

BIOLOGY OF INSHORE SQUID *LOLIGO DUVAUCELLI* ORBIGNY, WITH A NOTE ON ITS FISHERY OFF MANGALORE

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ABSTRACT

Loligo duvaucelii is emerging as one of the important components of by-catch of trawl landings at Mangalore. Males mature at 124 mm and females around 108 mm. This species spawns from December to May. An analysis of intra ovarian eggs indicated that females spawn only once. In contrast, males appear to spawn continuously. Females were dominant at length below 150 mm during most of the months of study. There was a sudden and steep decline in their proportion beyond 150 mm indicating post-spawning mortality. The relation between length, ovary weight and fecundity showed good correlation. On an average *L. duvaucelii* produces about 5,300 eggs. The gonad index and nidamental gland index were correlated with the maturity of *L. duvaucelii*. The length-weight relationship between males and females showed significant difference. The largest recorded male *L. duvaucelii* was 355 mm and female 228 mm, which are highest so far from Indian coasts. A brief account on fishery aspects of squids is also presented. There has been a spurt in the squid landings around Mangalore area.

INTRODUCTION

The contribution of cephalopods to the total marine fish catch during 1984-'85 was about 24,000 tonnes (Anon. 1986). In spite of their good demand for export, no diversification has taken place in the methods of catching cephalopods. Along the Karnataka coast cephalopods are caught by shrimp trawlers as by-catch. On an average they formed about 5.9% of the total trawl catches at Mangalore during 1982-86.

Loligo duvaucelii is the only commercially important inshore squid resource landed in Mangalore. It accounts for more than 70 % of the cephalopod landings of this area. Information on the biology of this species is very scanty (Silas *et al.*, 1985). Hence detailed investigations were carried out on

some biological aspects of *L. duvaucelii* and the results are presented here.

MATERIAL AND METHODS

The material for this study was collected at weekly intervals from the landings of shrimp trawls at Bunder, Mangalore during 1982-'86.

Length-weight relationship was determined by least square method, separately for males and females. For fixing the stage of maturity, Lipinski's universal scale (Juanico, 1983), with slight modifications, was followed. The length (dorsal mantle length) at first maturity was determined as the length at which 50% of the squids attained maturity. For the purpose of estimating fecundity, the total weight of ovary was taken nearest to one mg. A part of the ovary was removed, weighed and the ova were counted under a binocular microscope. The total number

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of ova in an ovary was estimated by proportionately raising the number of ova in the sample to the total ovary weight. The relative fecundity (R.F.) was calculated by the following formula.

$$\text{R.F.} = \frac{F}{W}$$

Where F = Total fecundity
and W = Ovary free female weight in grams.

Gonad index (GI) is the percentage of gonad weight in the total weight of squid. Nidamental gland index (NGI) and hepatic (liver) index (HI) were determined in a similar manner. Sex ratio and maturity studies were based on the observations of over 4,200 specimens, during the study period.

Data on catch and effort were collected at bi-weekly intervals at the Bunder (Mangalore) landing centre. Species-wise, boat-wise catches were recorded on a random basis and proportionately raised to the total number of units landed on an observation day. The species-wise catch per day was proportionately raised to the number of fishing days in a month to get the estimate for a given month.

BIOLOGY

Size at First Maturity

The dorsal mantle length (DML) at first maturity for males and females was determined separately, as there was difference. In male *L. duvaucelii*, mature individuals occurred from a length of 70 mm and above. At 124 mm (120-129 mm length group) the mature males reached 50% representation and hence 124 mm may be considered as size at first maturity for male *L. duvaucelii*. At 180 mm and beyond, all the male specimens were in mature condition. In the case of females also mature specimens started their appearance at 70 mm and reached 50% level at 108 mm (100-109 mm group). Thus 108 mm may be considered as size at first maturity for female of

L. duvaucelii. It is clear from the foregoing that female *L. duvaucelii* reach maturity at an early size.

Maturity and Spawning

The stages of maturity in the females are as given below.

