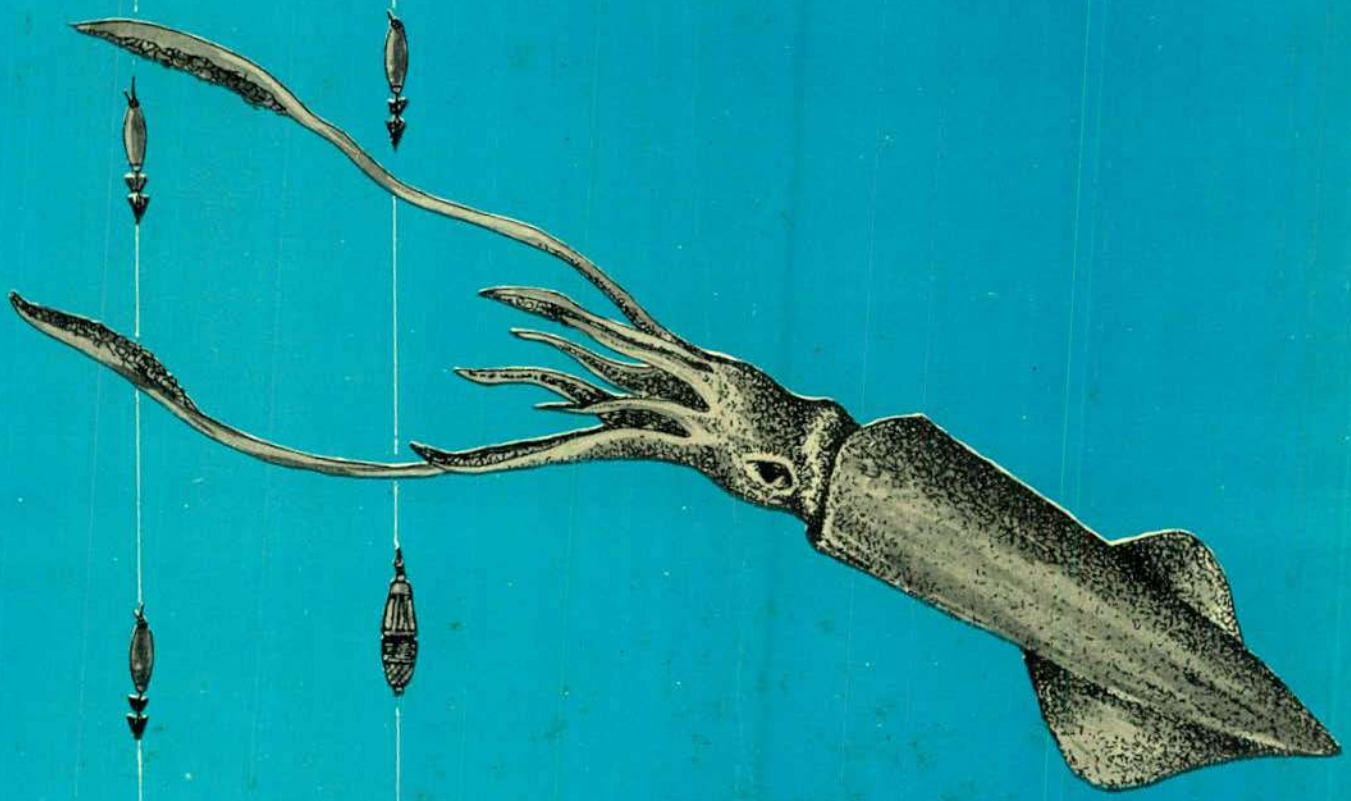
Bulletin 23

EXPLORATORY SQUID JIGGING IN INDIA WITH NOTES ON BIOLOGY OF SQUIDS



FISHERY SURVEY OF INDIA
Government of India
(Ministry of Food Processing Industries)
Bombay

July 1992

EXPLORATORY SQUID JIGGING IN INDIA
WITH NOTES ON BIOLOGY OF SQUIDS

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Bulletins are issued by Fishery Survey of India with the objective of presenting results of comprehensive studies on the marine fisheries resources

Abbreviation: ***Bull. Fish. Surv. India***

Published by: D. Sudarsan, Director General, Fishery Survey of India
Botawala Chambers, Sir P.M. Road, Bombay 400 001
Secretarial Assistance: Meena A. Chawla and Radha P. Balchandani
Cover Design: R. Selvaraj, Drawing: R.V. John

Price : Rs. 19/-

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AN ACCOUNT OF EXPLORATORY SQUID JIGGING OFF WEST COAST OF INDIA

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Fishery Survey of India

INTRODUCTION

Cephalopods comprising mainly squids and cuttle fishes form an important resource of world oceans. The world cephalopod production was around 2.54 million tonnes during 1989 (FAO, 1991). Japan is the leading cephalopod producing country with an average annual landing of 0.66 million tonnes during 1984-89, of which 90% is constituted by squids. The other important contributors to cephalopod landing are Spain, Republic of Korea, Thailand, U.S.S.R., Philippines etc. The rapid increase in the landings of this group was mainly due to increase in demand for this group in the Japanese market and simultaneous increase in fishing effort to exploit this group all over the world using sophisticated methods especially for squids by jigging.

Cephalopods form only 2.85% of the total marine fish landings in India. Even today cephalopods are landed as by-catches all along the coast by trawlers. However, there was a phenominal increase in the landings of this group during the last two decades, from less than thousand tonnes during late sixties to about 61147 tonnes in 1989. This was mainly due to growing export of this group. During 1988-89, 24672 tonnes cephalopods valued at Rs. 58.4 crores were exported from India of which squids constituted 25% of the total marine products export from the country (Anon, 1989).

Cephalopods are landed mainly as by-catches of bottom trawlers all over the world. However, light attracted jigging is a fishing method exclusively developed to catch squids. Hand jigging was done in Japan, Philippines, Korea and elsewhere using single or multiple jigs. After 1945, the squid jig and jigging methods underwent radical changes and subsequently automatic squid jigging from large factory vessels of 300-500 GRT was introduced especially for distant water fishing.

The demersal resources survey carried out by Fishery Survey of India in the recent past had revealed existence of potential grounds for cephalopods all along the coast. Sulochanan and John (1982), Joseph (1986) and Philip and Somvanshi (1991) have dealt in detail about the distribution and abundance of cephalopods along west coast based on the demersal resources surveys.

In India light fishing experiments were conducted in the Gulf of Mannar for Clupeids where the squids also formed substantial quantities in the catches. CMFRI (1957), Chellappan (1959), Nair (1985) and Nair and Omana (1985) have given fairly good account on the light fishing experiments conducted in the Gulf of Mannar and Vizhinjam.

The Fishery Survey of India acquired a long liner cum squid jigger **Matsya Sugundhi** and attempted squid jigging off south west coast during 1980. However, the operation was not successful mainly due to lack of expertise and technical know-how. A demonstration cum training squid jigging programme was organised by Marine Products Export Development Authority during 1985 by employing a 13m vessel under the guidance of a Japanese master fisherman, Cap. Makotu Yamasaki. In 1988, services of a Japanese expert, Capt. E. Haruta was provided to FSI and squid jigging programme was taken up by the organisation during June 1988-May 1989. In this study, results of squid jigging operations conducted off south west coast from **Matsya Sugundhi** and operations conducted to a limited extent along Gujarat coast from the 17.5 m vessel **Meena Prapi** are presented.

METHODOLOGY

Principle of squid jigging

The basic principles involved in jigging are:

(i) Squids are attracted to artificial light and they aggregate close to the illuminated area and

(ii) Squids are easily attracted to a fast-moving bait or a bait like object.

Advantage of these two habits of squids are taken in the above fishing method.

Fishing vessel and gear

The vessel **Matsya Sugundhi** (31.5m OAL, 245.8 GRT and 650 BHP) equipped with two 120 KVA generators of 440 V and a step down transformer, was deployed for the squid jigging operations. Fig.1 illustrates the deck lay out and general arrangement of the vessel.

Eight automatic squid jigging machines are provided on the aft deck of the vessel which are placed on raised platforms above 1.5 m

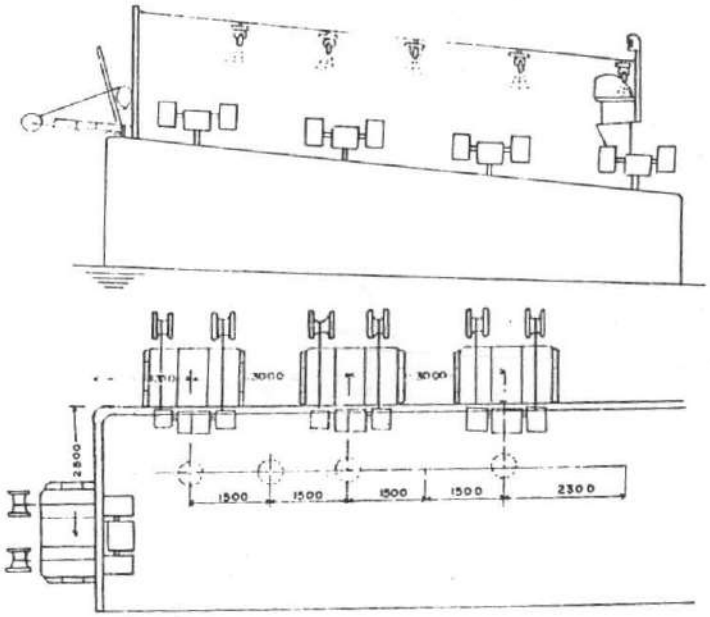

Fig.1 Aft deck layout showing arrangement of squid jigging machines and lamps (Port side)

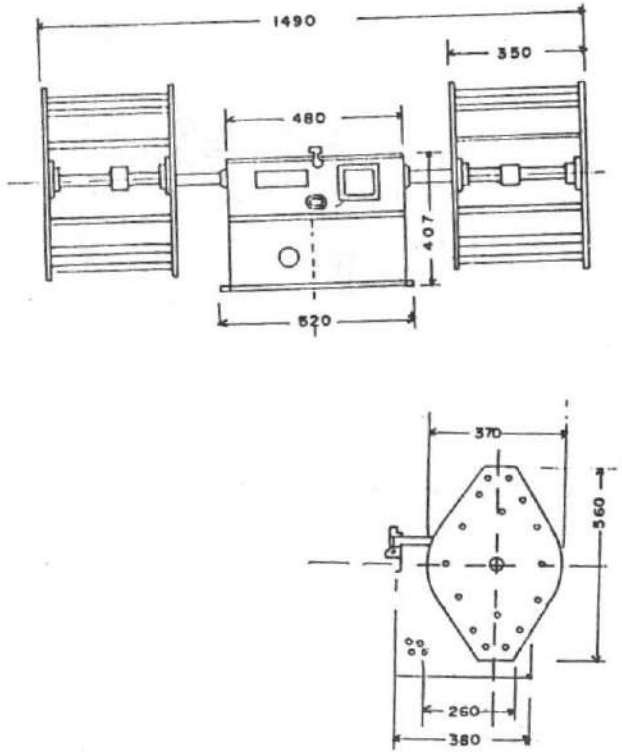

Fig.2 Schematic diagram of jigging machine and side view of hexagonal drum

from the deck level on either side and stern (starboard side-4, port side-3 and stern-1). The speed and depth of operation can be adjusted by control knobs. Two hexagonal drums (windlass drums) are mounted on either side of the machine, on a shaft which moves on either way horizontally and facilitates rotation of the drums. Fig.2 illustrates the schematic diagram of the machine and the side view of the drums. The "jigging" gear is wound on the above drums. Each unit is equipped with a push bottom remote control box on a cord which allows control of more units by one man.

A collecting net is mounted (Fig.3) in front of each machine on the gunwale of the ship protruding outward which facilitates collection of squids caught which fall on the net while the gear is in operation. Two front rollers are mounted on either side on the outboard end of the netting frame. The rollers are placed in alignment with the centre of the intermediate bearings on the horizontal shaft. The rollers are made of two plastic sheeves coupled together by a stainless steel coupling and a steel rod in the centre. While mounting the machine it should be ensured that the windlass drums of the machine are placed higher than the front rollers.

Two rows of halogen lamps (5 nos. each) of 3 KW/220V are provided on either side on the aft deck of the vessel between two poles and midship mast at about 3m height from the main deck for illumination. The position of the lamps are adjustable to ensure proper illumination in the fishing ground.

A 'jig' consists of a plastic body with one to three sets of barbless steel hooks at the lower end (Fig.4). The body of jigs varies in length from 45mm to 75mm and is made of soft or hard plastic of different colours such as red, green, orange, yellow, white or blue. Hollow vinyl steemed jigs are also being used recently. Jigs are both luminescent and non-luminescent. The jigs used in the experiments have body length of 50mm and two rows of 16 hooks each, 11mm in length.

