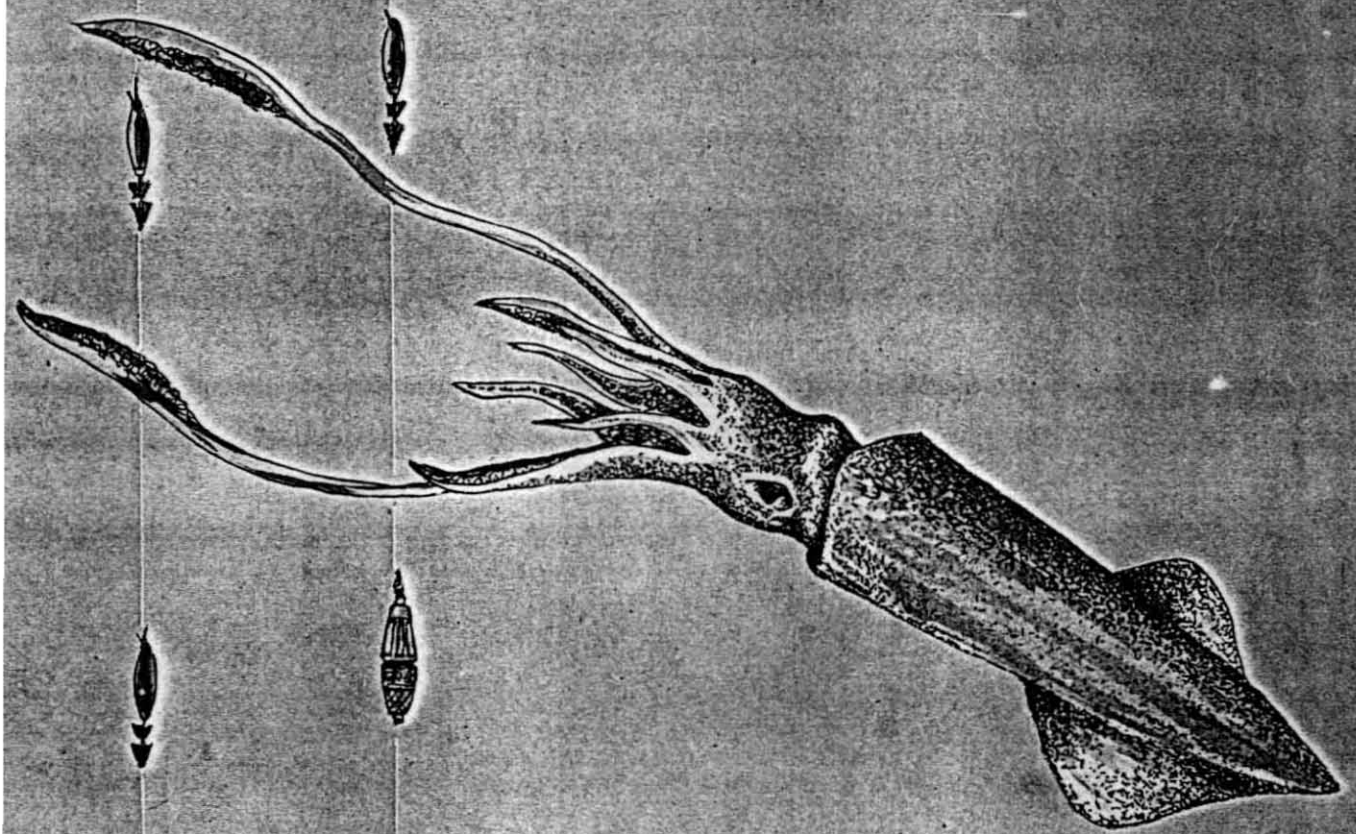
Bulletin 23

EXPLORATORY SQUID JIGGING IN INDIA WITH NOTES ON BIOLOGY OF SQUIDS



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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.