| | |
|--------------------|---|
| Stage I Juvenile | Sex organ not visible to naked eye. |
| Stage II Immature | Ovary small in size; ova minute, opaque, embedded in tissue. Nidamental glands small in size. |
| Stage III Maturing | Ovary size increased and occupies nearly half of posterior body cavity. Individual ova visible. Nidamental glands enlarged. |
| Stage IV Mature | Ovary very prominent with plenty of translucent eggs in oviducts and occupies entire posterior mantle space. Nidamental glands whitish cream and attain maximum size. Accessory nidamental glands coloured with a combination of yellow and orange. |
| Stage V Spent | No eggs in oviduct or only degenerating ones. Nidamental glands appear like shrunken sacs. Condition of animal poor. This stage was considered hypothetical by Lipinski (1979). |

Mature specimens of *Loligo duvaucelii* were observed in the landings almost throughout the year, except during July and August when observations could not be made due to absence

of fishing. Samples were inadequate during September-November due to non-operation of trawlers. However, the data from December to May (Fig. 1) indicate that mature specimens were more than 50%. Hence the

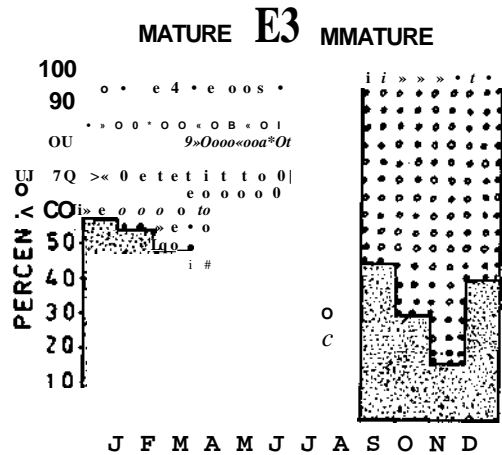


Fig. 1. Seasonal variation in the abundance of mature *L. duvaucelii*.

period from December to May with the exception of April can be considered as the major spawning season for *L. duvaucelii*, which happens to be the peak fishing season.

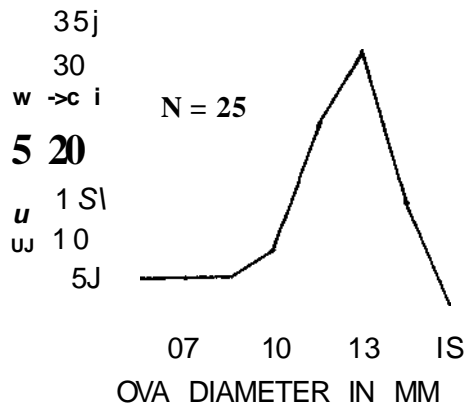


Fig. 2. Ova-diameter frequency of intra-ovarian eggs of mature *L. duvaucelii*.

Unlike many fish, the spawning in the case of females appears to be only once. An analysis of intra-ovarian eggs (Fig. 2) revealed that there was only one mode around 1.25 mm indicating that the ova may be released in a single batch during spawning. The largest intra-ovarian egg encountered measured 1.594 mm.

Sex Ratio

The monthly variations in sex ratio during 1982-'86 are presented in Table 1. In general there was dominance of female particularly during 1984 and 1985. Also females were significantly dominant in February, April, May and November. An analysis of length-wise sex ratio indicated that there was a general female dominance at lengths below 150 mm. Similar results were obtained for all the four years of study. There was a sudden decline in proportion of females at 150 mm in all the years except 1984, when the decline was noticed at 160 mm. The presence of females beyond 180 mm was nominal during different years. On the other hand the presence of male specimens was unmistakably prominent beyond 150 mm. Hence the data for all the years are pooled (Fig. 3). In the case of females the proportion beyond 150 mm was 5% and after

