88	08° 35' N 76° 15' E	235-307	0820-0900	40	470
2	2.1.'88	08° 38' N 76° 11' E	273-293	1140-1203	23	512
3	2.1.'88	08° 50' N 76° 00' E	130-156	1716-1746	30	470
4	3.1.'88	08° 48' N 75° 45' E	322	0735-0830	55	350
5	3.1.'88	08° 56' N 75° 45' E	328-334	1055-1155	60	5,000
6	3.1.'88	08° 42' N 75° 41' E	312-314	1810-1855	45	155
7	4.1.'88	08° 43' N 75° 49' E	398-421	0842-0907	25	90
8	4.1.'88	08° 55' N 75° 35' E	304-307	1652-1740	48	6,000
9	5.1.'88	08° 55' N 75° 55' E	348-350	0740-0815	35	1,250
10	5.1.'88	08° 55' N 75° 45' E	344-358	1515-1548	33	160
11	6.1.'88	09° 04' N 75° 40' E	246-260	1005-1035	30	60
12	6.1.'88	09° 04' N 75° 45' E	299	1223-1257	34	300
13	6.1.'88	09° 08' N 75° 40' E	341	1504-1530	30	110
14	7.1.'88	09° 32' N 75° 33' E	731-777	1515-1530	15	1
15	8.1.'88	09° 12' N 75° 44' E	361-382	1135-1208	33	110
16	8.1.'88	09° 09' N 75° 50' E	313-315	1612-1642	30	100
17	8.1.'88	09° 16' N 75° 55' E	135-203	1912-1942	30	115
18	8.1.'88	09° 18' N 75° 35' E	239-306	2056-2130	34	270
19	9.1.'88	09° 19' N 75° 52' E	275-380	1036-1105	29	550
20	10.1.'88	09° 26' N 75° 41' E	348	1832-1910	38	65

In Cruise - 42, out of the 25 hauls taken, only 16 hauls contained prawns in varying quantities ranging from 0.4 to 90 kg/hr of trawling. There was absolutely no prawn catch at stations 1, 2, 3, 12, 13, 14, 24 and 25 lying in the mid-shelf between 60 and 120 m depth and at station 16 lying in the Quilon Bank. The catch rates of the positive stations were also relatively less when compared to the catch rates recorded during Cruise - 40 from more or less the same depth zone of the Quilon Bank. The total prawn catch for the entire cruise amounted to 537 kg forming 95 % of the crustacean catch, with the highest catch rate of 90 kg/hr at Station 6 at 325 m depth. Fairly good concentration of prawns (64-88 kg/hr) was also noticed at Stations, 7, 8, 9 and 18 between 330 and 370 m depth.

The prawn catches of both the cruises were multispecies in composition, and represented by atleast 15 species of which eight species, namely, *Heterocarpus woodmasoni* (7-41 %), *H. gibbosus* (12-17 %), *Plesionika spinipes* (33-52 %), *P. martia* (1-2 %), *Aristeus alcocki* (3-4 %), *Solenocera hextii* (1-2 %), *Penaeopsis jerryi* (8-13 %), *Metapenaeopsis andamanensis* (1-4 %) were common (Figs. 2-9). The species composition varied considerably at different depths as observed by Suscelan (1985, 1988). In general, the

penaeid prawns *P. jerryi*, *M. andamanensis* and *M. coniger* and the pandalid prawn *P. spinipes* formed the major constituents of the catch in the 201-300 m depth zone while in still deeper waters the pandalid prawns *H. woodmasoni*, *H. gibbosus*, *P. spinipes* and *P. martia* and the aristeid prawn *A. alcocki* dominated the catch.

The maximum abundance of *H. woodmasoni* was recorded at stations 4 to 6 (11-15 kg/hr) of Cruise 40 and stations 6, 9 and 18 (31-69 kg/hr) of Cruise 42. In the case of *H. gibbosus*, the highest

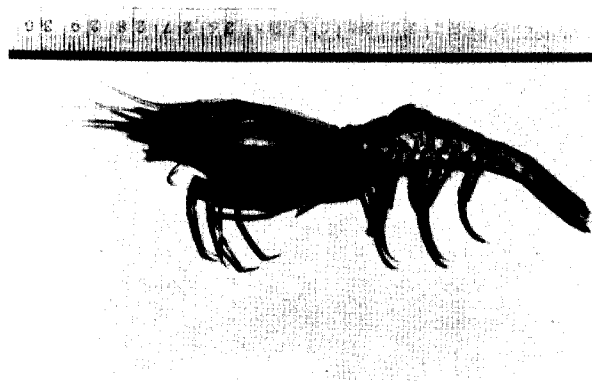
Fig. 2. *Heterocarpus woodmasoni*.