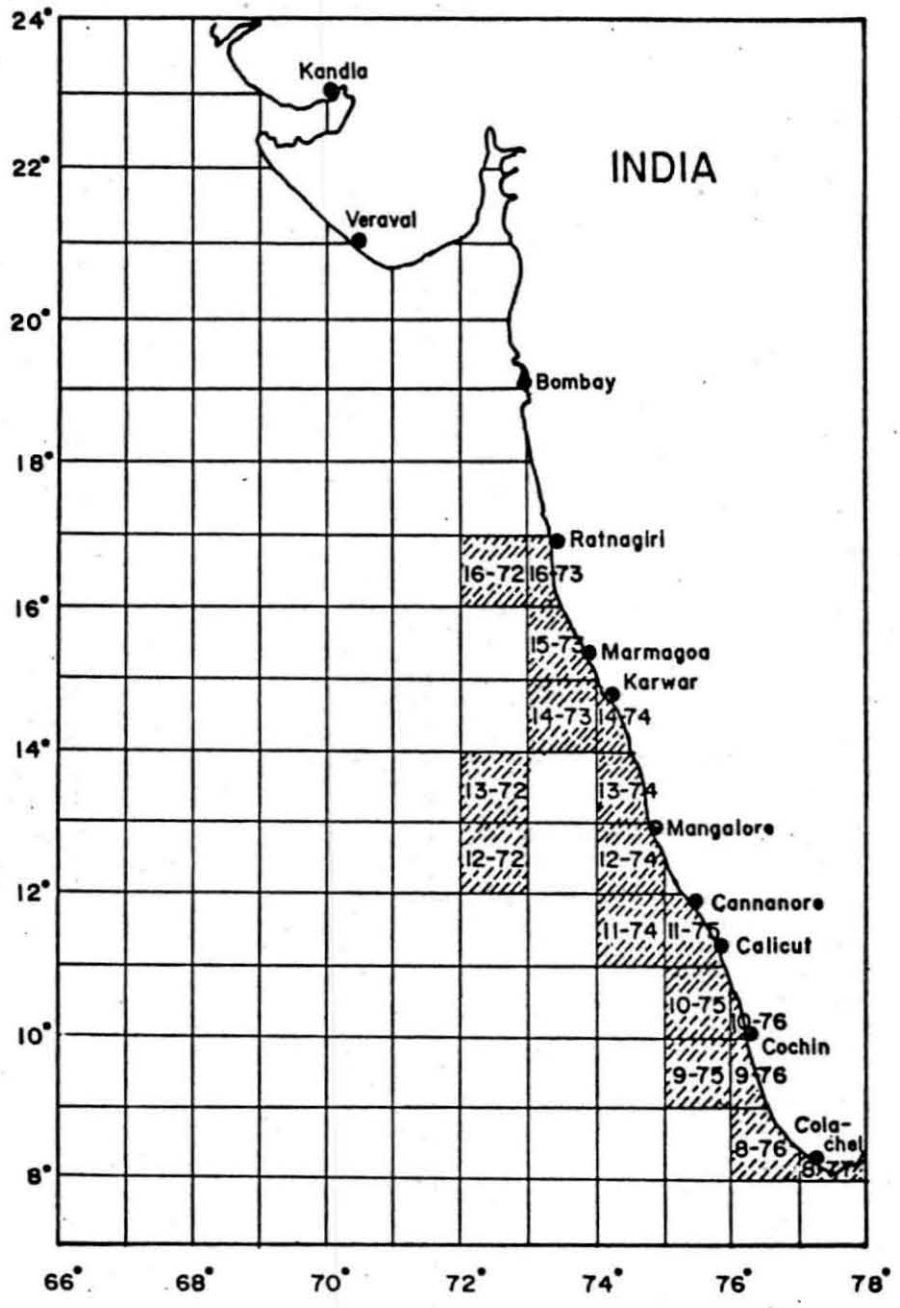

Fig.1 Areas (one-degree squares) of squid jigging operations on the west coast of India.