The jigging line consists of a main line attached with a number of jigs (Fig.4). The main line is 2 mm dia. nylon monofilament gut. The jigging line is also made of nylon monofilament guts and its diameter varies from 0.5 mm to 0.9 mm according to the depth of operation. The line near the sinker has lesser diameter than that near the main line since the latter receives more strain. Thinner the line more will be the catch due to less visibility. In a jigging line about 25-30 jigs are attached in a series spaced 90-100 cm apart. The jigging line is attached with main line by means of a swivel (No. 4/0). A lead sinker weighing about 750 to 1000 gms is tied at the end of each line to keep

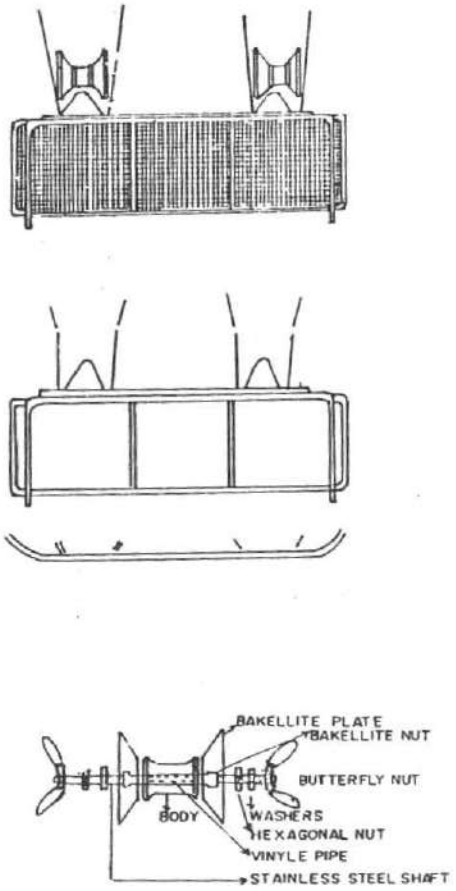

Fig. 3 Collecting net and front roller

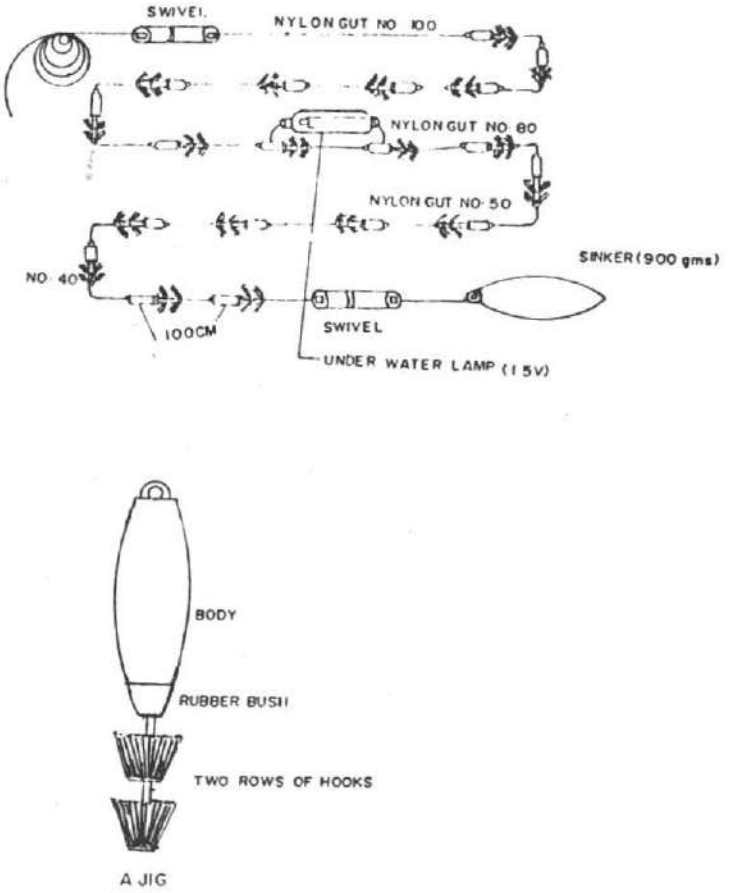

Fig.4 Schematic diagram of assembly of squid jigging gear and jigs

the gear in vertical position as it enters in water. When strong currents are encountered additional weights are added to each line. The jigging line while in motion runs through the front roller. One or two under water luring lamps (1.5V) are attached to jigging line separately, for luring the squids from deeper waters to the surface.

Fishing operations

On reaching the fishing ground, the illuminating lamps are switched on at around 6-7 p.m. depending upon the darkness. The presence of squids in the area is determined either visually or by an echosounder.

Squids attracted by the artificial light aggregate near the shadow zone of the vessel. Squids generally attack the jigs as they rise from the shadow zone to the lighted zone. Therefore the position of the boundary between the light zone and shadow zone is significant and jigging lines enter the water at or near this boundary. Fig.5 illustrates the position of illuminating lamps, light zone and shadow zone in relation to the position of vessel.

If sizable concentration of squid shoals are observed in the area, a parachute type sea anchor is shot from the bow of the vessel thus allowing the vessel to drift slowly with the current. A 25m dia sea anchor was used on board **Matsya Sugundhi.** Fig.6 illustrates the rigging details of sea anchor and its position while in operation.

When presence of squids is detected, one or two machines are set so that the jigs will fish at the depth indicated. The deeper running jigs lure the squids to the surface. Once the squids are near the surface all machines are switched on and the depth controls adjusted so that the last jig coming off the drum reaches about one meter below the water surface before the line is retrieved. As the jigs pass over the squid shoals, individual squids are caught on the jigs and while hauling the line with jigs over the front-roller, the squids get unhooked and fall on the collecting net. The fishing continues till 4-5 a.m. depending on the catch.

AREA AND PERIOD OF OPERATIONS

The vessel conducted jigging for neritic squids between lat. 8°N and 17°N in the depth range 25 to 200 m during June 1988 to May 1989 and for oceanic squids between lat. 10°N and 14°N in areas beyond 500m depth including Bassas-de-pedro (Paduva Bank) and Angria Bank during January and February. The squid jigging stations covered during the period under report is depicted in Fig.7.

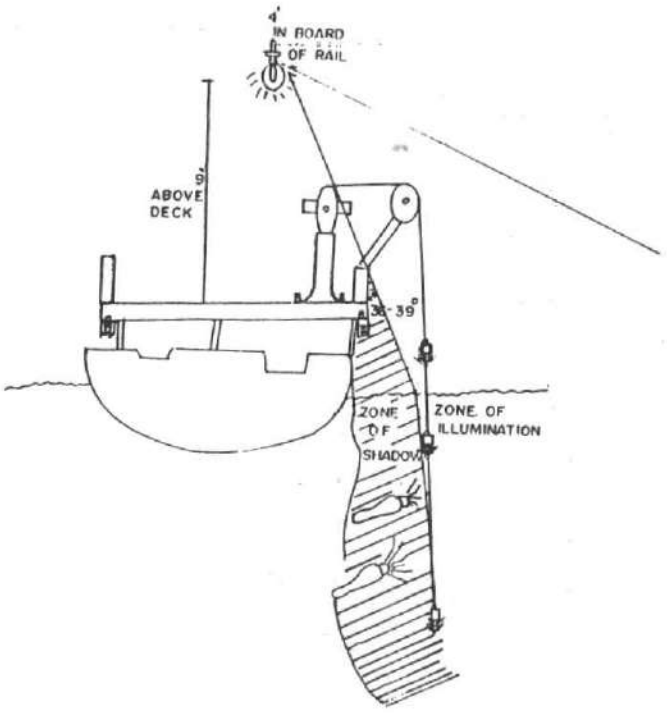

Fig.5 Position of lamp, light zone and dark zone in relation to vessel.

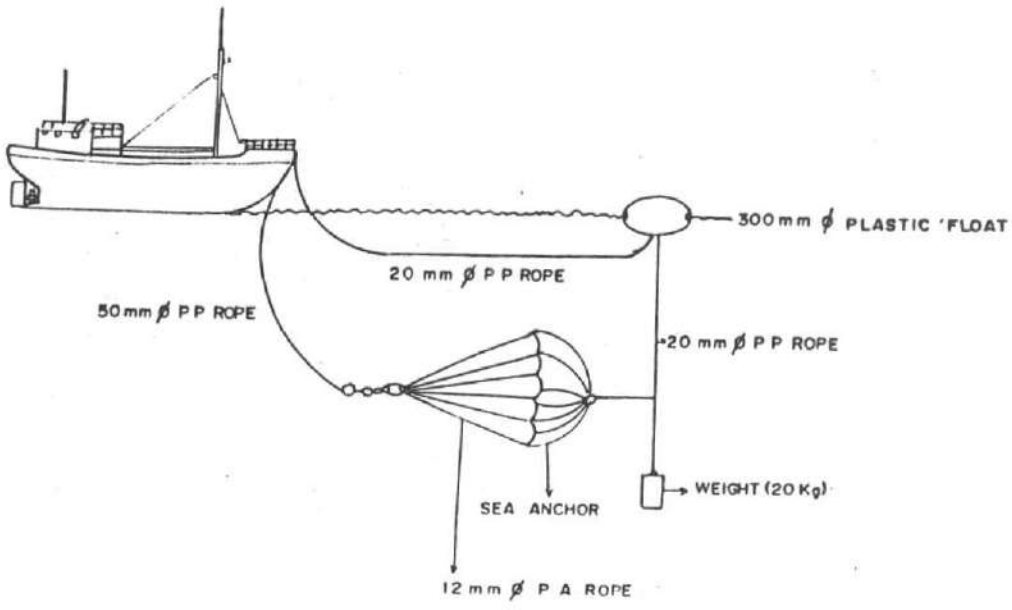

Fig.6 Rigging of sea anchor

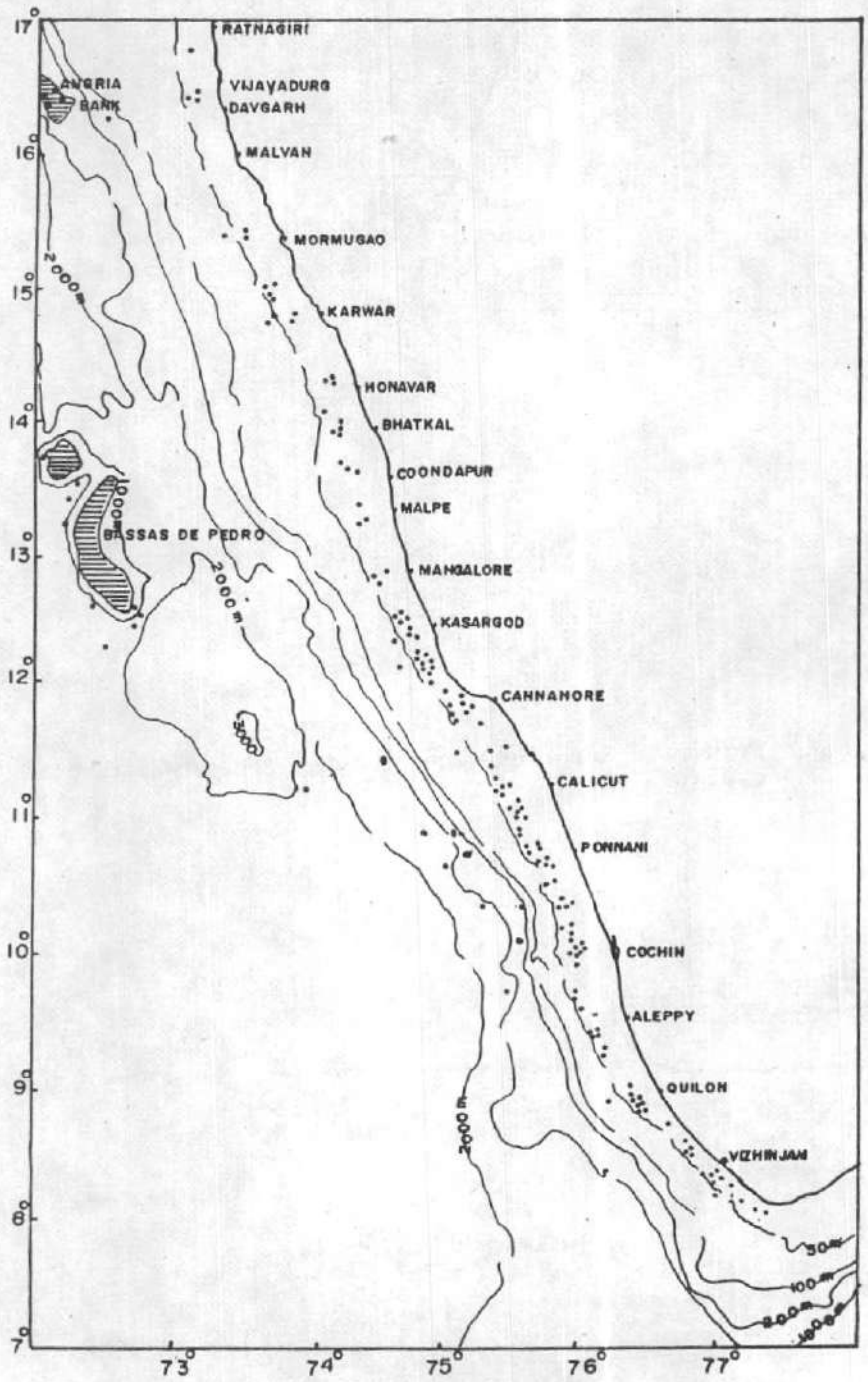

Fig.7 Areas of operation of squid jigging by Matsya Sugundhi

RESULTS

Distribution and abundance of neritic squids

Species composition

98% of the catch comprised of the short-fin squid **Loligo duvauceli.** This species has been observed from all the areas surveyed. Another species obtained during the survey was **Doryteuthis sibogae** which is caught mostly off Quilon (lat. 8°N), north of Cochin (lat. 10°N), off Cannanore (lat. 11°N), off Mangalore (lat. 12°N) as well as off Netrani island (lat. 13°N). Few specimens of **Loligo investigatoris** have also been recorded from the area lat. 11°N (34-36 m depth) during December 1988.