TABLE 2. Trawling details of Cruise No. 42

Stn. No.	Date	Position Lat. / Long.	Depth (m)	Time (hrs)	Duration of haul (minutes)	Total catch (kg)
1	8. 2. 88	10° 30' N 75° 40' E	60	1725-1755	30	225
2	9. 2. 88	10° 37' N 75° 30' E	80	0820-0920	60	200
3	9. 2. 88	10° 39' N 75° 25' E	120	1210-1225	15	250
4	11. 2. 88	09° 17' N 75° 35' E	350	1115-1200	45	500
5	11. 2. 88	09° 10' N 75° 47' E	348	1610-1710	60	9
6	12. 2. 88	09° 05' N 75° 52' E	325	1110-1210	60	1,000
7	12. 2. 88	08° 58' N 75° 51' E	332	1440-1540	60	2,000
8	12. 2. 88	09° 01' N 75° 46' E	340	1735-1820	45	250
9	13. 2. 88	08° 57' N 75° 37' E	360-368	0840-0940	60	2,000
10	13. 2. 88	08° 51' N 75° 40' E	360-365	1200-1230	30	53
11	13. 2. 88	08° 40' N 75° 48' E	340	1640-1740	60	450
12	14. 2. 88	08° 54' N 76° 09' E	63-65	0750-0850	60	40
13	14. 2. 88	08° 49' N 76° 22' E	60	1140-1225	45	14
14	14. 2. 88	08° 30' N 76° 37' E	84-86	1615-1715	60	53
15	15. 2. 88	08° 57' N 75° 42' E	328-335	1345-1430	45	7,000
16	15. 2. 88	08° 46' N 75° 43' E	337-340	1720-1750	30	5,000
17	16. 2. 88	08° 58' N 75° 34' E	362	0845-0930	45	68
18	16. 2. 88	08° 57' N 75° 33' E	361-366	1055-1155	60	200
19	16. 2. 88	08° 47' N 75° 34' E	335-340	1715-1720	5	10
20	17. 2. 88	08° 47' N 75° 35' E	324-326	1020-1050	30	27
21	17. 2. 88	08° 44' N 75° 32' E	315	1335-1435	60	12,000
22	17. 2. 88	08° 46' N 75° 39' E	305	1650-1720	30	200
23	18. 2. 88	09° 15' N 75° 53' E	225-238	0830-0900	30	5
24	18. 2. 88	09° 19' N 75° 56' E	73	1215-1315	60	10
25	18. 2. 88	09° 22' N 76° 02' E	60	1455-1555	60	1

concentration was observed at stations 4, 7, 13 and 20 (15-24 kg/hr) of Cruise 40 and stations 6 and 9 (12-16 kg/hr) of Cruise 42. *P. spinipes* recorded maximum catch rates at stations 1, 4, 10 and 12 (48-90 kg/hr) of Cruise 40 and stations 7 to 10 (20-59 kg/hr) of Cruise 42. The highest catch rate of *A. alcocki*

(9 kg/hr) was obtained at station 4 of cruise 42. Among the other important species, significant catch rates were recorded for *P. jerryi* at stations 1, 12 and 18 (12-29 kg/hr), *M. andamanensis* at station 1 (18 kg/hr) and *S. hextii* at station 12 (6 kg/hr) of Cruise 40.

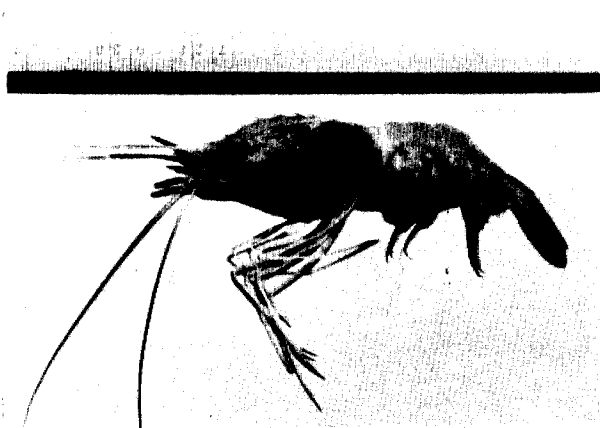
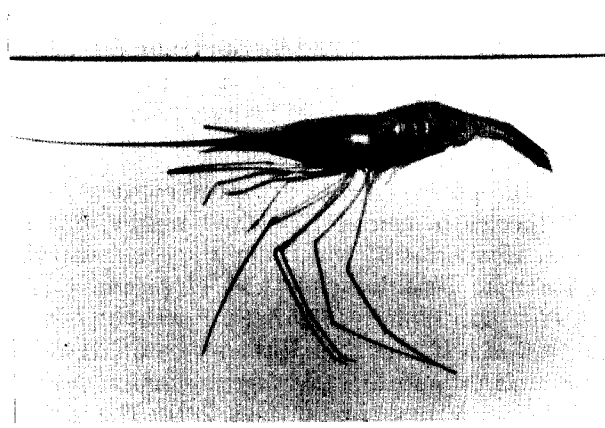
Fig. 3. *Heterocarpus gibbosus*.Fig. 4. *Plesionika spinipes*.