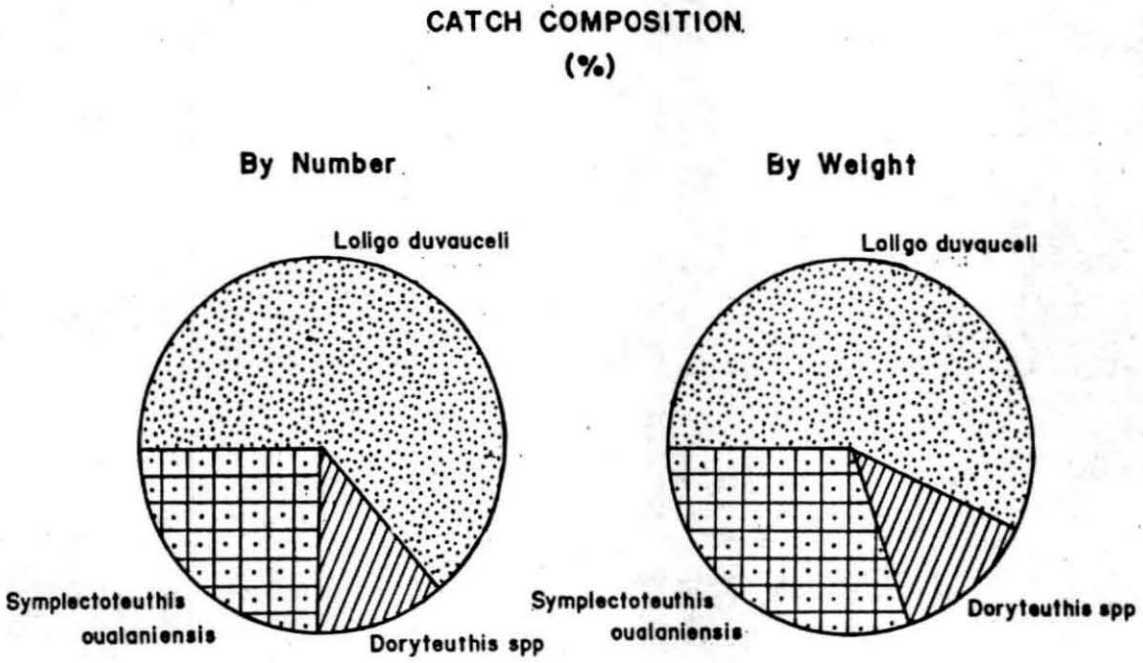

Fig.2 Species composition of squid catches by number and weight.

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.