Month-wise results

The month-wise results of squid jigging operations are given below:

Month	No.of nights operated	No. of machine hrs.	Catch		CPUE			
			No.	Wt. (kg)	Per night		Per machine hr	
					No.	Wt. (kg)	No.	Wt. (kg)
June '88	18	444	2161	85	120	4.7	5	0.19
July '88	16	559	16409	1044	1026	65.25	29	1.90
Aug. '88	17	687	3796	304	223	17.9	6	0.44
Sept '88	15	508	1465	120	98	8.0	3	0.24
Oct. '88	17	918	4231	324	249	19.06	5	0.35
Nov. '88	16	458	1066	81	67	5.06	2	0.18
Dec. '88	16	898	3038	167	190	10.4	3	0.19
Jan. '89	4	154	102	9	26	2.25	1	0.06
Feb. '89	4	140	58	3	15	0.75	1	0.02
Apr. '89	6	228	79	8	13	1.30	1	0.04
May '89	15	706	2544	180	170	12.0	4	0.26
Total	**144**	**5700**	**34949**	**2325**	**242.7**	**16.15**	**6**	**0.40**

It may be seen from the table that the catch per unit effort (CPUE) is worked out on the basis of two parameters viz. number and weight of squids caught per night as well as per machine hour, since the number of machines/jigs operated in a day and during the entire period of operations was not uniform.

It may be seen from the above table that the highest catch rate of 1026 squids (65.25 kg) per night or 29 squids (1.90 kg) per machine hour was recorded during July 1988. Jigging operations were carried out for 144 nights expending 5700 machine hours in shallow waters (below 70m depth) for neritic squids with an average catch rate of 242.7 squids (16.15 kg) per night or 6 squids (0.40 kg) per machine hour. In general it was noticed that the squids were abundant during south-west monsoon period especially in the areas south of Cochin. The table given below presents details of some encouraging results recorded during the course of operations.

Month	Lat.	Depth (m)	No. of machines/ jigs	No. of machine hours	Catch per unit effort (per machine hour)	
					No.	Weight (kg)
June '88	8°	42-47	4/300	24.30	18	0.86
July '88	8°	42	7/420	49.00	67	4.1
July '88	8°	45	7/420	56.00	46	3.1
July '88	8°	46	8/480	72.00	48	3.1
July '88	8°	48	8/480	72.00	76	4.6
Aug. '88	8°	43	8/480	52.00	13	1.5
Sept '88	13°	37-42	5/300	39.00	16	1.4
Oct. '88	11°	50	8/480	86.00	16	1.0
May '89	10°	32	8/400	72.00	12	0.8

Area-wise results

Area-wise results are presented in the table given below:

Lat.	Depth range (m)	No. of nights operated	No. of machine hours	Catch		CPUE			
				No.	Wt. (kg)	Per night		Per machine hour	
						No.	Wt. (kg)	No.	Wt. (kg)
8°	32-59	32	675	20277	1346	634	42.06	30	2.00
9°	28-65	27	868	2315	134	86	4.90	3	0.15
10°	25-92	35	1557	5098	331	146	9.46	3	0.21
11°	34-55	17	808	3819	227	225	13.35	5	0.28
12°	27-65	19	815	1836	159	97	8.36	2	0.20
13°	32-42	4	183	1189	106	297	26.5	7	0.58
14°	35-56	5	93	159	6	32	1.2	2	0.06
15°	35-42	2	45	50	2	25	1.0	1	0.04
16°	35-132	3	12	206	15	69	5.0	3	0.20

The highest catch rate of 634 squids (42 kg) per night or 30 squids (2.0 kg) per machine hour was recorded from lat. 8°N followed by lat. 13°N (297 squids/26.5 kg per night or 7 squids/0.58 kg per machine hour). Some of the important areas where high concentrations were observed are off Quilon, off Ponnani, off Kasargod along Kerala coast, off Mangalore and off Netrani island along Karnataka coast. During July '88, 11 nights operation recorded an average catch rate of 1454 number of squids (92.6 kg) per night or 38 squids (2.4 kg) per machine hour in the areas off Quilon (lat. 8°N). Off Alleppy (lat. 9°N) yielded a catch rate of 389 squids (17.5 kg) per night or 12 squids (0.52 kg) per machine hour during December '88 and off Ponnani yielded 221 squids (18.29 kg) per night or 4 squids (0.36 kg) per machine hour during October 88. During the same month 432 squids (29.2 kg) per night or 8 squids (0.36 kg) per machine hour were also recorded off Kasargod (lat. 11°N). Limited operations carried out off Netrani island (lat. 13°N) recorded an average catch rate of 340 squids (28.5 kg) per night or 10 squids (0.80 kg) per machine hour during September 88 and 255 squids (24.5 kg) per night or 5 squids (0.44 kg) per machine hour during November 88.

Distribution and abundance of oceanic squids

The occurrence of oceanic squids in the Indian Ocean was reported by Clarke (1966), Filippova (1968) and Silas (1968). Based on the survey cruises of **R. V. Varuna,** Silas (op.ct) indicated that the ommastrophid squid viz. **Symplectoteuthis oualaniensis** (Lesser) was abundant in the plankton collections especially in areas between lat. 7°N and 17°N and long. 70°E and 78°E beyond the continental shelf and that the species exhibits positive phototaxis and is of aggressive nature.

The attempts made by **Matsya Sugundhi** during the cruises in January and February 1989 revealed that the oceanic squids are abundant in the areas east of Lakshadweep islands as well as around Bassas-de-pedro Bank (Padua Bank) and they are amenable to jigging. The results of jigging operations carried out for oceanic squids are presented in the table given below:

Month	No. of nights operated	No. of machine hours	Catch		CPUE			
			No.	Wt. (kg)	Per night		Per machine hour	
					No.	Wt. (kg)	No.	Wt. (kg)
Jan. '89	10	662	9343	525	934	52.5	14	0.80
Feb. '89	8	526	1032	68	129	8.5	2	0.13
Total	**18**	**1188**	**10375**	**593**	**576**	**32.94**	**9**	**0.50**

Comparatively encouraging results were obtained in respect of oceanic squids. Operations were made during 18 nights expending a total effort of 1188 machine hours in the oceanic region where the average catch rates were estimated as 576 squids (33 kg) per night or 9 squids (0.50 kg) per machine hour. During January 89, 934 squids (52.5 kg) per night or 14 squids (0.80 kg) per machine hour were recorded.

The area-wise results are presented in the table given below.

Lat.	Depth range (m)	No. of nights operated	No. of machine hours	Catch		CPUE			
				No.	Wt. (kg)	Per night		Per machine hr.	
						No.	Wt. (kg)	No.	Wt. (kg)
9°	1250	1	60	6	0.2	6	0.2	-	-
10°	674-2300	7	422	805	52	115	7.4	2	0.12
11°	1000-1594	2	154	333	23	167	11.5	2	0.15
12°	200-2000	5	344	4918	292	984	58.4	14	0.85
13°	900-1200	3	208	4313	225	1438	75	21	1.08

The areas lat. 13°N and 12°N around Bassas-de-pedro Bank yielded highest catch rates of 1438 squids (75 kg) per night or 21 squids (1.1 kg) per machine hour and 984 squids (58.4 kg) per night or 14 squids (0.85 kg) per machine hour respectively. In the southern areas from lat. 9°-11°N the concentration of oceanic squids was less or some of the larger specimens do not attack the jigs though they were present in sizeable numbers.

SEX RATIO AND LENGTH FREQUENCY

Loligo duvauceli

Sex ratio

In general the female squids were found dominant over male squids (M 48:F 52) and the female squids were dominant in all regions except Konkan coast (lat. 15°-17°N) where the sex ratio was M 54:F 46. Male squids outnumbered females in lat. 9°N (M 62:F 38), lat. 13°N (M 52:F 48) and lat. 16°N (M 63:F 37). Silas **et al.** (1986) based on the studies carried out both along east and west coasts of India during 1976-86 period observed that there is no significant difference in the male and female composition and they were distributed more or less in equal proportion.

The chi-square (X^2) test has been applied to find out significance of variations of sex ratio in different areas surveyed. It may be seen from the below mentioned table that significant difference in sex ratio could be observed only in geographical sector lat. 8°-10°N and

also on taking into consideration of the whole region. However, it is noticed that the sex ratio is not dependant on the area (X^2 = 5.991 d.f = 2). The sex ratio in different regions is depicted in Fig.8.

Area	Male	Female	X^2
8°-10°N	503	586	6.3259871**
10°-12°N	484	528	1.9130435
12°-15°N	420	429	0.0954063
15°-17°N	100	86	1.0537634
Total	**1507**	**1629**	**4.7461755****

** Significant

From the available data it is also observed that during July-October the female squids were found dominant over males whereas during November-December the male squids were dominant. The occurrence of female and male squids during different months and X^2 values are given below.

Month	Male	Female	X^2
July	264	287	0.9600726
August	197	283	15.488333 **
September	257	290	0.9954296
October	129	238	32.373297 **
November	341	306	1.3933539
December	307	201	17.280374 **
February	12	24	-
Total	**1507**	**1629**	**4.7461755 ****

** Significant

Thus it could be seen that significant variation in sex ratio was observed during the months August, October and December and the sex ratio is dependant on the months. (X^2 = 12.592 d.f = 14). The monthwise sex ratio of male and female squids is presented in Fig.9.

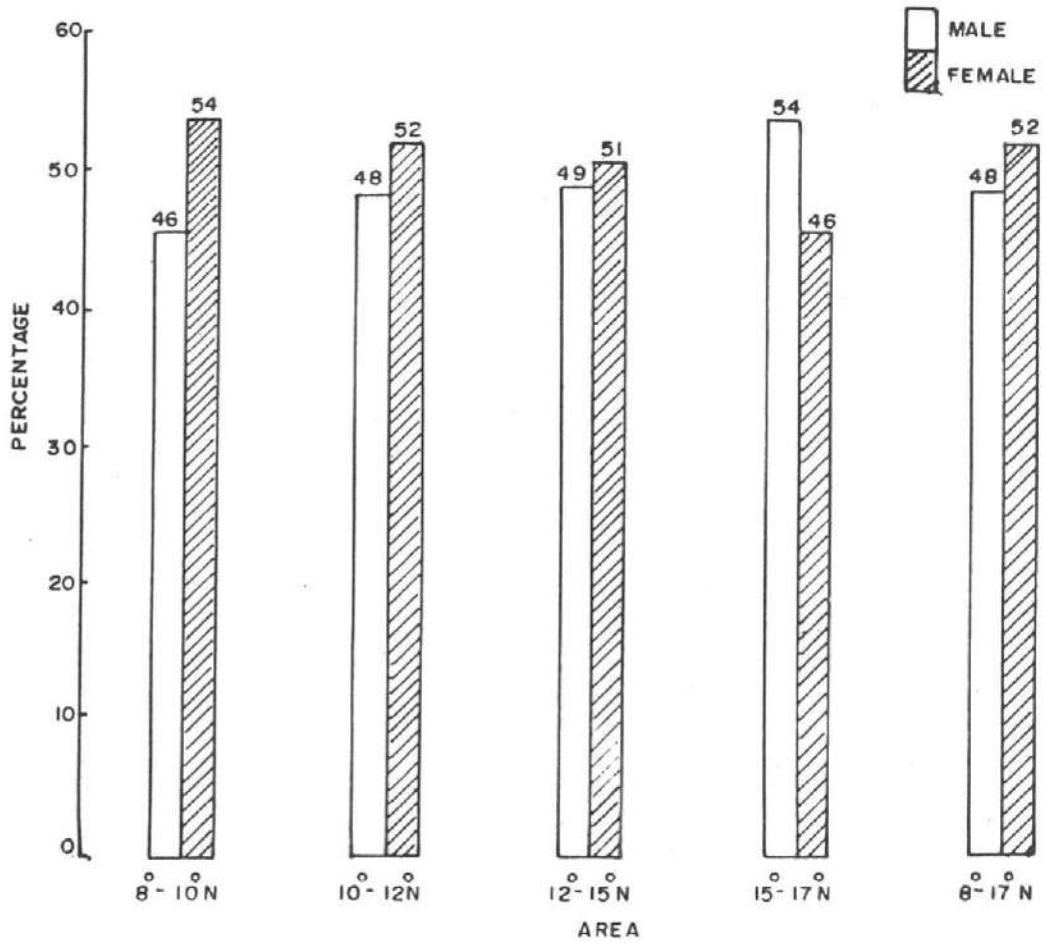

Fig.8 Sex ratio of *Loligo duvauceli* in different geographical divisions

Length frequency

The length frequency distribution of male and female specimens is presented in Fig.10. In general 130-139mm size group was dominant both in the case of male and female. The minimum and maximum sizes recorded were 65 mm and 310 mm respectively in the case of male whereas it was 60 mm and 205 mm in respect of female. The mean sizes in the case of male and female were 136.7 mm and 129.7 mm respectively. Meiyappan and Srinath (1989) indicated that the maximum sizes of male and female recorded along west coast were 285mm and 190mm respectively whereas the present observation indicates much higher values.