TABLE 3. Haulwise catch (C) in kg and catch rate (C/E) in kg/hr of crustaceans during Cruise No. 40 of FORV Sagar Sampada

Haul No.	Depth (m)	Prawns		Lobsters		Crabs		Total crustaceans	
		C	C/E	C	C/E	C	C/E	C	C/E
1	235-307	100	150	120	180	50	75	270	405
2	273-293	16	42	12	31	11	29	39	102
3	130-156	—	—	—	—	—	—	—	—
4	322	120	132	5	5	—	—	125	137
5	328-334	50	65	2	3	—	—	52	68
6	312-314	43	57	5	7	—	—	48	64
7	398-421	44	106	5	12	—	—	49	118
8	304-307	25	31	5	6	—	—	30	37
9	348-350	20	34	7	12	—	—	27	46
10	344-358	80	146	9	16	—	—	89	162
11	246-260	10	20	—	—	12	24	22	44
12	299	114	201	7	12	25	44	146	257
13	341	46	92	3	6	1	2	50	100
14	731-777	—	—	—	—	—	—	—	—
15	361-382	19	35	2	4	—	—	21	39
16	313—315	29	58	5	10	—	—	34	68
17	135—203	—	—	—	—	—	—	—	—
18	239-306	23	40	2	3	79	139	104	182
19	275-380	10	21	—	—	512	1059	522	1,096
20	348	27	43	7	11	1	2	35	56

Lobsters

The deep-sea spiny lobster *Puerulus sewelli* (Fig. 10) was caught from the upper continental slope between 235 and 421 m depth, with maximum abundance upto 350 m depth. During Cruise 40, a total quantity of 196 kg of the lobster was obtained at an average catch rate of 17 kg/hr, which formed nearly 12 % of the total crustaceans caught. It was encountered at most of the stations occupied on the upper continental slope in varying proportions. It is interesting to note that the lobster, with a catch of

120 kg for 40 minutes trawling accounted the largest crustacean component at station 1, which was the highest catch recorded for this species during the entire cruise. The catch rate and percentage contribution of lobster in this particular haul were as high as 180 kg/hr and 44.4 % respectively. The catch rates for the other positive stations ranged from 3 to 31 kg/hr. During cruise 42, the lobster catch was much less when compared to the catches obtained during cruise 40. Out of the 17 stations occupied on the upper continental slope, *P. sewelli* was recorded

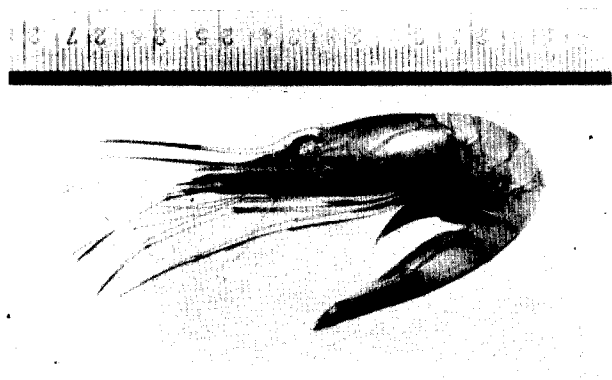
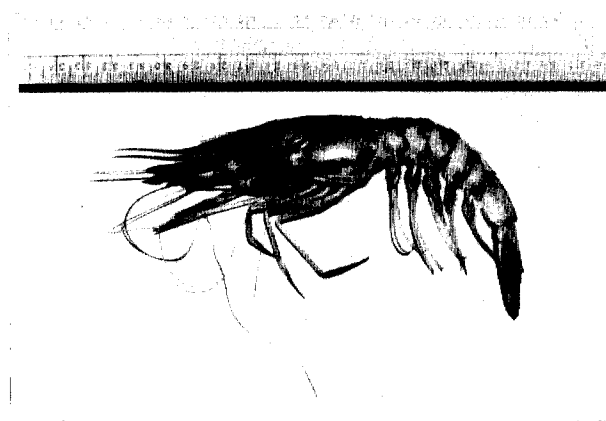
Fig. 5. *Plesionika martia*.Fig. 6. *Aristeus alcocki*.

TABLE 4. Haulwise catch (C) in kg and catch rate (C/E) in kg/hr of crustaceans during Cruise No. 42 of FORV Sagar Sampada

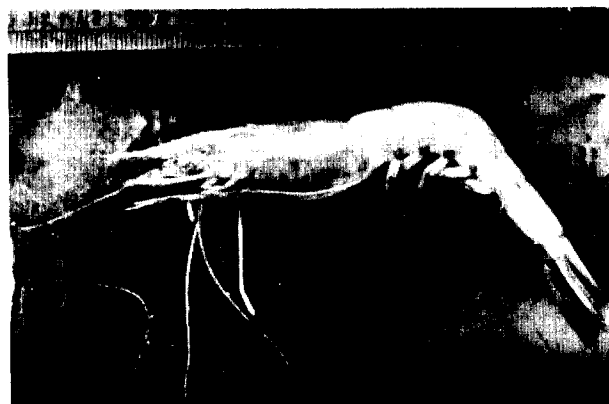
Haul No	Depth (m)	Prawns		Lobsters		Total crustaceans *	
		C	C/E	C	C/E	C	C/E
1	60	—	—	—	—	—	—
2	80	—	—	—	—	—	—
3	120	—	—	—	—	—	—
4	350	20	27	2	3	22	30
5	348	3.7	3.7	0.3	0.3	4	4
6	325	90	90	2	2	92	92
7	332	76	76	4	4	80	80
8	340	66.3	88	1.5	2	68	90
9	360-368	88	88	4	4	92	92
10	360-365	21	42	0.1	0.2	21.1	42.2
11	340	31.5	31.5	—	—	31.5	31.5
12	63-65	—	—	—	—	—	—
13	60	—	—	—	—	—	—
14	84-86	—	—	—	—	—	—
15	328-335	4.9	6	2.1	3	7	9
16	337-340	—	—	—	—	—	—
17	362	18	24	1.1	1	—	19.1
25							
18	361-366	64	64	3.2	3.2	67.2	67.2
19	335-340	1	12	3.5	42	4.5	54
20	324-326	0.2	0.4	2.9	6	3.1	6.4
21	315	24	12	—	—	24	12
22	305	1	2	—	—	1	2
23	225-238	0.2	0.4	—	—	0.2	0.4
24	73	—	—	—	—	—	—
25	60	—	—	—	—	—	—