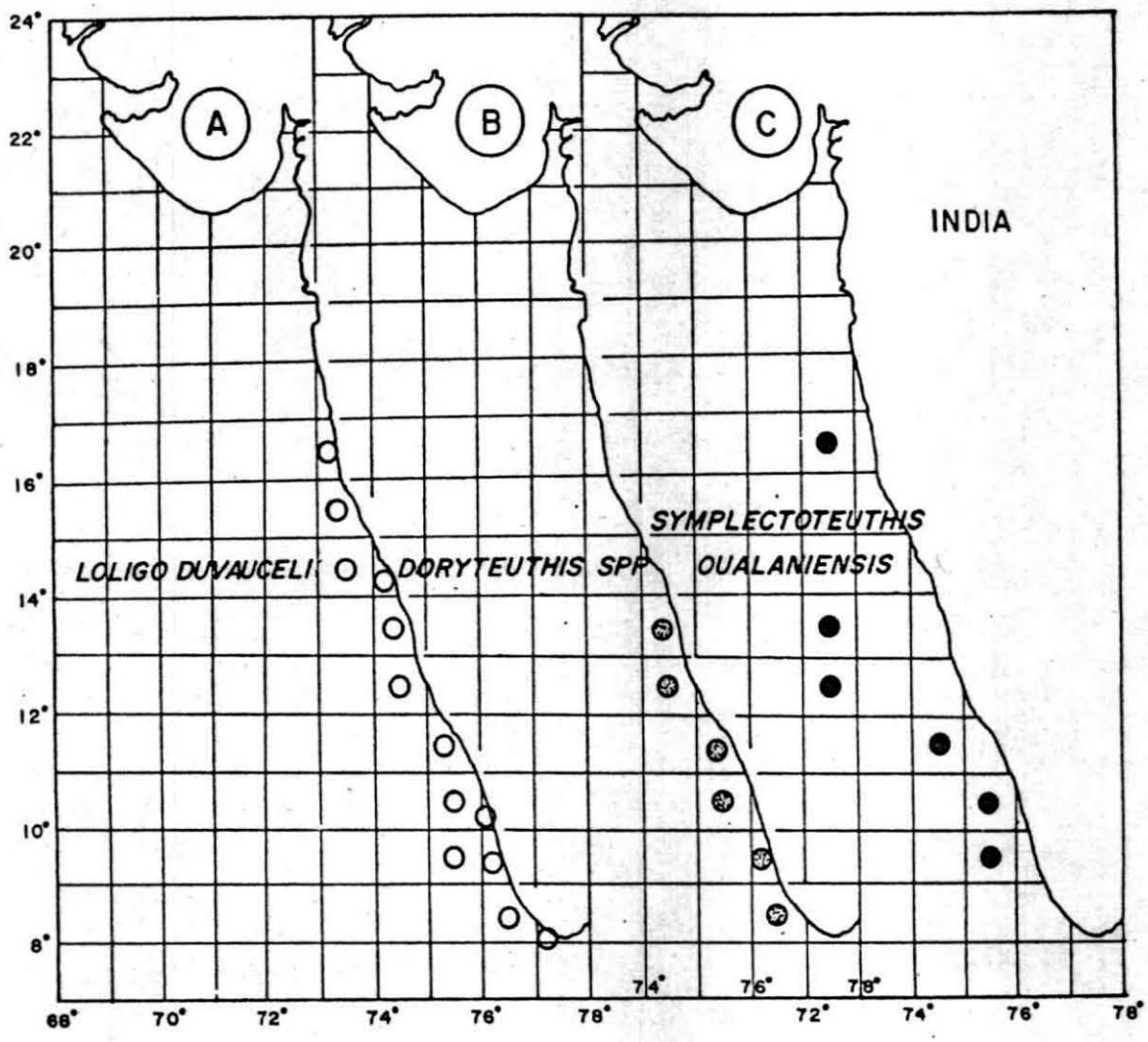

Fig.3 Areas of occurrence of different species of squids taken in jigging operations. A. *Loligo duvauceli* ; B. *Doryteuthis* spp.; C. *Symplectoteuthis oualaniensis.*