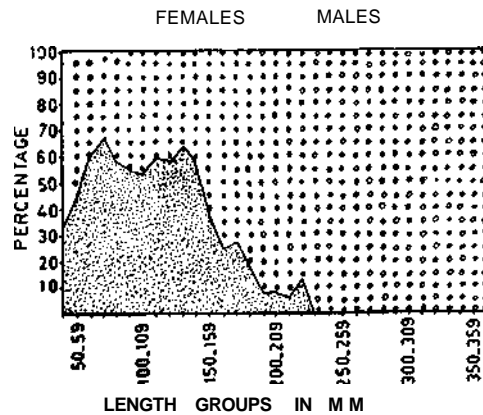


Fig. 3. Sex ratio at different length groups in *L. duvaucelii* (Pooled data for 1982-'86).

TABLE 1. *Monthly variations in sex ratio of L. duvaucelii during 1982-'86*

| | 1982 | | | 1983 | | | 1984 | | | 1985 | | | 1986 | | | Pooled | | | |
|-------|------|----|----------------|------|-----|-------|------|-----|----------------|------|-----|----------------|------|-----|----------------|--------|-------|----------------|----|
| | M | F | X ² | M | F | X* | M | F | X ¹ | M | F | X ² | M | F | X ¹ | M | F | X ¹ | |
| Jan. | — | — | — | 27 | 23 | 0.11 | 76 | 75 | 0.01 | 97 | 93 | 0.08 | 99 | 101 | 0.02 | 299 | 292 | 0.08 | |
| Feb. | — | — | — | 59 | 66 | 0.39 | 72 | 92 | 2.44 | 108 | 137 | 3.43 | 125 | 125 | — | 364 | 420 | 4.00* | |
| Mar. | — | — | — | 73 | 91 | 3.13 | 89 | 72 | 1.80 | 48 | 62 | 1.78 | 42 | 42 | 3.76 | 236 | 272 | 2.55 | 3 |
| Apr. | 14 | 11 | 0.36 | 133 | 182 | 7.62* | 34 | 66 | 10.24* | 94 | 104 | 0.50 | | | | 275 | 363 | 12.14* | 3 |
| May | 23 | 27 | 0.32 | 120 | 116 | 0.07 | 120 | 161 | 5.98* | 30 | 70 | 16.00* | | | | 293 | 374 | 9.84* | *" |
| Jun. | 9 | 14 | 1.09 | 31 | 34 | 0.14 | — | — | — | — | — | — | | | | 40 | 48 | 0.73 | 5 |
| Jul. | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 0 |
| Aug. | 14 | 6 | 3 | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | |
| Sep. | 14 | 6 | 3.2 | — | — | — | — | — | — | — | — | — | — | — | — | 14 | 6 | 3.20 | |
| Oct. | — | — | — | — | — | — | — | — | — | 3 | 3 | — | — | — | — | 3 | 3 | — | |
| Nov. | 1 | 4 | 1.8 | 7 | 18 | 4.84* | 27 | 5 | 15.13* | 96 | 140 | 8.20* | | | | 131 | 167 | 4.35* | |
| Dec. | — | — | — | 104 | 79 | 3.42 | 88 | 137 | 10.67* | 108 | 127 | 1.54 | | | | 300 | 343 | 2.88 | |
| Total | | | | 554 | 614 | 3.08 | 506 | 608 | 9.34* | 584 | 736 | 17.5* | | | | 1,955 | 2,288 | 26.13* | |

* Significant at 5%. M = Males, F = Females.

180 mm it was just 0.35%, whereas the proportion of males beyond 150 mm was 32.7% of the total exploited population. The sudden decline in the proportion of females beyond 150 mm might indicate post-spawning mortality.