* There was no catch of crabs during the cruise

at 12 stations all beyond 315 m depth. The total catch for the entire cruise amounted to only 27 kg, forming 5% of the total crustacean catch. The highest catch rate of 42 kg/hr was recorded off Quilon at station 19 between 335 and 340 m depth. The catch rates at other positive stations ranged

from 0.2 to 6 kg/hr.

Apart from *P. sewelli*, stray specimens of the Indian Ocean lobsterette *Nephropsis stewarti* (Fig. 11) were also recorded during both the cruises from 304 to 421 m depth off Quilon - Alleppey coast. On the west coast of India, it is known to occur off

FIG. 7. *Solenocera hextii*.Fig 7. *Solenocera hextii*.Fig 8. *Penaeopsis jerryi*.

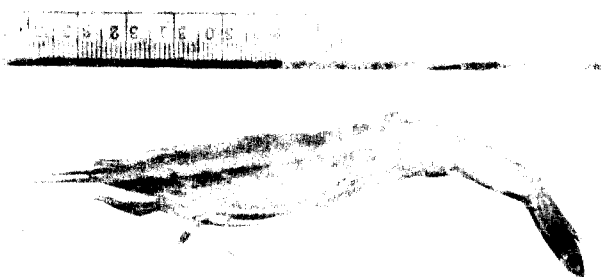


Fig. 9. *Metapenaeopsis andamanensis*.

Lakshadweep Islands between 660 and 840 m depth (Alcock, 1901; Holthuis, 1984) and the present collections extend its distributional range to the upper continental slope off the mainland. The total length of the lobster ranged from 105 to 112 mm for males and 120 to 128 mm for females. Some of the females above 125 mm were found to be in ovigerous state.

Crabs

The swarming crab *Charybdis* (*Goniohellenus*) *smithii* (Fig. 12) was an important component of the crustacean catch taken during cruise 40 between 235 and 380 m depth. It was represented at 8 stations, majority having bottom depths less than 310 m. A total of 691 kg of the crab obtained during this cruise at an average catch rate of 59.5 kg/hr formed nearly 42 % of the whole crustacean catch. The species formed the bulk of the catch at station 19 with a total harvest of 512 kg for 29 minutes trawling. The catch rate for this haul worked out to 1,059 kg/hr, while the same for the other positive hauls ranged from 2 to 139 kg/hr.

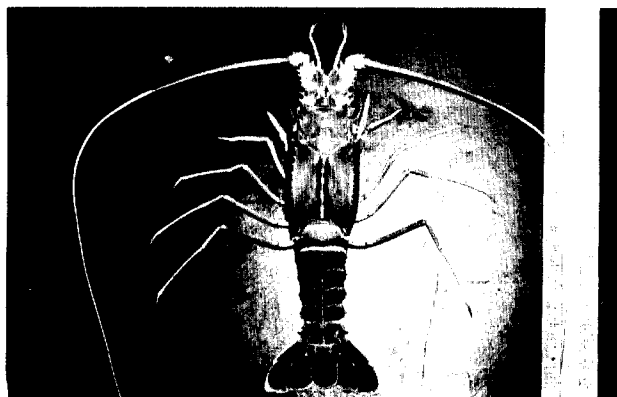


Fig. 10. *Puerulus sewelli*.

Among other crabs recorded during the survey, two species namely *Thelxiope megalops* (Fig. 13) and *Carcinoplax verdensis* showed moderate concentrations between 300 and 400 m depth.

Other crustaceans

A variety of other deep-sea crustaceans including those listed by Mohamed and Suseelan (1973) have been encountered during this survey. Among them a species that deserves special mention is the deep-sea stomatopod *Squilla leptosquilla* (Fig. 14) which was observed quite often in the catches, some times in fairly good numbers indicating the existence of a rich population of it in the study area. Distinguished by a prominent red spot on telson this species was first reported from this coast by Rao *et al.* (1965). By virtue of its large size (120-160 mm TL) it might prove to be potentially important in due course.



Fig. 11. *Nephropsis stewarti*.