The month-wise distribution of different sizes of both male and female is presented in Fig.11. During July male specimens of size groups 110-119 mm and 130-139 mm were dominant whereas in the case of female 120-129 mm size group was predominant. However, during August comparatively large males of size 140-149 mm were found more and the same was the case of female as well. Marginally smaller size groups of 130-139 mm and 120-129 mm male and female respectively were dominant in September. More or less similar distribution pattern was noticed in October in respect of male, while 140-149 mm females were dominant. During November comparatively smaller sizes of male (120-129mm) and female (110-119mm) squids were more in the catches whereas still smaller sizes of male and females (100-109mm) in both cases were observed during December. During February the data were limited and hence not taken into consideration for this study.

Doryteuthis spp.

Two species viz. **Doryteuthis sibogae** and **D. singhalensis** were obtained. Length frequency data for the period July-December were taken into consideration. However, the sampling was very less during August and December.

Sex ratio

Unlike **L. duvauceli,** the male specimens were found predominant for this species (M 81:F 19). The male- female ratio observed during different months is given below.

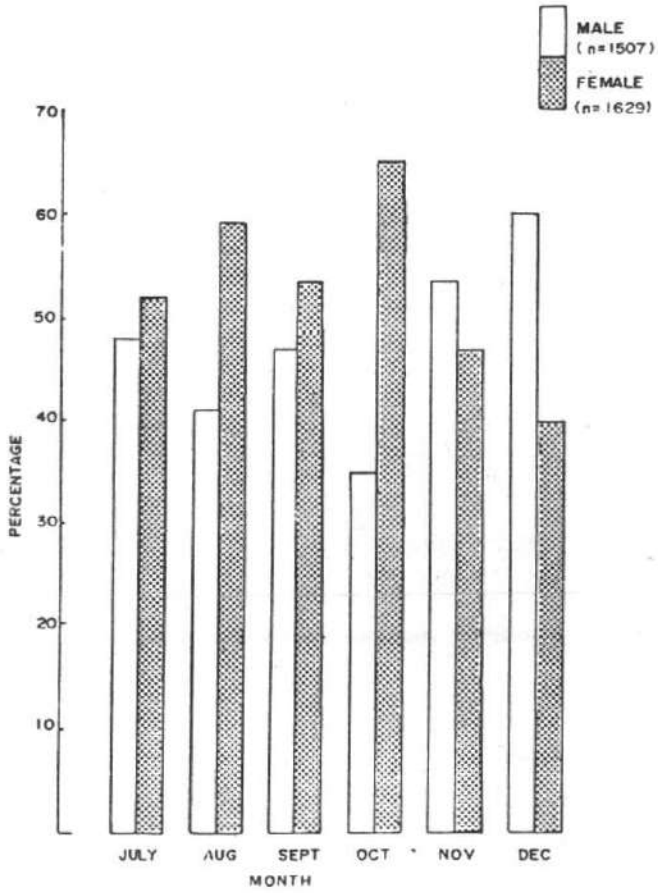

Fig.9 Sex ratio of *Loligo Juvaucelli* in different months

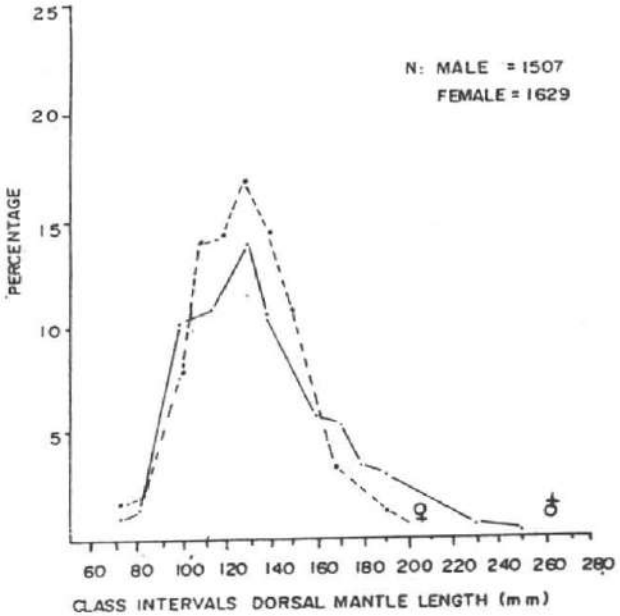

Fig.10 Length frequency of distribution of *Loligo duvaucelli*

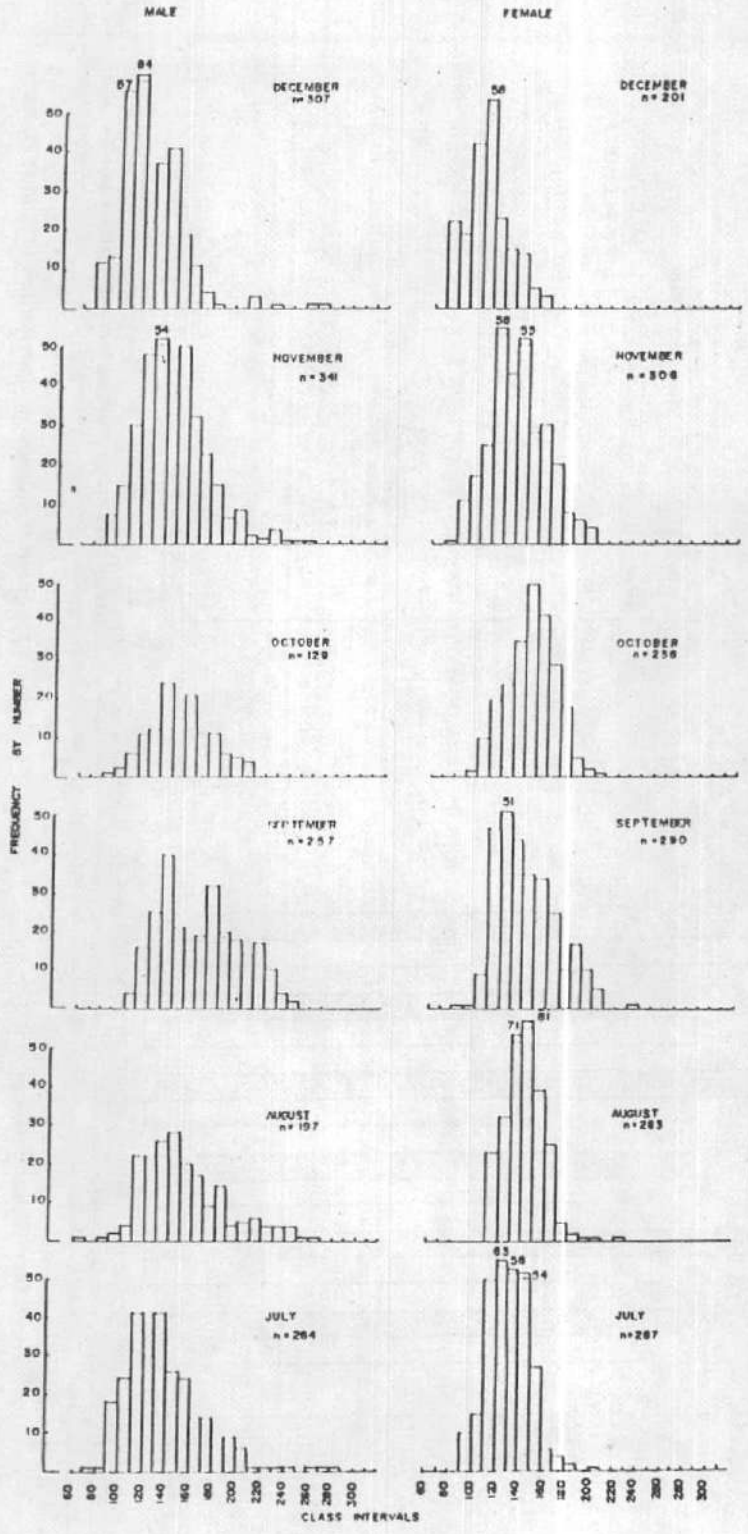

Fig.11 Monthly size distribution of *Loligo duvaucelli*

Month	Male	Female
July	57 (52%)	53 (48%)
August	29 (94%)	3 (6%)
September	3 (100%)	-
October	170 (94%)	10 (6%)
November	68 (86%)	11 (14%)
December	6 (67%)	3 (33%)
Total	**333 (81%)**	**80 (19%)**

Significant recording of female specimens were evident only in the areas off Quilon (lat. 8°N).

Length frequency

The length frequency distribution is depicted in Fig.12. In general, 220-229mm length group (dorsal mantle length) was dominant in respect of male squids whereas comparatively smaller size group of 150-159 mm was dominant in the case of female squids.

From the month-wise distribution depicted in Fig.13 it may be seen that 200-209 mm male specimens and 150-159 mm female specimens were dominant in July whereas during August comparatively larger male specimens of 250-259 mm size group were dominant. During October occurrence of male specimens of size group 240-249 mm were more whereas in November 220-229 mm size groups were dominant. Silas **et al.** (1986) reported the maximum size of male and female as 250 mm and 165 mm whereas in the present study male and female specimens of size 310 mm and 259 mm respectively were observed. The data during September and December were very limited and hence not taken into consideration.

Symplectoteuthis oualaniensis

Data for two months viz., January and February 89 only are available.