Fecundity

Number of ripe ova produced by *Loligo duvaucelii* ranged from 1,500 to 13,156, the average being 5,284. The relation between length and fecundity and ovary weight and fecundity were worked out, as these two biological parameters are to a great extent, directly related to maturity and fecundity. In the case of length, the fecundity at different length groups (10 mm) was pooled to

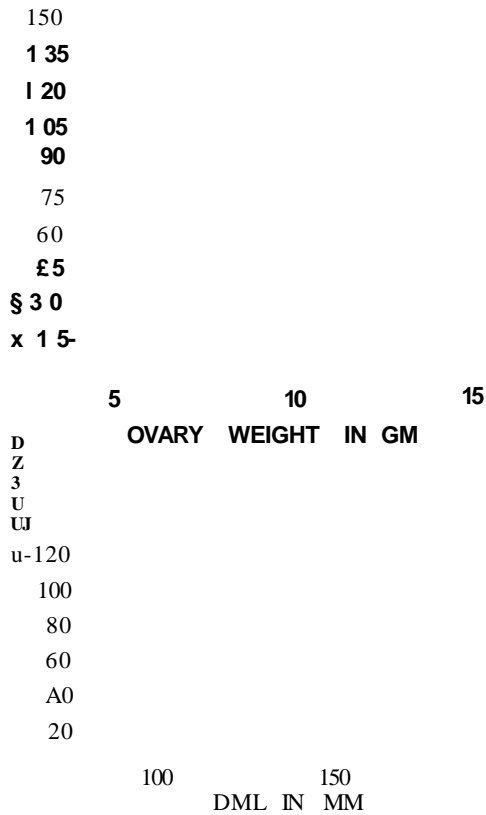


Fig. 4. Length-fecundity, and ovary weight-fecundity relationship in *L. duvaucelii*.

work out the relationship, based on 59 observations (Fig. 4). The corresponding logarithmic and parabolic equations are given below:

i. *Length-Fecundity Relationship*

$$\begin{aligned} \text{Log Fecundity} &= 1.151692917 + 2.336303331 \log \text{Length.} \\ \text{Fecundity} &= 0.070519152 \text{ LTMMM}'' \quad (r = 0.9035) \end{aligned}$$

ii. *Ovary Weight - Fecundity Relationship :*

$$\begin{aligned} \text{Log Fecundity} &\ll= 2.89891088 + 1.012861813 \log \text{Ovary weight} \\ \text{Fecundity} &= 792.3387216 \text{ Ov. wt. I-«MI»U} \quad (r = 0.6935) \end{aligned}$$

In the above relationships the correlation is significant between the parameters studied.

Relative Fecundity

The relative fecundity ranged from 60 to 86 (Fig. 5). The values showed peak between 110 and 140 mm, indicating the size at which spawning may take place. The values of relative fecundity beyond 140 mm length showed sharp decline.

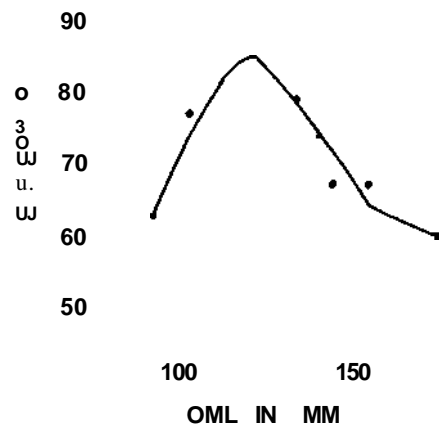


Fig. 5. Length-relative fecundity curve in *L. duvaucelii*. (The dots are actual values).

Gonad Index (GI)

The gonad index for mature and immature *L. duvaucelii* are presented in Fig. 6A. It has shown higher values in most of the months, for which data were available, with the exception of March and October. GI showed upward trend during March-June period. In the case of immature forms the values of index were high in all months of observations other than November.