Population characteristics and biology

Data on population parameters such as sex ratios, size-frequency distribution, breeding stock etc. of the major species of crustaceans have been collected from each of the trawling stations. The size of the animal refers to total length of body measured from tip of rostrum to tip of telson in the case of prawns and from anterior margin of carapace to tip of telson in the case of *P. sewelli*, while for crabs (*C. (G.) smithii*) it refers to carapace width measured between the last pair of anterolateral teeth. The length measurements were grouped into 5 mm size classes sex-wise, and the frequency data of all the individual samples pooled together for

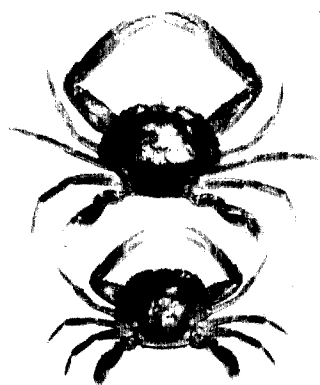


Fig. 12. *Charybdis (Goniohellenus) smithii*.

two major depth zones, namely, 201-300 m and 301-400 m cruise-wise. Tables 5-9 give the overall size frequency distribution (indicated against mid-points of length groups) together with estimates of mean sizes of different species in the two depth zones.

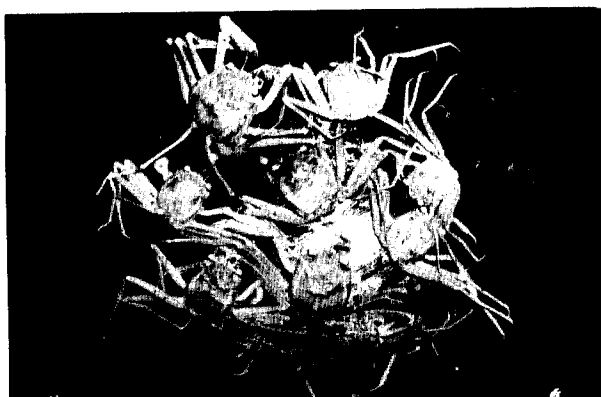


Fig. 13. *Thelxiope megalops*.

Heterocarpus woodmasoni (Table 5)

This species was caught mainly in the depth zone 301-400 m. Out of 830 specimens examined, as many as 683 were males forming 82 % of the total population. A high degree of male dominance over females was observed in almost all the samples examined.

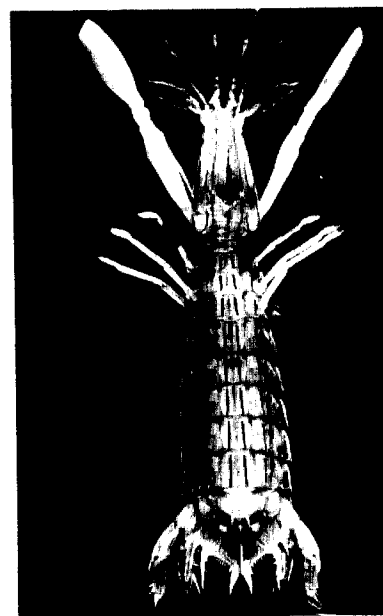


Fig 14. *Squilla leptosquilla*.

TABLE 5. Length- frequency and mean size distribution of *Heterocarpus woodmasoni* at 301-400 m depth by cruise and sex

Total Length (mm)	Cruise No. 40		Cruise No.42	
	Male	Female	Male	Female
83		1	1	
88			2	
93	5	1	5	2
98	10	3	19	1
103	24	1	49	12
108	35	2	109	18
113	30	3	177	43
118	9	2	169	42
123	1	1	34	11
128			1	3
133			3	1
Total number	114	14	569	133
Mean size (mm)	107.6	106.2	112.6	113.9

The size of the prawns ranged from 81 to 135 mm for both sexes. About 78-95 % belonged to the size group 96-120 mm. The larger size groups above 120 mm were more numerous in the catches of Cruise-42. The mean sizes ranged 107.6-112.6 mm for males and 106.2-113.9 mm for females.

The species was found to breed intensively during February when nearly 90 % of the females carried eggs on the pleopods. The smallest egg-laden female measured 92 mm in total length.

Heterocarpus gibbosus

This species was recorded at depths between 235 and 421 m. Males and females were almost equally represented in the catch. The size range of a total of 288 specimens measured was 73-138 mm for males and 83-143 mm for females, the major size groups being 96-110 mm and 101-125 mm for the two sexes respectively. Among females 5.5 % were in ovigerous state.

This is the largest among the pandalid prawns of this coast and hence can attract the processing industry.

Plesionika spinipes (Table 6)

Previously known as *Parapandalus spinipes*, this species has been recently placed under genus *Plesionika* by Chace (1985). Occurring at all depths between 225 and 421 m it formed one of the most common deep-sea prawns of the area. Females invariably outnumbered the males, the overall sex ratio of 1,463 specimens examined being 40 : 60.

The size ranged from 46 to 123 mm for males and 51 to 125 mm for females. In general, the size group 81-110 mm constituted over 80 % of the population. Comparison of the size-frequency data from different depth zones reveals the occurrence of younger prawns in relatively deeper waters. The mean sizes were 90.9 mm for males and 97.6 mm for females in depth zone 201-300 m, while in depth zone 301-400 m the same were 92 mm and 98 mm for the two sexes respectively during Cruise-40. The prawns caught during Cruise-42 were considerably larger in size than those caught during Cruise-40, the mean sizes being 98.7 mm for males and 102.5 mm for females.