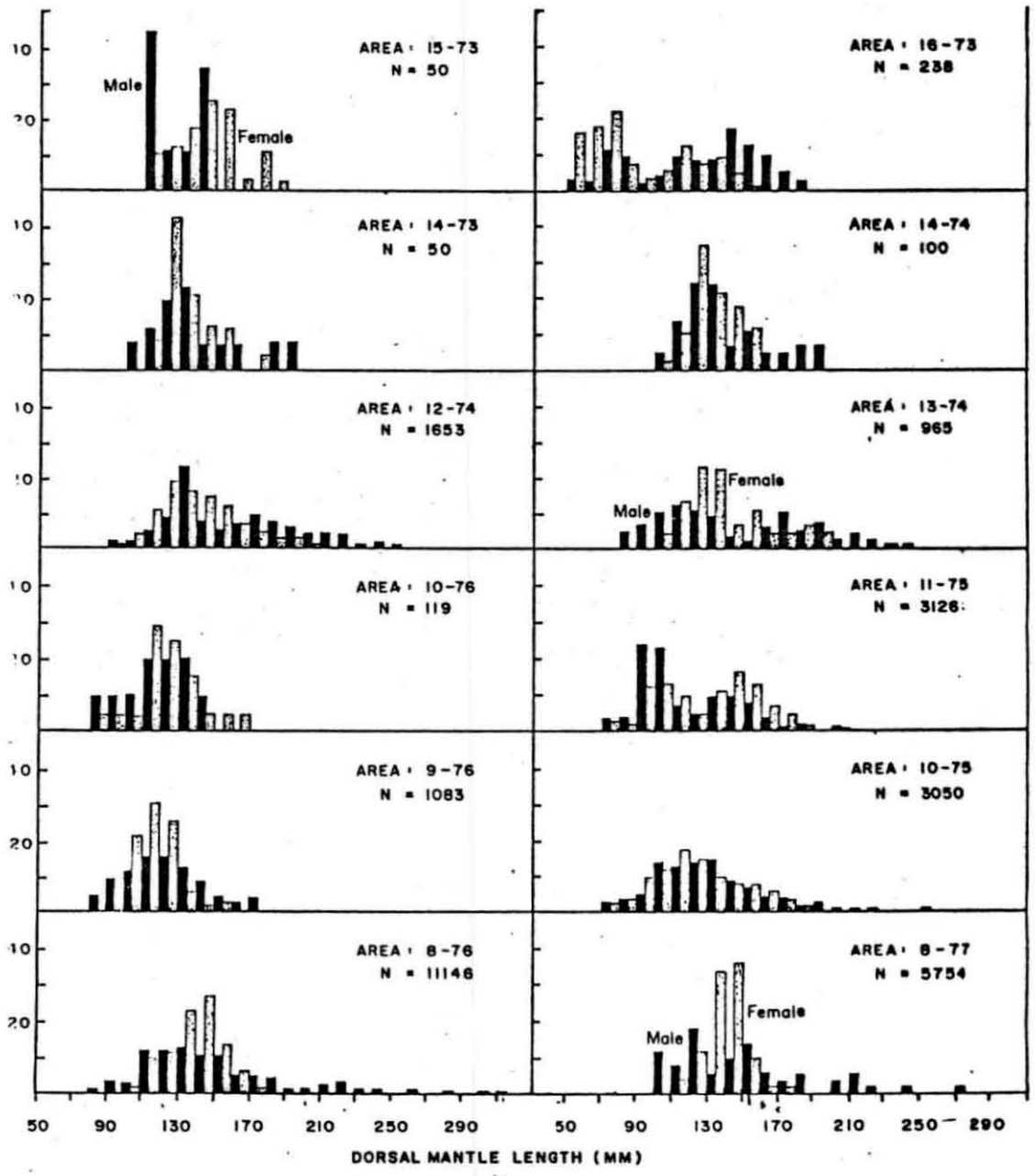

Fig.4 Length-frequency distribution of *Loligo duvauceli* by sex in 12 out of 13 areas for which data are available.

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 overlapping 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 canniballistic tendency.

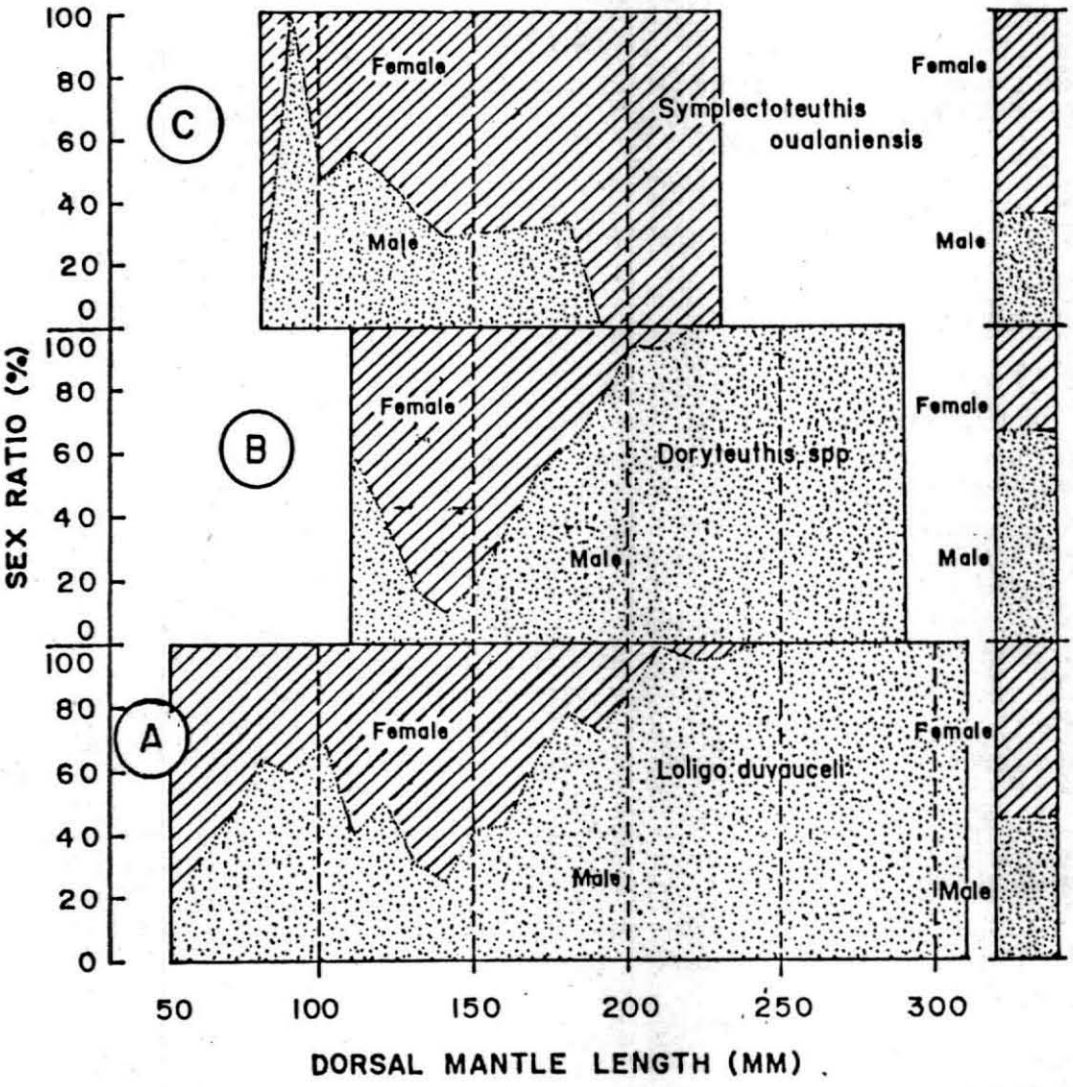

Fig.5 Sex ratio of three species of squids by size groups and by all sizes combined. A. *Loligo duvauceli*, B. *Doryteuthis spp.*, C. *Symplectoteuthis oualaniensis.*

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%.