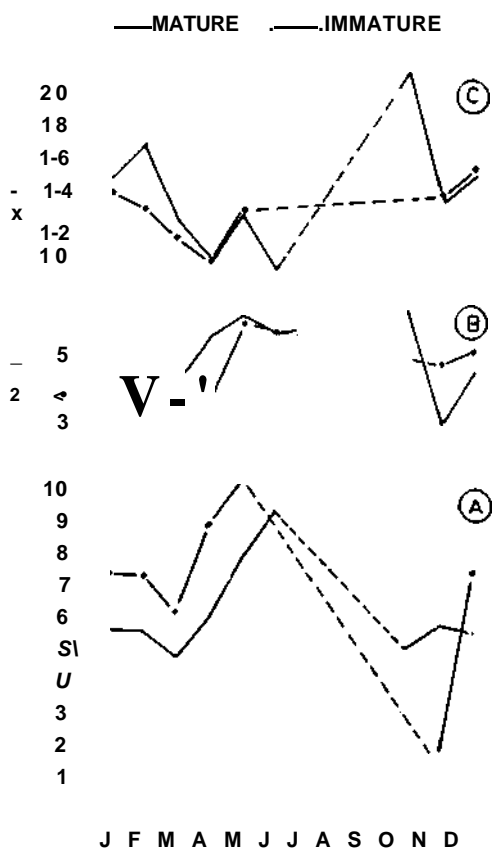


Fig. 6. Seasonal variation in (A) gonad index (GI), (B) nidamental gland index (NGI) and (C) hepatic index (HI) in *L. duvaucelii*.

Nidamental Gland Index (NGI)

The values of NGI for mature forms were also generally high during the months of

observation except November, similar to the pattern of GI. The NGI showed upward trend during March-May period. The values of NGI were generally low in immature forms during the months of observation with the exception of November and December (Fig. 6 B).

Hepatic Index (HI)

Hepatic index in mature forms showed three peaks (Fig.6C), during February, May and November. The HI for immature forms was generally lower than mature forms, except in December.

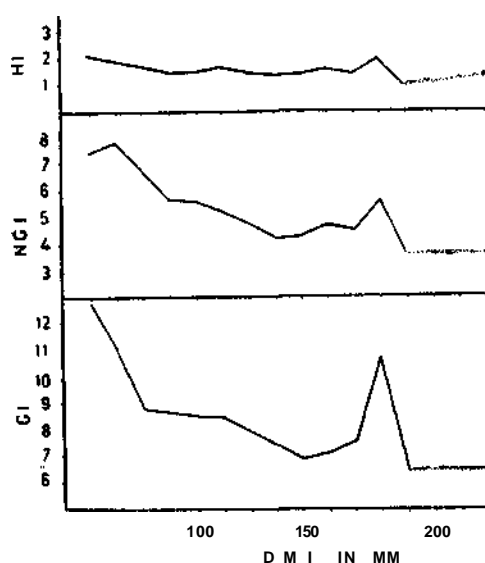


Fig. 7. Length-wise gonad index (GI), nidamental gland index (NGI) and hepatic index (HI) in female *L. duvaucelii*.

In females all the three indices were high at lengths below 100 mm (Fig. 7). Again the indices showed an upward trend beyond 150 mm, wherein, only negligible number survive beyond this length. From the foregoing, it is also clear that GI and NGI put together form nearly 15 to 20% of the body weight. The variations in the gonad weight may cause fluctuations in the total body weight from individual to individual.

BIOLOGY OF *LOLIGO DUVAUCELLI*

Length- Weight Relationship

The length-weight relationship is calculated by least square method. The length is expressed as dorsal mantle length in mm and weight in g. The equations are based on observations on 580 males (58-366 mm length range) and 595 females (67-228 mm length range).

Males :

a. 119 mm and below:

$$\log W = -2.688611351 + 2.158734223 \log L$$

$$W = 0.002048277 L^{0.8168} \quad (r=0.9696)$$

b. 120 mm and above (mature):

$$\log W = -2.293927222 + 1.952462375 \log L$$

$$W = 0.005082446 L^{1.0718} \quad (r = 0.9742)$$

c. Full length range:

$$\log W = -2.267684375 + 1.94204437 \log L$$

$$W = 0.005399029 L^{1.0417} \quad (r=0.9895)$$

Females ;

a. 109 mm and below:

$$\log W = -3.408958794 + 2.527671845 \log L$$

$$W = 0.000389979 L^{1.18} \quad (r = 0.8993)$$

b. 110 mm and above (mature):