Active breeding of the species was noticed at all depths. Out of the total number of 879 females examined, 497 (57 %) were in berried condition. The

TABLE 6. Length-frequency and mean size distribution of *Plesionika spinipes* by depth, cruise and sex

Total length (mm)	Depth : 201 - 300 m		Depth : 301 -400m			
	Cruise No. 40		Cruise No. 40		Cruise No. 42	
	Male	Female	Male	Female	Male	Female
48			1			
53			2	2		
58				1		
63	1		2	2		
68	1	1	1	1		
73	1		2	1		
78	5	2	4	1		
83	12	8	22	10	3	
88	20	18	16	10	16	15
93	18	33	52	32	62	44
98	17	43	42	53	123	144
103	4	34	23	65	84	155
108	2	11	5	22	27	97
113	2	8	1	9	8	22
118		2		3	1	23
123		1			2	5
Total	83	161	175	213	326	505
number						
Mean	90.9	97.6	92.0	98.0	98.7	102.5
size (mm)						

percentage of berried females in total females was relatively more at 201-300 m depth (85 %) than at 301-400 m (40-73 %), which would suggest that the species prefers shallower areas for breeding. The minimum size of berried female was 80 mm in total length.

Aristeus alcocki (Table 7)

Many authors have reported this species from Indian waters as *A. semidentatus* assigning commercial prospects. Recently Suseelan (1985, 1989) established its true identity as *A. alcocki*. During the present survey this species was caught between 273 and 421 m depth. Out of 321 specimens examined only 4 were males and the rest were all females.

The species exhibited a high degree of sexual dimorphism, males being considerably smaller than females. The sizes ranged from 91 to 98 mm for

TABLE 7. Length- frequency and mean size distribution of *Aristeus alcocki* by depth, cruise and sex

Total length (mm)	Depth : 201 - 300 m		Depth : 301 -400m			
	Cruise No. 40		Cruise No. 40		Cruise No. 42	
	Male	Female	Male	Female	Male	Female
93			1		1	
98			2			
103						1
108				1		2
113				1		3
118				3		
123				4		3
128		1		6		6
133				9		4
138				12		6
143		3		18		15
148		4		20		18
153		1		28		16
158		2		25		23
163		2		28		10
168				14		7
173				8		3
178				5		
183				3		
188				2		
<hr/>						
Total number	nil	13	3	187	1	117
<hr/>						
Mean size (mm)		148.0	96.3	152.8	93.0	148.5

males and 102 to 188 mm for females. Among females, majority were in the size range 141-165 mm. The mean size of female prawns ranged 148.0-152.8 mm.

Impregnated females were quite common in the catches at all depths. Spawners were, however, observed only in the 301-400 m depth zone. The smallest mature female measured 123 mm in total length. Fully mature ovary was purple in colour, with the posterior lobe extending upto the end of 6th abdominal segment. At 301-400 m depth about 18 % of the females were in fully mature condition.

Being the largest of the deep-sea prawns of

this area, this species is likely to be targeted for large-scale exploitation.

Penaeopsis jerryi (Table 8)

Previously known from these waters as *P. rectacuta*, this species occupied more or less the same habitat of *P. spinipes*. Females were found far in excess of males in the population, the overall sex ratio of 931 specimens studied being 30 : 70.

Females were invariably larger than males. The total length ranged from 51 to 100 mm for males and 62 to 120 mm for females. Bulk of the catch, however, was constituted by the size groups 71-90 mm in males and 81-105 mm in females. The mean sizes were slightly smaller for male (78.8 mm) as well as for female (88.0 mm) prawns at 201-300 m depth, while at 301-400 m depth the mean sizes of the male and female populations ranged 79.5-85.6 mm and 89.4-92.5 mm respectively.

Fully mature females were encountered in

TABLE 8. Length- frequency and mean size distribution of *Penaeopsis jerryi* by depth, cruise and sex

Total length (mm)	Depth : 201 - 300 m		Depth : 301 -400m			
	Cruise No. 40		Cruise No. 40		Cruise No. 42	
	Male	Female	Male	Female	Male	Female
53	1					
58	1		4			
63	5	9	4	12	1	1
68	3	11	3	2	1	4
73	11	6	6	6	2	2
78	15	6	13	1	15	12
83	23	8	16	21	42	44
88	8	18	13	23	64	75
93	3	31	3	34	14	117
98	1	24	2	26	3	79
103		9		12		39
108		4		4		5
113				1		4
118		1		1		2
<hr/>						
Total number	71	127	64	143	142	384
<hr/>						
Mean size (mm)	78.8	88.0	79.5	89.4	85.6	92.5

the catches at 301-400 m depth. In February, about 5 % of the female population were in spawning condition. The minimum size at first maturity of female was observed at about 83 mm. In fully mature condition the ovary appeared dark green as in most of the littoral penaeids.