Sex ratio

The pattern of distribution of males and females of the oceanic

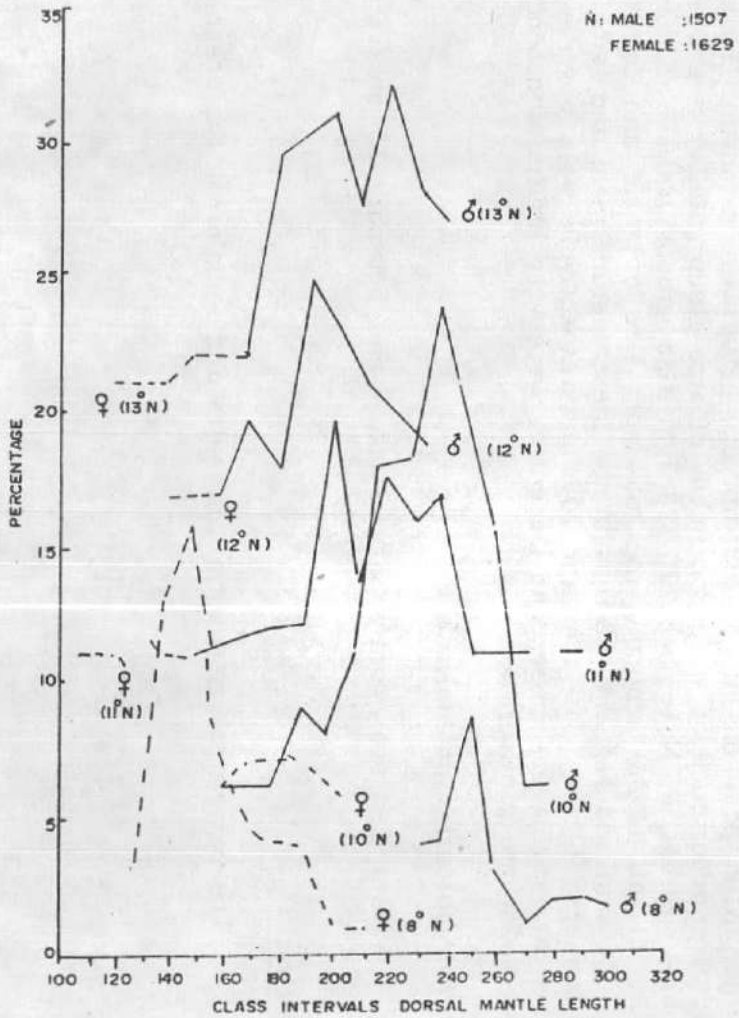

Fig.12 Length frequency distribution of *Doryteuthis sibogae*

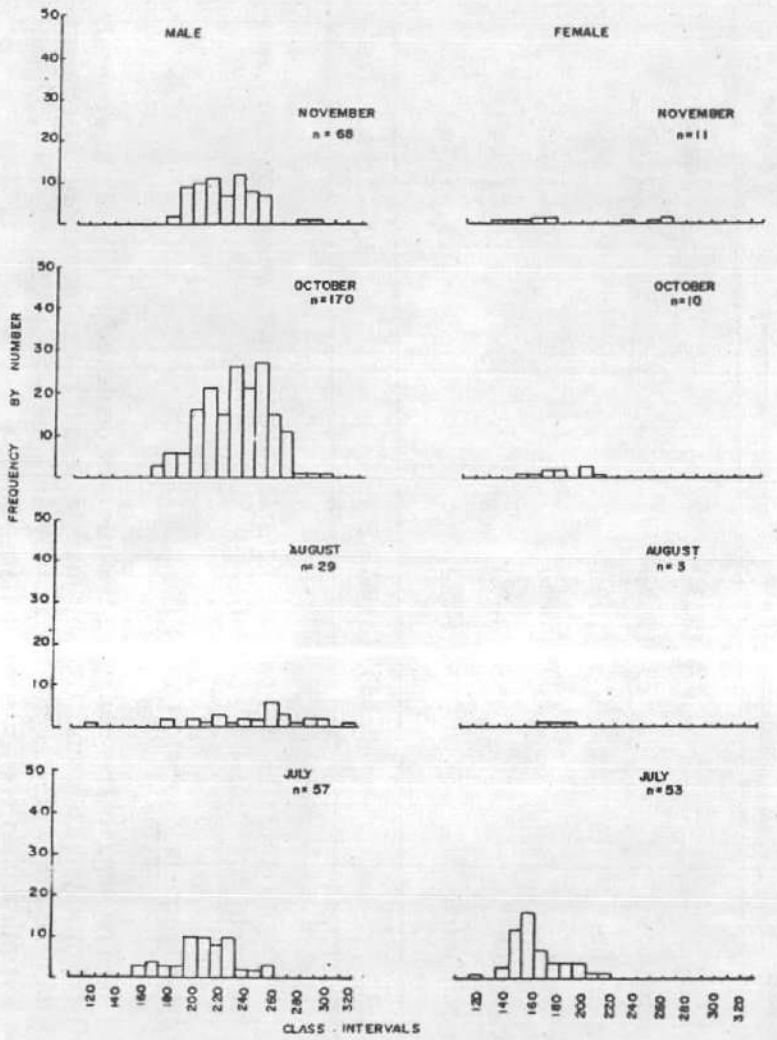

Fig.13 Monthly size distribution of *Doryteuthis sibogae*

squid was found different from that of the neritic squid and the female squids were dominant in all areas surveyed (M 30:F 70).

Length frequency

The maximum size of male squids recorded was 182 mm mantle length while the female specimens recorded upto 265mm. The month-wise length frequency distribution is presented in Fig.14. In general 110-129 mm size groups were dominant among both male and female.

SQUID JIGGING OPERATIONS OFF GUJARAT COAST

The 17.5 m vessel **Meena Prapi** based at Porbandar was utilised for a limited period from 15.1.90 to 8.2.90 for squid jigging operations off Gujarat coast. 2 sets of manually operated drum-type hand-jigging devices with line reels rigged with jigs, 2-3 numbers of hand casting jig-lines and 6 numbers of pole and lines with jigs were employed for fishing. 2 numbers of 2 KW halogen lamps with power supply from the vessel's generator were used for lighting. The jigs were operated during 14 nights spending 65.84 hours for actual fishing in the area lat. 20°N and 21°N between 30-50m depth range.

Altogether 271 numbers of squids weighing 34.4 kg were caught by the jigs. The area-wise operational details are furnished below:

Area	Depth range (m)	Fishing effort (Hrs)	Catch	
			No.	Wt. (kg)
Lat. 20°N	25-42	9.50	-	-
Lat. 21°N	32-47	56.34	271	34.42
Total	**25-47**	**65.84**	**271**	**34.42**

The catch was composed of only **L. duvauceli.** Biological observations indicated that females are dominant (M 46:F 54). 77% of the specimens were in matured stage. All the specimens were seen to be in well-fed condition with full stomach.

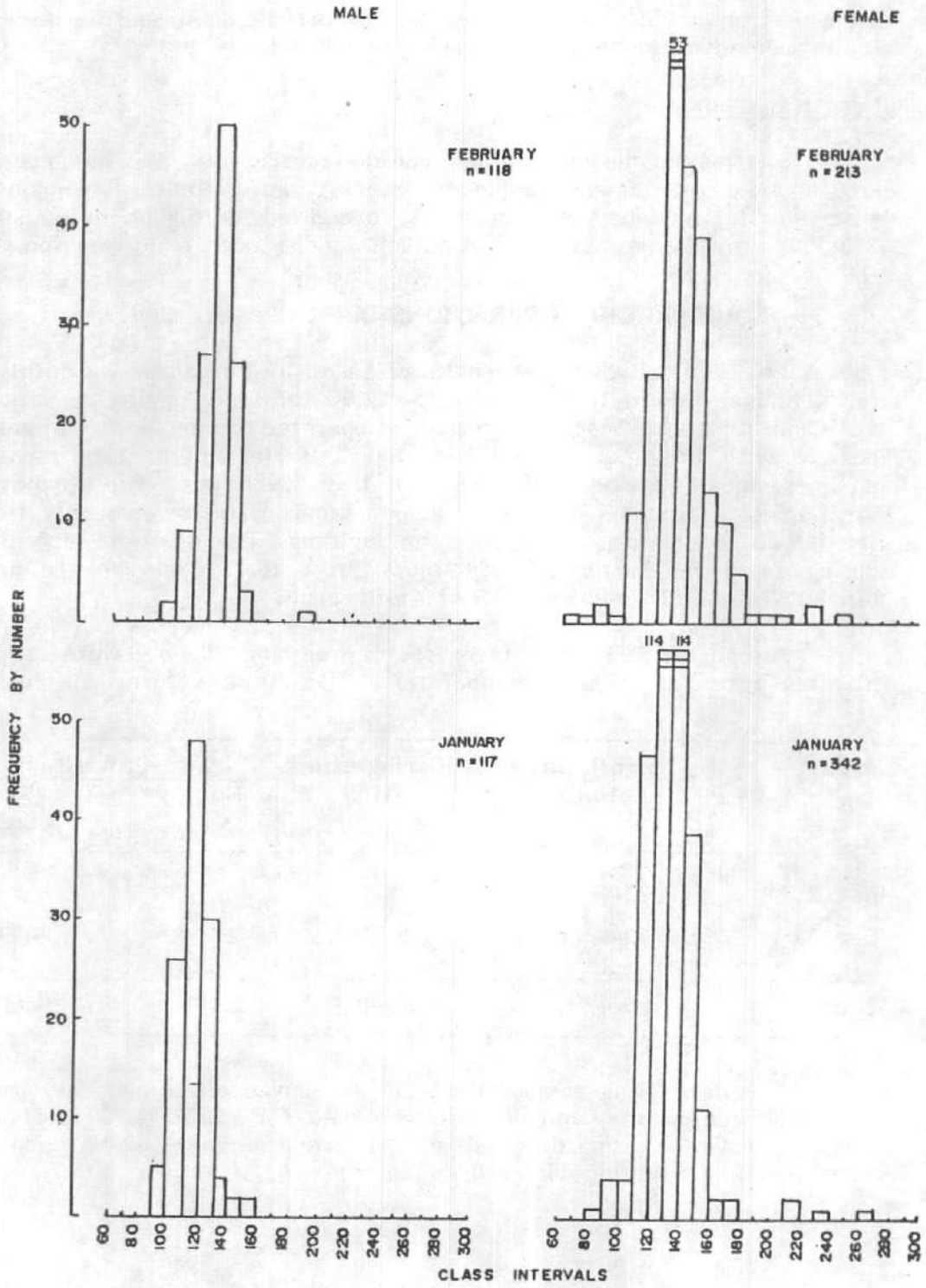

Fig.14 Monthly size distribution of *Symplectoteuthis oualaniensis*

DISCUSSION

Probably this is the first attempt to conduct experimental jigging to capture squids in Indian waters by employing a vessel fully equipped for this type of fishing. Though, the results were not so encouraging, the experiments show adaptability of the fishing method to Indian waters. Sizable concentration of squid shoals could be observed in the operational area during the entire period of operation.

The main reasons attributed to the low catch per unit effort recorded during the present experiments are :

(i) Major part of the cephalopod catch from our waters is taken from the shallow waters of less than 40 m depth, where the jigging operations were practically impossible due to presence of large number of gill netters during night all along the operational area.

(ii) Presence of predatory fishes like ribbon fishes, lizard fishes etc. in the operational area was observed as a major handicap for the successful jigging operations. Often, though sizable squid shoals were noticed near to the vessel, they were hesitant to come to the jigs and thereby the catches were very poor especially when ribbon fishes are present.

(iii) Presence of juveniles of other fishes and prawn larvae in the operational area also adversely affect the catches, as squids were observed actively feeding on them.

(iv) Large specimens of oceanic squids were found to be very active and aggressive in the light zone. However, they seldom come to the jigs on many occasions.

The predominent size groups encountered in the catches were 120-149mm size weighing 80-100 gms per piece.

From the limited operations carried out off Gujarat coast, it is rather premature to arrive at a conclusion about the feasibility of squid jigging in the above region, which is a potential area for squids where high catch rates have been recorded in bottom trawling.

The present study revealed that in general, the concentration of neritic squids was found to be more near river mouths than other areas. The studies on the relationship between lunar periodicity and

squid catch showed that in general relatively better catches were recorded during dark nights and new moon phase. Maximum catches were recorded during days immediately after new moon and a declining trend was noticed as lunar phase advances towards full moon. However, there were instances of good catches even on full moon days, when the sky was cloudy. Moreover, squid catches were observed to increase as night advances and in general high catch rates were recorded from midnight to early hours.

Another important observation is that the squids of size less than 60mm mantle length were practically nil in the catches and smaller groups do not appear to be attracted much to the jigs, though present in sizable quantities in the operational area.

Limited attempts made for oceanic squids in the areas around Lakshadweep islands were promising. Nair and Patwari (MS) reported that sizable concentration of oceanic squids were observed in the oceanic waters of north west coast (lat. 15°N-23°N). Oceanic squids are known to form a major food item of yellowfin tuna.

George **et al.** (1977) and Joseph (1985) have estimated potential yield of cephalopods from Indian waters at 180,000 tonnes. Silas (1986) opined that India's harvest of cephalopod by 2000 AD by the small scale sector would be at 50,000 tonnes and the oceanic sector at 25,000 - 50,000 tonnes. Based on demersal resources survey Sudarsan **et al** (1988) estimated a potential of 17,300 tonnes of cephalopods from 50-300m depth of Indian coast, which is further revised to 20,600 tonnes by Sudarsan **et al** (1991). Philip and Somvanshi (1991) have estimated the total biomass and MSY of squids and cuttle fishes from the continental shelf and slope at 46,036 tonnes and 49,100 tonnes respectively. Squids form 59% of the total biomass of cephalopods. The magnitude of oceanic squid resources of Indian EEZ and the contiguous zone is not fully known.

From the foregoing it may be seen that there is great potential for developing a fishery for cephalopods, particularly squids. There is need for immediate exploitation of neritic squid resource of the continental shelf by directed fishing methods viz. light fishing with dip nets, jigging etc. to augment the production of squid resources, which would definitely contribute to increase in the export earning of our country.

In Gulf of Thailand 13m vessels are being employed in squid fishing with light attraction in dipnet fishery. Some of available crafts in our country can be suitably modified for this type of fishing without much additional capital investment. Reduction in the cost of operation by way of fuel and lubricants by about 50% is yet another advantage.

Introduction of medium sized multi-purpose vessels suitable for trawling and light fishing in the night or lean period for shrimp is another proposition.

The studies on oceanic squid resource have to be taken up on a top priority basis to understand the magnitude of the resource as well as to develop suitable technology for effective exploitation of the hitherto unexploited resource of our Exclusive Economic Zone.

ACKNOWLEDGEMENTS

The authors are very much thankful to Dr. D. Sudarsan, Director General, Fishery Survey of India, Bombay for the valuable advice and encouragement given for undertaking the project as well as for the preparation of this paper. We also record our sincere thanks to Shri P. Sulochanan, then the Zonal Director of Cochin Base of Fishery Survey of India for his guidance as well as his keen interest in the operation of this vessel and preparation of this paper. We wish to record our sincere thanks to Capt. E. Haruta, Japanese Master fisherman for his sincere effort in rigging up the vessel as well as in training the crew in the operation of squid jigging gear. The master and crew of the vessel deserve special mention as without their whole hearted co-operation, the operation would not have been successful. We wish to record our sincere thanks and appreciation to all of them for their co-operation. Our thanks are also due to other scientist participants for the implementation of survey programme and collection of the data.

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BIOLOGY OF SQUIDS

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This section is based on the data collected in the squid jigging survey made by two vessels, **M.F.V. Matsya Sugandhi** and **M.V. Blue Fin** on the southwest coast of India during the 9-month period from June 1988 to February 1989. The data were collected onboard by the scientists of CMFRI who participated in the survey.