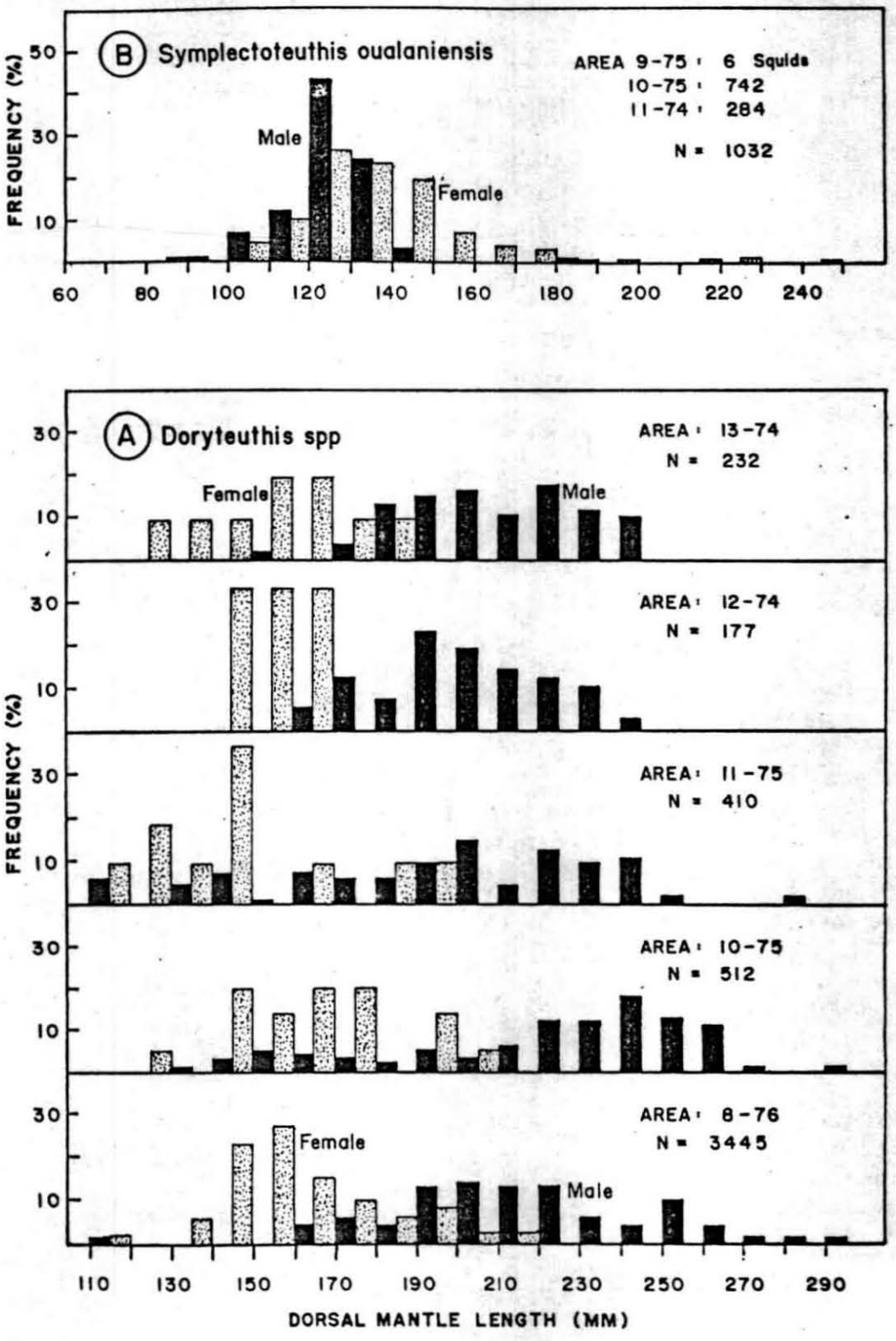

Fig. 6 Length frequency distribution of A. *Doryteuthis* spp., B. *Symplecteuthis oualaniensis*

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 bv 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

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