Solenocera hextii

Though numerically less abundant in the deep-sea catches, this species assumes importance on account of its attractive size. It can be easily made out in a catch from its light colour and robust body. The males and females were more or less evenly distributed in the population. The size ranged from 80 to 115 mm for male and 91 to 140 mm for female. Majority of the catch belonged to the size groups 110-115 mm and 120-135 mm for the two sexes respectively.

Puerulus sewelli (Table 9)

Represented in both the depth zones. A total number of 932 lobsters have been examined, of which 513 were males and 419 females. In 201-300 m depth zone females dominated forming 63 % of the entire population. In 301-400 m depth zone, the proportion of females reduced to 46 % in January and 34 % in February.

The size range of the lobster observed during this survey was 71-200 mm, of which the size group 121-170 mm accounted the bulk of the catch in 301-400 m depth. Between the sexes no appreciable difference in size was noticed. In 201-300 m depth zone the principal size group was 136-145 mm for males and 151-175 mm for females. Individuals smaller than 96 mm total length were caught only during Cruise - 40 at 301-400 m depth. The mean size of the species was estimated at 141.4 mm for male and 157.9 mm for female in the 201-300 m depth zone. The distribution of mean sizes in the 301-400 m depth zone showed slightly a different picture. In males, the mean size values for the two cruises were significantly higher (142.1 & 147.2 mm), while in females a marked reduction in the mean size values (143.5 & 143.7 mm) was noticed as compared to the mean size estimates of the 201-300 m depth zone.

The species was found to breed more actively in depth zone 201-300 m as evidenced by a greater proportion of ovigerous females (85.3 %). In the 301-400 m depth zone also a high percentage of ovigerous females (30.5-59.4 %) was noticed during both the cruises. According to Kathirvel *et al.* (1989) the species breeds throughout the year, with two

TABLE 9. Length- frequency and mean size distribution of *Puerulus sewelli* by depth, cruise and sex

Total length (mm)	Depth : 201 - 300 m		Depth : 301 -400m			
	Cruise No. 40		Cruise No. 40		Cruise No. 42	
	Male	Female	Male	Female	Male	Female
73				2		
78				1		
83			1	1		
88			2			
93	1	1	6	4		
98			3	4	2	
103			1	5	2	3
108	1		3	2	4	6
113		1	3	2	4	
118	2	2	6	7	7	5
123	3	1	10	11	11	5
128	5		12	9	10	13
133	4	5	25	11	10	8
138	10	4	41	14	28	11
143	12	7	30	26	17	10
148	6	5	24	34	21	8
153	4	17	28	19	19	4
158	2	12	24	21	15	7
163	2	11	8	11	10	4
168	3	12	10	11	20	7
173	4	10	9	7	9	7
178		9	2	4	6	1
183		2	2	2	3	3
188	1	1		3	3	1
193		1		1	2	2
198		1				
<hr/>						
Total number	60	102	250	212	203	105
<hr/>						
Mean size (mm)	141.4	157.9	142.1	143.5	147.2	143.7

peaks, the major one during January-April and the other in October. The smallest berried female encountered during the present study measured 120 mm.

Examination of the stomach contents of 100 specimens has revealed that the lobster mainly

feeds on deep-sea prawns, bivalves, cephalopods and fishes.

Charybdis (Goniohellenus) smithii

The swarming crab was recorded only during Cruise 40. A total number of 260 specimens were sexed and measured. In the record haul at station 19, females accounted about 75 % by number, while in all the other hauls males dominated. The overall size ranged from 42 to 72 mm in carapace width. The major size groups were 56-65 mm for males and 46-55 mm for females. All the crabs examined were mature. Among females, about 90 % were berried thereby indicating that the species breeds actively in January.

DISCUSSION

A comparison of the prawn catches obtained during the two cruises of *Sagar Sampada* would indicate that Cruise-40 registered higher catch rates than cruise-42 from more or less the same fishing grounds. This may be due to the change in the cod end mesh size of the nets used for the survey. During Cruise-40, the smaller cod end mesh size (22 mm) has yielded better prawn catch together with the capture of smaller size groups for some of the species in significant numbers (Tables 6 and 8). A cod end mesh size of 40 mm, which was used during Cruise-42, appears unsuitable for the exploitation of prawn resource which includes several species growing to different sizes. It is therefore possible that for economic shrimp fishing in the Quilon Bank, a medium mesh-size of about 30 mm for the cod end may prove better in terms of yield and size of the prawns. From the conservation point of view also this will be helpful since destruction of young prawns will be less when the resource is subjected to commercial fishing.

Among the various species of prawns observed during the survey, species such as *A. alcocki*, *H. woodmasoni*, *H. gibbosus*, *S. hextii*, *P. spinipes* and *P. jerryi* attain fairly good sizes which are comparable to many of the coastal species presently used for export. It is therefore suggested that commercialised fishing on these specific resources may be encouraged in order to augment our export earnings. The post-harvest technology for deep-sea prawns in the country does not seem to have attained perfection which is an essential prerequisite for promotion of their export. Priority attention is therefore required for more research input on preservation and processing of this new resource.