Three species of squids were jigged during the survey, and to understand some aspects of the biology of each of these species a general idea about their distribution and relative abundance in space and time is necessary. For this purpose, a one-degree square where jigging was done during the period is taken as a unit area.

Areas of operation

Sixteen one-degree were covered for jigging operations within 8-76 and 8-77 off Muttom-Colachel in the south and 16-72 and 16-73 off Ratnagiri in the north (Fig.1). These squares are so identified only to indicate the geographical location of jigging operations, and not related to the estimation of the resource potential of squids (which is not the aim of this section). The bottom depths ranged from 20 m to 80 m at areas near the coast; the squares 12-72 and 13-72 are in the oceanic region where the depth is very high, upto about 2,500 m.

Species composition

The squids taken in the jigging survey belong to three genera: **Loligo** (one species), **Doryteuthis** (two species) and **Symplectoteuthis** (one species). The relative abundance of these squids by number as well as by weight is shown in Fig.2. The squid belonging to the first neritic genus is **Loligo duvauceli** which accounted for 64% by number and 57% by weight of the total quantity of squids taken by jigging. Two species **(Doryteuthis singhalensis** and **D. sibogae)** belonging to the second neritic genus together constituted 12% by number and 13% by weight. The second in importance by number as well as by weight was the oceanic squid **Symplectoteuthis oualaniensis** contributing 24% and 30% respectively.

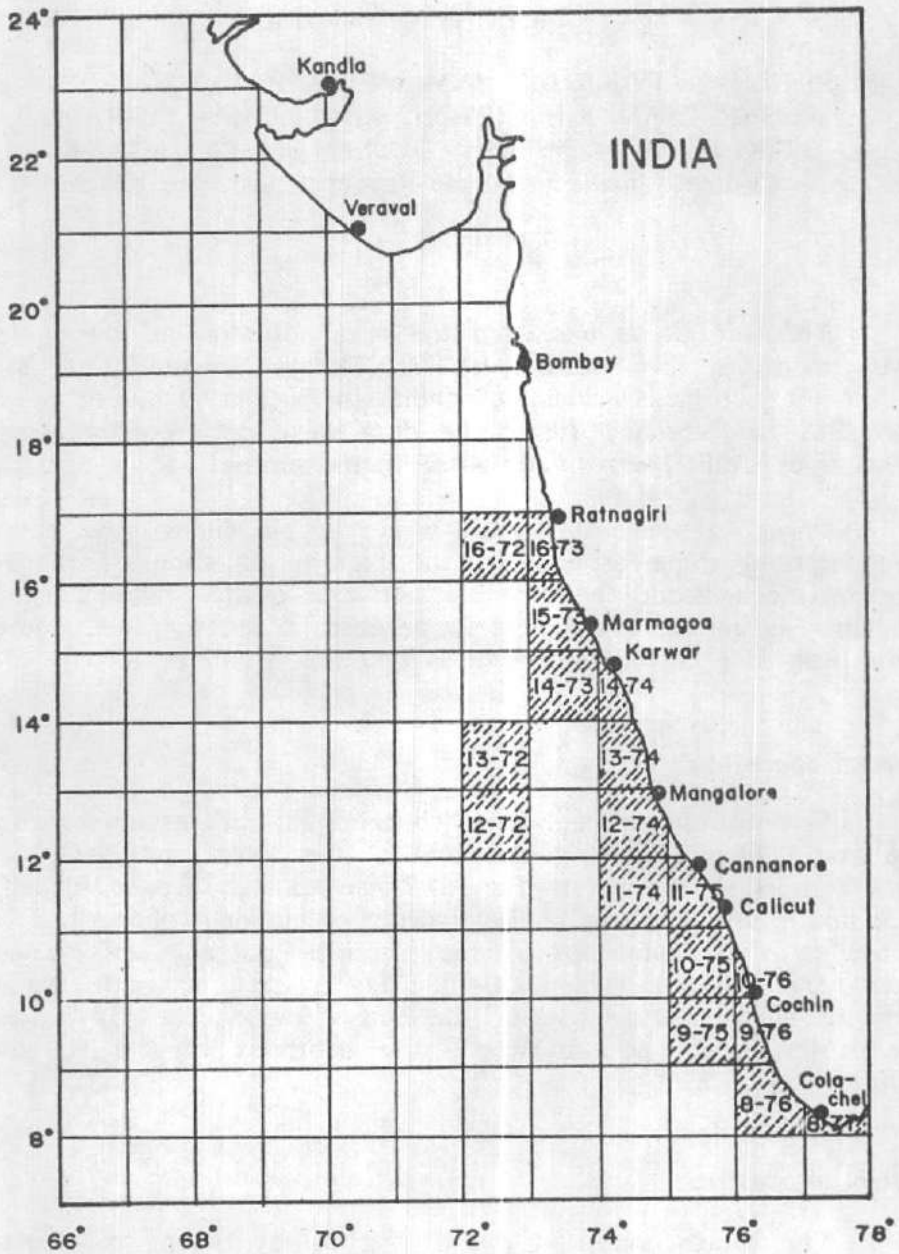

Fig.1 Areas (one-degree squares) of squid jigging operations on the west coast of India.

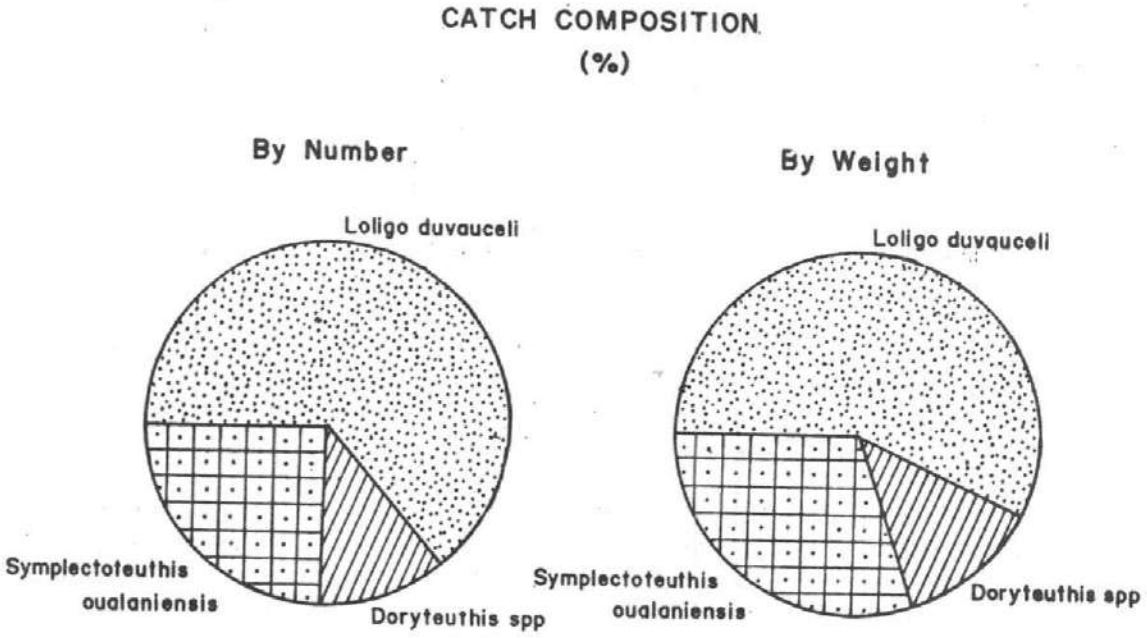

Fig.2 Species composition of squid catches by number and weight.

Species distribution by area

Fig.3 shows the distribution of different species of squids, based on their occurrence during the course of the jigging operations. The most widely distributed squid is **Loligo duvauceli** which occurred in 13 out of 17 squares off Muttom to Ratnagiri (Fig.3 A), mostly restricted to the coastal region within 100 m depth with abundant occurrence within 60 m. The maximum number of squids were taken from 8-76. Over 1000 squids each were obtained from 8-77, 9-76, 10-75, 11-75 & 12-74. While the catch was generally poor from 14 to 16 degree latitude squares, this squid did not occur in the oceanic areas of 12-72 and 13-72. Temporal distribution shows that the squid was obtained in almost all months when there was jigging operation. The maximum number (over 16,000) was caught in July 1988, mostly from the square 8-76.

The distribution of **Doryteuthis** spp is shown in Fig.3 B. These species occurred in six areas but abundantly (3,445 numbers) in 8-76, north of which their distribution was continuous but in lesser numbers. The data show that beyond 14 degree latitude these species are not distributed. Another significant observation was that the outer distributional limit of **Doryteuthis** is closer to the shore when compared to that of **Loligo duvauceli.** Most of these squids were taken from areas with bottom depths upto 62 m, particularly within 45 m and in the months of June to December.

Fig.3 C shows the distribution of the oceanic squid **Symplectoteuthis oualaniensis.** This species occurred in 6 out of 17 squares, confined to deeper areas. The southern limit was 9-75 with depth more than 1,200 m. Over 1,000 squids were obtained from 10-75 but the maximum numbers, above 4,000 each, were caught from 12-72 and 13-72 where the bottom depth range was 200-2,000 m. The northern limit for this squid was 16-72 from where only one squid was recorded. Since jigging operations in deeper areas were very limited, the occurrence of this species was recorded only in November, January and February.

Information collected on the biological aspects such as size composition, sex ratio, maturation, food and length-weight relationship of the squids is presented below:

1. LOLIGO DUVAUCELI

Size Composition

The size (dorsal mantle length) of male **Loligo duvauceli** jigged during the entire period ranged from 50 mm to 310 mm. Females were smaller in length, ranging between 50 mm and 230 mm. Fig.4 shows the length-frequency distribution by sex and by area (square) of occurrence.

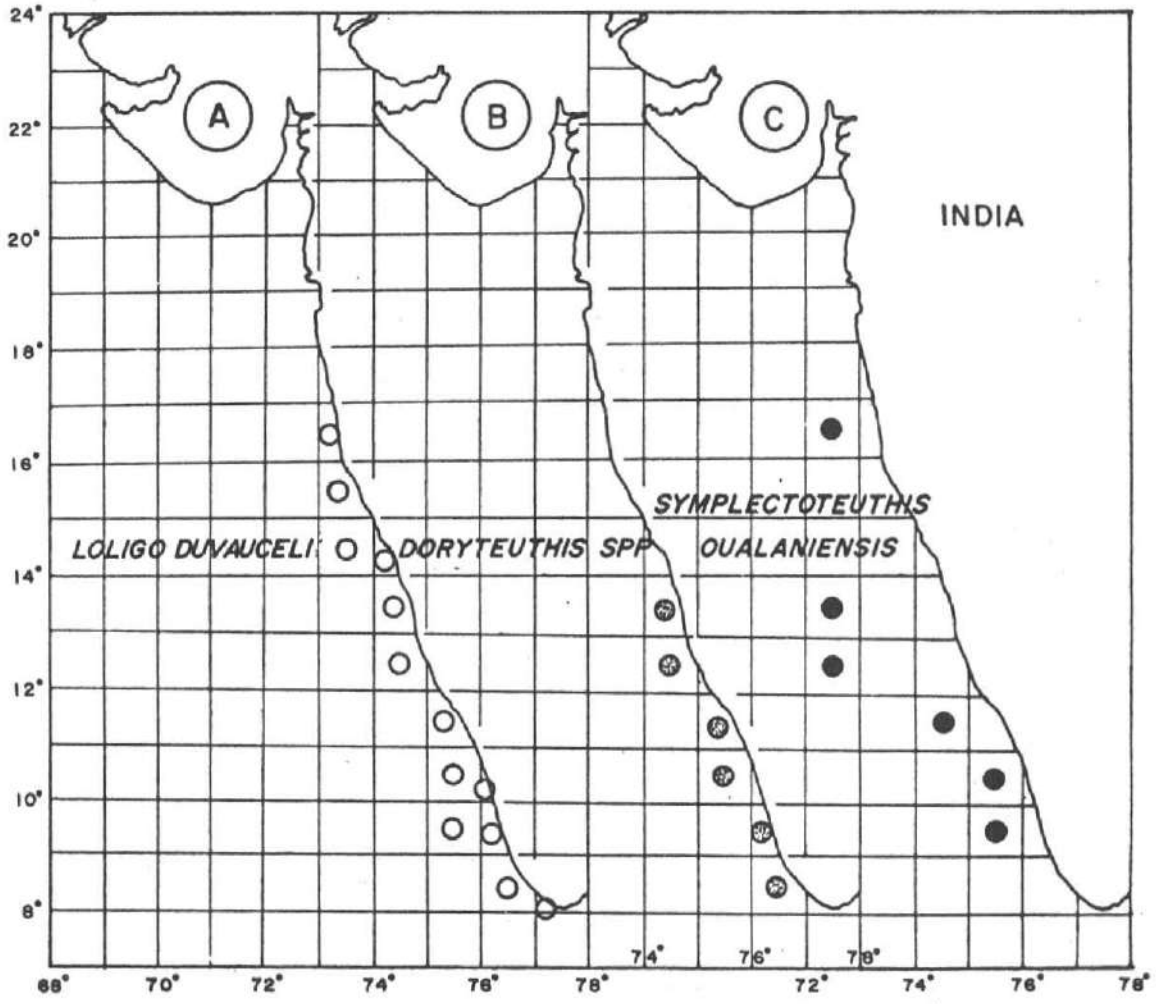

Fig.3 Areas of occurrence of different species of squids taken in jigging operations. A. *Loligo duvauceli* ; B. *Doryteuthis* spp.; C. *Symplecto-teuthis oualaniensis*.