Being cold water species, the chances of post-harvest spoilage are more for these animals as compared to coastal shrimps. During the course of this survey it was observed that the vulnerability to and time taken for spoilage (indicated by blackening of cephalothorax) on deck varied considerably from species to species. Some of the species like *P. jerryi* and *S. hextii* were found to spoil quickly and hence required immediate removal from the catch and proper preservation. It will be worthwhile to investigate on the biochemical or other factors responsible for the quick spoilage of these species.

The deep-sea lobster *P. sewelli* is an important resource considering its high export potential. During the present survey considerable variations were noticed in the proportion of male and female in the population. The distribution of sex ratios with reference to depth indicates migration of females to shallower areas during January-February. According to Kathirvel *et al.* (1989), *P. sewelli* performs bathymetric movements associated with breeding activity. In January the lobsters move to 150-200 m depth zone from the deeper waters and linger there till April/May. They return to the deeper waters in June and remain there till December. These authors have also observed that in the Quilon Bank females dominated in the population during January-April and August-December. The data on hand suggest that among the two sexes female lobsters tend to migrate to shallower areas earlier or more actively than males. The reduction in mean size of females at 301-400 m depth and a corresponding increase in the same at 201-300 m depth would be an added evidence pointing to migration of larger population from deeper to shallower areas. As maximum percentage of ovigerous females is recorded in the 201-300 m depth zone the migration of larger population to shallower areas may be correlated with breeding.

ACKNOWLEDGEMENT

The authors are grateful to Dr. P.S.B.R. James, Director CMFR Institute, Cochin for his keen interest and encouragement in this study.

REFERENCES

- ALCOCK, A. 1901. *A Descriptive Catalogue of the Indian Deep-Sea Crustacea, Decapoda, Macrura and Anomala, in the Indian Museum, Being a Revised Account of the Deep-Sea Species Collected by the Royal Marine Survey Ship "Investigator"*. Calcutta, India, 286 P.

- CHACE, F. A., JR. 1985. The caridean shrimps (Crustacea : Decapoda) of the Albatross Philippine Expedition, 1907-1910, Part 3: Families Thalassocarididae and Pandalidae. *Smithsonian Contributions to Zoology*, No. 411 : 143 P.
- HOLTHUIS, L.B. 1984. Lobsters. In: *FAO Species Identification Sheets for Fishery Purposes. Western Indian Ocean (Fishing Area 51)* Fischer, W. and G. Bianchi (Eds.), Vol.5 (Unpaginated).
- JAMES, P.S.B.R. 1987. The potential marine fisheries resources and possibilities of exploiting the same to increase marine fish production. *Proc. Inter. Sem. Training and Education for Marine Fisheries Management and Development*, January 1986, Cochin, India, pp. 5-17.
- KATHIRVEL, M., C. SUSEELAN AND P. VEDAVYASA RAO 1989. Biology, population and exploitation of the Indian deep-sea spiny lobster, *Puerulus sewelli* Ramadan. *Fishing Chimes*, 8 (11): 16-25.
- KURIAN, C.V. 1965. Deep-water prawns and lobsters off the Kerala coast. *Fish. Tech.*, 2 (1) : 51-53.
- MOHAMED, K.H. AND C. SUSEELAN 1973. Deep-sea prawn resources off the southwest coast of India. *Proc. Symp. Living Resources of the seas around India*, Spl. Pub. C.M.F.R.I., India, pp. 614-633.
- OOMMEN, P. VARGHESE 1980. Results of the exploratory fishing in Quilon Bank and Gulf of Mannar. *IFP Bulletin* No. 4: 1-49.
- RAO, P. VEDAVYASA, M.J. SEBASTIAN AND P.K. NAIR 1965. On the occurrence of *Squilla Leptosquilla* Brooks (Crustacea, Stomatopoda) in the west coast of India. *J. mar. biol. Ass. India*, 7 (2) : 468-469.
- SILAS, E.G. 1969. Exploratory fishing by R.V. Varuna. *Bull. Cent. Mar. Fish. Res. Inst.*, No. 12 : 1-86.
- SUSEELAN, C. 1974. Observations on the deep-sea prawn fishery off the southwest coast of India with special reference to pandalids. *J. mar. biol. Ass. India*, 16(2) : 491-511.
- SUSEELAN, C. 1985. Studies on the deep-sea prawns off south west coast of India. Ph.D. Thesis, Cochin, Univ. Science and Technology, Kerala, India, pp. 1-334.
- SUSEELAN, C. 1988. Bathymetric distribution and relative abundance of potentially commercial deep-sea prawns along the southwest coast of India. Symposium on Tropical Marine Living Resources, Cochin, India, 12-16 January, 1988. *Abstracts*, p.37.
- SUSEELAN, C. 1989. Taxonomic notes on a potentially commercial deep-sea prawn from the southwest coast of India. *J. mar. biol. Ass. India*, 31 (1 & 2) : 54-58.
- SUSEELAN, C. AND K.H. MOHAMED 1968. On the occurrence of *Plesionika ensis* (A. Milne Edwards) (Pandalidae, Crustacea) in the Arabian Sea with notes on its biology and fishery potentialities. *Ibid.*, 10 (1) : 88-94.