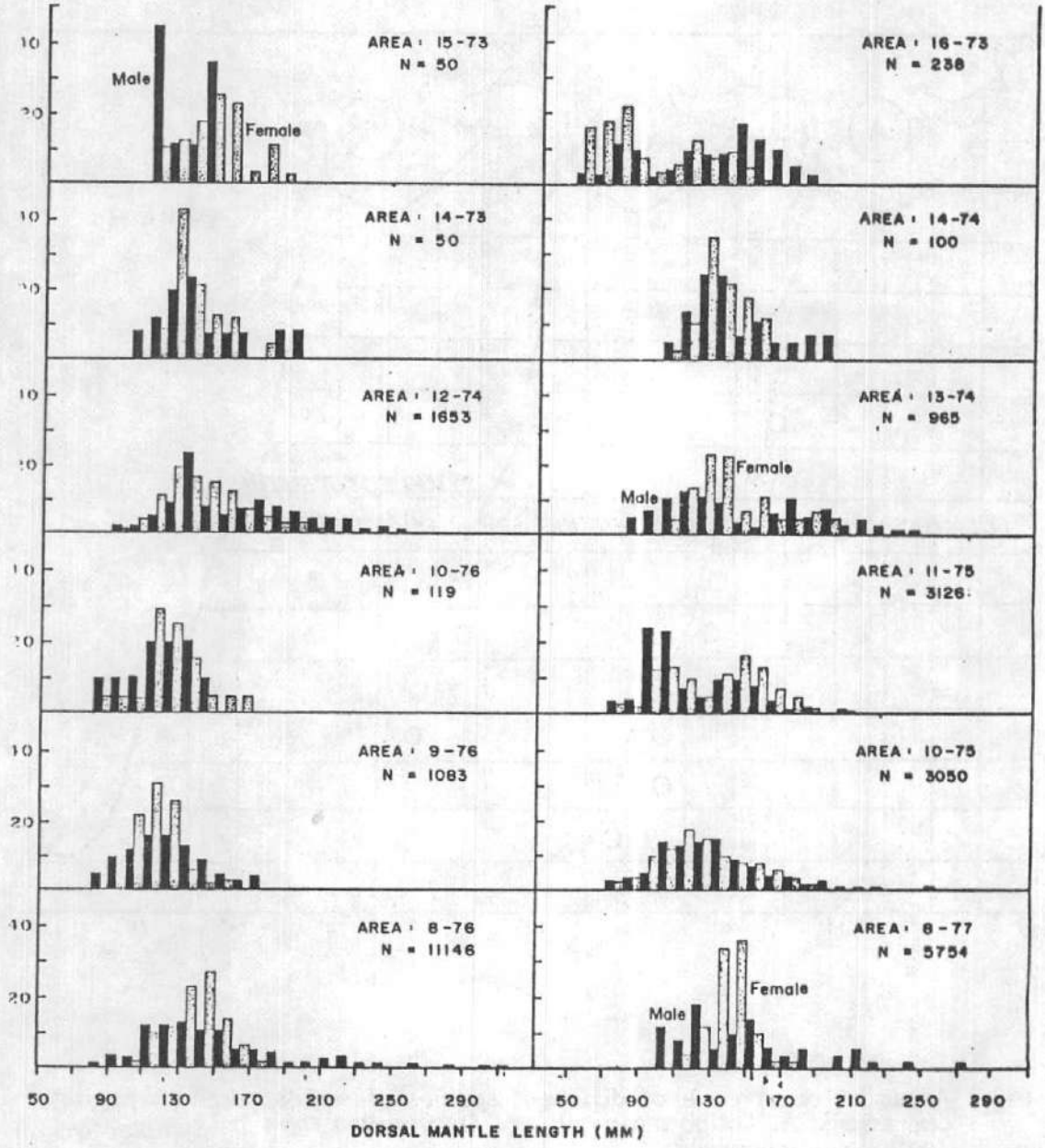

Fig.4 Length-frequency distribution of *Loligo duvauceli* by sex in 12 out of 13 areas for which data are available.

Males

The males had multimodal distribution in all the squares with the highest modal sizes ranging from 95 mm (mid-point of length class) to 175 mm. In the area 8-76 from where the maximum numbers of squids were caught, they had five modes, with the main mode at 135 mm and subsidiary modes at 95 mm, 155 mm, 225 mm and 265 mm. In most other squares also the highest modal size was the same or very close to it (125 mm and 145 mm).

Taking the males caught from all the squares as a whole, the maximum frequency was that of squids having the modal size of 125 mm, with secondary modes at 105mm, 155mm, 215mm, 245 mm & 275mm. Bulk of the quantity of male squids, about 83%, was composed of those having sizes within 100 mm and 200 mm, with small-sized squids below 100 mm contributed 8% and those above 200 mm, 9%.

Females

The females, which had a smaller size range than the males, also showed multimodal or bimodal distribution except in some squares where there was only a single mode. The main modes of females were in the range of 115 mm and 145 mm, except in the northern square 16-73 where there was a shift towards smaller size of 75 mm. As in the case of males, the maximum number of females were taken from 8-76 but the distribution was unimodal with the maximum frequency at 145 mm.

When the female squids jigged from all the squares are pooled, the distribution was trimodal, with the main mode at 145 mm and smaller modes at 75 mm and 115 mm. Squids within the size range of 100-200 mm constituted about 94% of the total number, with smaller squids forming 5%; those above 200 mm were negligible.

In the southern sector (8°-10°) which accounted for the bulk of the catch taken by jigging, squids below 100 mm belonging to both the sexes accounted for only 10% of the total catch from this sector, whereas in the middle (11°-13°) and northern (14°-16°) sectors they accounted for 26% and 28% respectively. This shows that larger squids above 100 mm are more concentrated in the southern parts of the west coast.

Sex Ratio

There was always differential numerical distribution between sexes, except in a very few cases. The equal or near-equal distribution

of males and females was noticed only in squares 8-77, 10-75, 12-74, 13-74, 14-73, 14-74 and 16-73. In other squares the male-female ratio ranged from 61:39 to as much as 18:82. In general, when all the data for the period from June 1988 to February 1989 are pooled, the average sex ratio was 45:55 (Fig. 5A).

Fig.5 A also shows the sex ratio of **Loligo duvauceli** by size groups. Among small squids below 100 mm, males were slightly more than females in the ratio 53:43 but in the group between 100 mm and 200 mm which accounted for the bulk of the number of squids caught in jigging operations, females outnumbered the males in the ratio 42:58. As females above the size of 200 mm were only a very few, among the squids above this length the males almost constituted the bulk in the ratio 94:6.

Maturation Stages

Majority of squids belonging to either sex were found to be mature. The largest immature male observed was 120 mm while the smallest mature male was 90 mm, indicating that there is slight over-lapping of sizes. The same was the case with the females also in which the largest immature squid was 120 mm and the smallest mature squid 90 mm. The size at first maturity, which, as is generally followed, is the size at which 50% of the individuals attain maturity, was found to be 134 mm for the males and 130 mm for the females.

Length weight Relationship

A study of the length-weight relationship of 225 males and 310 females showed that the rate of increase in weight in relation to length differed in the two sexes. The allometric growth formula for males and females are given below:

Males : $W = 0.00125 \times L^{2.167553}$

Females : $W = 0.000652 \times L^{2.360356}$

Food

Most of the squids caught by jigs had empty stomachs. In others the stomach contents were in varying stages of digestion. The stomach content was always observed as mascerated pieces of the prey animals beyond recognition, but from the component fragments it could be deduced that the squids have preyed upon fish, crustaceans and also on cephalopods exhibiting cannibalistic tendency.

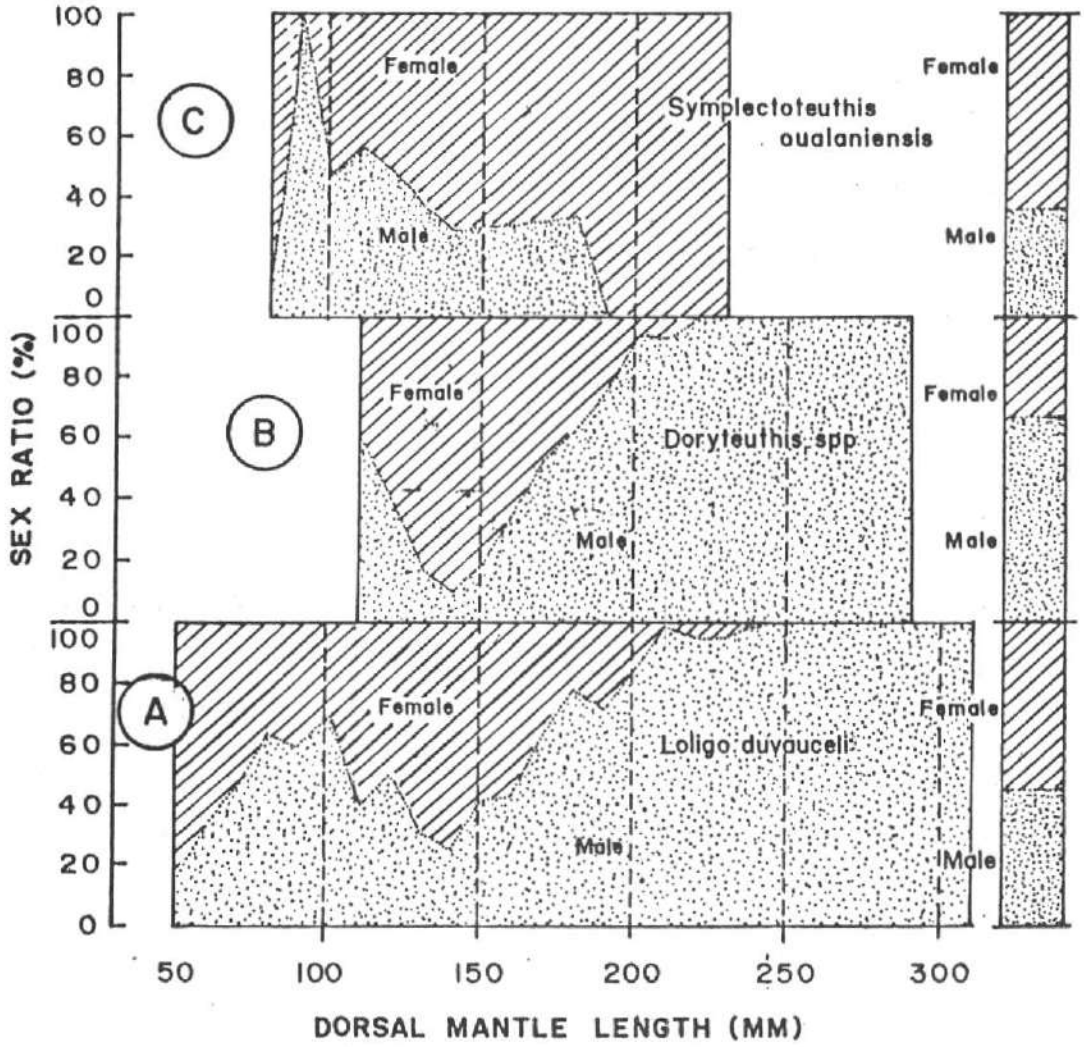

Fig.5 Sex ratio of three species of squids by size groups and by all sizes combined. A. *Loligo duvauceli*, B. *Doryteuthis spp*., C. *Symplectoteuthis oualaniensis*.

2. DORYTEUTHIS SPP

The two species of **Doryteuthis, (sibogae** and **singhalensis),** were taken together in squid jigging, and often they could not be sorted separately onboard because of their close resemblences in many morphological characters. Therefore separate data on each species are not available and hence they are treated here as a single group denoted as **Doryteuthis** spp.

Size Composition

The size of **Doryteuthis** spp ranged from 110 mm to 300 mm for males, and from 110 mm to 260 mm for females, which indicate that males were larger, as in the case of **Loligo duvauceli**. Fig.6 A shows the length-frequency distribution of **Doryteuthis** spp by sex and area (square) of occurrence. The males had multimodal distribution in all the areas. In the square 8-76 from where the maximum numbers of squids were taken, the main mode was at 205 mm with secondary modes at 175 mm and 255 mm. In other areas the main modes were within 155-245 mm. In the case of females, in four areas (8-76, 10-75, 11-75 and 13-74) they had bimodal distribution with modes in the close range of 145-165 mm; in one area (12-74) the number of female squids obtained was too small to show any modal size.

Among male squids caught from all the areas together, the maximum frequency was that of squids having the modal size of 205 mm with subsidiary modes at 115 mm, 175 mm and 255 mm. Bulk of the quantity of male squids (67%) was composed of those above 200 mm, while those below this size formed 33%.

The maximum number of females had a modal length of 155 mm with smaller modes at 115 mm and 195 mm. Almost the entire quantity (98%) of female squids were less than 200 mm, while those above this length accounted for only 2%.

Sex Ratio

The difference in sex ratio of this squid was very pronounced in most of the areas, with the minimum male-female ratio of 57:43 in 8-76; in other areas the ratio varied from 86:14 in 13-74 to 93:7 in 12-74. In general the average ratio for the entire catch was 66:34 (Fig.5 B), indicating that the males numerically outnumbered the females by about 94%.

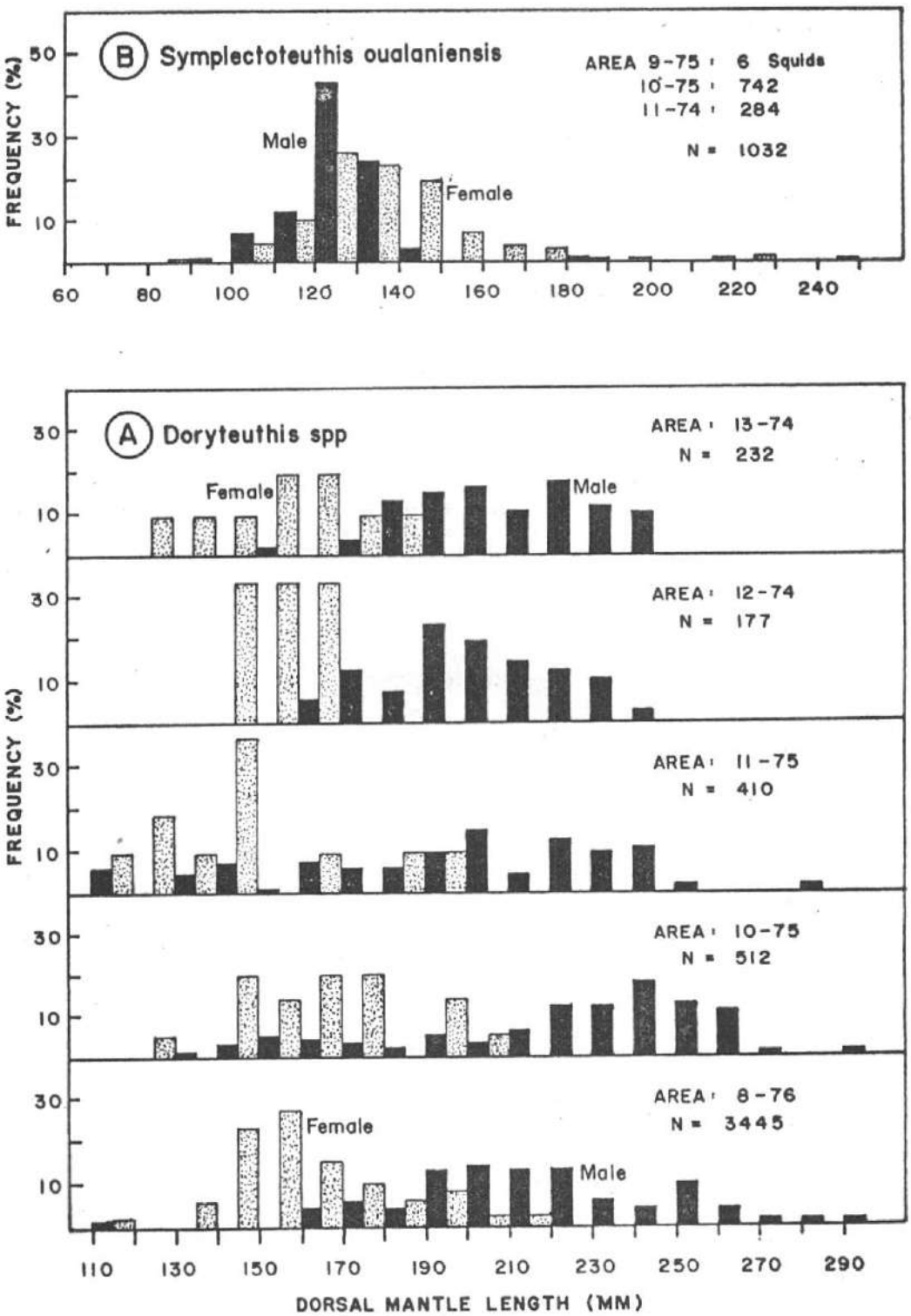

Fig. 6 Length frequency distribution of A. *Doryteuthis* spp., B. *Symplecteuthis oualaniensis*

Fig.5 B also shows the sex ratio of **Doryteuthis** spp by size. There were no squids below the size of 110 mm. From this length upto 200 mm, the females outnumbered the males in the ratio 39:61, while among those above 200 mm which accounted for 45% of the catch the females were very few, in the ratio 99:1.

Though some data are available, aspects of maturation stages and length-weight relationship are not attempted here as more than one species are involved and their data are mixed.

3. SYMPLECTOTEUTHIS OUALANIENSIS

Size Composition

This oceanic squid was taken from six squares but the great majority was from squares 12-72 and 13-72 (4,150 and 4,757 respectively). The male squids had a size range of 80-190 mm. The females were larger than the males, unlike the neritic squids, and the length ranged between 80 mm and 250 mm. The length data of this squid by sex are available only from three squares; the frequency distribution of male and female squids caught from these areas together is shown in Fig.6 B. Both the sexes showed unimodal distribution with the modal size of 125 mm. Almost 99% of the total number of squids of both the sexes were constituted by those within the length range 100-200 mm.

Sex Ratio

In all the three squares for which data of squids by sex are available, the females outnumbered the males in the ratio ranging from 38:62 to 33:67. When all the squids are pooled, the sex ratio was found to be 36:64 (Fig.5 C). The Figure also shows the sex ratio of **Symplectoteuthis** by size. Except in the length class 110-120 mm, females were dominant over males in all the length classes. From 150mm onwards all were females with the exception of 180-190mm length class in which there were males in the ratio 33:67. Among squids within the length range of 100-200mm which contributed 99% of the total number of species, the male-female ratio was 36:64.

Maturation Stages

Most of the squids examined for stages of maturation (98% of the males and 97% of the females) were mature. The smallest size of the mature male was 90 mm and that of the mature female 100 mm.

Based on 30 mature males in the size range of 90-150 mm and 70 females of 100-160 mm, it was observed that 50% attain sexual maturity at about the length of 112 mm, and 50% of the females at 120 mm; these lengths are considered as the size at first maturity for the respective sexes.

DISCUSSION

Squids are well-known for their strong positive phototaxis, and this makes them aggregate near the surface of the sea at night when attracted by artificial light. The world's largest squid fishery of **Todarodes pacificus** and **Ommastraphes bartrami** by the Japanese exists on this behavioural aspect of the squid. In our waters many species of squids have been found to be attracted by artificial light, and these include the neritic squids **Loligo duvauceli., Doryteuthis sibogae** and **Sepioteuthis lessoniana,** and the oceanic squid **Symplectoteuthis oualaniensis** (Chellappa, 1959; Yamanaka **et al.,** 1976; Silas, 1969; Nair, 1986; Nair and Omana, 1986; Nair **et al.,** 1990). Among these the first mentioned two neritic squids and the oceanic squid were obtained in the present squid jigging operations but **Sepioteuthis lessoniana** was never caught even once though it is distributed on the southern part of the southwest coast of India, besides from its normal occurrence in the Palk Bay and the Gulf of Mannar. It has been obtained in small numbers during the light-fishing experiments with lift-net near the shore at Vizhinjam (Nair and Omana, 1986) and the **Kelong** fishery in the Gulf of Mannar (Chellappa, 1959), and this indicates that the squid shows positive phototaxis. Another species that was caught by jigging is **Doryteuthis singhalensis** along with **D. sibogae.** All these show that the important squids of the Indian waters are attracted by artificial light and can be jigged.

The size composition of **Loligo duvauceli, Doryteuthis** spp. and **Symplectoteuthis oualaniensis** indicated that medium and large-sized mature squids (74-98%) were the mainstay of jigging operations. The small and immature squids were extremely rare, and therefore jigging seems to be more or less selective for larger sizes.

The differential sex ratio of squids is as expected from previous observations. The ideal 1:1 male-female ratio does not exist in nature as seen from many earlier findings. In the case of **Loligo duvauceli** the average sex ratio observed off Vizhinjam was 42:58, but off Cochin the males were slightly more (Silas, **et al.,** 1986) and off Mangalore also the females dominated (Rao, 1988). The average sex ratio of the species taken during the present squid jigging was 45:55 which is more or less similar to the earlier observation. In the case of **Doryteuthis sibogae** also the female was found to be the dominant sex (Silas **et al.,** 1986) but there is no information on this aspect for **Doryteuthis singhalensis.** As regards the oceanic squid **Symplectoteuthis oualaniensis,**

the earlier observation based on data collected in pelagic trawling shows that the male had numerical dominance over the female (Nair, **et al.,** 1990) but in the present study the females outnumbered the males in the ratio 36:64.

All the above observations show that the sex ratio varies from area to area, month to month and size to size. It is not evident whether a particular sex is more attracted towards artificial light and more often jigged than the other.

The size at first maturity (taken here as the size at which 50% of the individuals are found mature) for males of **Loligo duvauceli** is observed to be 134 mm, which is higher than 108 mm recorded for male squids off Vizhinjam, but closer to the value of 122 mm at Cochin (Silas **et al.,** 1986) and 124 mm at Mangalore (Rao, 1988). In the case of females this size is 130 mm as against 110 mm observed at Vizhinjam and very close to 128 mm at Cochin but higher than 108 mm obtained for females at Mangalore. These variations are within a reasonable range and not quite unexpected, since the comparison is based on data collected from different areas over a number of years. From the above values it can be taken that the size at first maturity for males is between 105 mm and 135 mm, and for females it lies between 110 mm and 130 mm.

The size at first maturity for **Doryteuthis sibogae** observed by Silas **et al.** (1986) is 97 mm for males and 84 mm for females. In the present study this aspect was not considered as separate data were not available for this species alone.

For **Symplectoteuthis oualaniensis,** Nair **et al.** (1990) have observed that the size at first maturity is 100 mm for males and 110 mm for females. The values obtained in the present investigation were closely identical, 112 mm for males and 120 mm for females, confirming that both the sexes become mature at more or less the same length.

The length-weight relationship of **Loligo duvauceli** obtained in the present investigation is almost similar to the values derived earlier for the same species (Silas **et al.,** 1986; Rao, 1988). In all the cases the allometric growth formulae show that the rate of increase in weight in relation to length differes in males and females. Rao (1988) has observed that in this species there is good correlation between length and weight at different stages of maturity, and that the weight increment in females seems to be more than in males.

The length-weight relationship in **Doryteuthis** and **Symplectoteuthis** was not studied.

In conclusion, the above observations drive home certain points:

1. Jigging is aimed fishing, targeted exclusively for squids, so that no other groups of finfish or shellfish are caught.

2. Four species of squids, **Loligo duvauceli**, **Doryteuthis sibogae**, **Doryteuthis singhalensis** (all neritic) and **Symplectoteuthis oualaniensis** (oceanic) in our waters are attracted by artificial light and can be jigged.

3. Mostly the medium and large-sized squids are jigged, indicating that this is a selective gear, without exploiting juveniles.

4. Both the sexes are attracted by lights and are jigged, the sex ratio showing no regular trend.

5. Larger squids are concentrated in the southern part (Vizhinjam-Muttom) than in the central (Mangalore) and northern (Ratnagiri) parts.

6. The biological aspects studied are in close agreement with earlier observations.

7. The squids taken in jigging are sea-fresh, unmutilated and practically uncontaminated with their own ink, as against those taken in trawling which are often flabby, highly pressed with the weight of other fish and discoloured with ink.

The economics of squid jigging is not discussed in this section but if this method is found economically feasible, it will be the most ideal of fishing for squids, especially oceanic squids. Since the gear is highly selective for medium and larger sizes without affecting juvenile populations, the management and conservation problems are expected to be far less than in other modes of fishing. Moreover, the freshness of squid is a prime prerequisite in export trade and for this, jigging is the most suited fishing method.

ACKNOWLEDGEMENTS

We are grateful to Dr. P.S.B.R. James, Director, CMFRI for sanctioning our participation in this co-operative venture, and thankful to the then Zonal Director, FSI, the Director, CIFNET, the Skippers and Crew of **M.F.V. Matsya Sugandhi** and **M.V. Blue Fin,** the Scientists and other cruise participants from these organisation for all the help and co-operation extended for carrying out this work. We wish to record our sincere thanks and goodwill to Capt.E.Haruta, the Japanese Squid Jigging Expert.

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