$$\log W = -2.184402382 + 1.935624084 \log L$$

$$W = 0.006540279 L^{1.0718} \quad (r=0.8993)$$

c. Full length range:

$$\log W = -2.84859134 + 2.242262392 \log L$$

$$W = 0.001417127 L^{1.0718} \quad (r=0.9624)$$

An analysis of co-variance indicated significant difference between the regression equations of male and female *L. duvaucelii*. The length-weight relationship between immature female (< 109 mm) and mature female (> 109 mm) differed significantly, hence separate equations were derived. Corresponding equations for immature male (< 119 mm) and mature male (> 119 mm)

were also given. It is observed from the above that there is a good correlation between the length and weight at different stages of maturity. In general the weight increment in females appears to be more than in males.

Size Distribution

The dosal mantle length of *L. duvaucelii* landed at Mangalore ranged from 40 to 365 mm. In the case of females, the maximum recorded length was 228 mm and males 365 mm.

FISHERY

Cephalopods are landed only by shrimp trawlers. These trawlers operate at depths upto 50 m. The mechanised fishing operations are suspended from 1st June to 31st August, due to southwest monsoon and restrictions imposed by the Government of Karnataka. Between September and November, trawlers operate only for few days depending upon the availability of prawns. Hence active trawling usually starts from December only. However, during certain years trawling continued for a few days in June due to delayed monsoon. The mesh size of the trawl net at the cod end is 18-28 mm.

Loligo duvaucelii is the most important species of cephalopods and constituted 68 to 94% during December-June period. On an average *L. duvaucelii* formed 75.13% of cephalopods landed at Mangalore. The details of landings of *L. duvaucelii* during 1982-'86 are presented in Table 2. The catches of squids increased from 10 tonnes (April-December period) in 1982 to 601 tonnes during the first quarter of 1986. In general the catch per unit effort (CPUE) was more during December-May period, indicating the peak season. From the scanty data available during June, September, October and November, it appears that squids are present in the fishing grounds. *Loligo duvaucelii* was observed in the bottom trawl along Dakshina Kannada area at depths of even 100 m during May - June, 1984 (Anon., 1984).

TABLE 2. Catch (in kg) details of *Loligo duvancelii*, during 1982-'86 at Mangalore by trawls

| Month | 1982 | | 1983 | | 1984 | | 1985 | | 1986 | |
|-------|--------|------|------------|-------|----------|-------|----------|-------|----------|-------|
| | Catch | CPUE | Catch | CPUE | Catch | CPUE | Catch | CPUE | Catch | CPUE |
| Jan. | | | 45,176 | 6.62 | 53,692 | 7.65 | 96,117 | 9.90 | 1,75,452 | 9.79 |
| Feb. | | | 71,411 | 13.54 | 70,658 | 12.08 | 96,411 | 12.58 | 1,55,546 | 17.89 |
| Mar. | | | 1,12,881 | 15.96 | 95,298 | 15.27 | 39,808 | 6.03 | 3,71,961 | 55.99 |
| Apr. | 4,343 | 0.74 | 1,04,395 | 15.47 | 74,184 | 13.29 | 73,311 | 10.59 | | |
| May | 4,069 | 0.75 | 29,946 | 5.07 | 98,692 | 17.12 | 52,549 | 10.50 | | |
| Jun. | 1,000 | 2.34 | 9,975 | 10.63 | — | — | — | — | | |
| Jul. | | | No Fishing | | | | | | | |
| Aug. | | | No Fishing | | | | | | | |
| Sep. | 483 | 0.24 | — | — | 2,831 | 1.80 | 164 | 0.48 | | |
| Oct. | — | — | — | — | 28,037 | 7.97 | 13,084 | 6.23 | | |
| Nov. | 279 | 0.05 | 2,140 | 0.73 | 61,982 | 6.54 | 1,25,925 | 24.96 | | |
| Dec. | — | — | 11,533 | 2.85 | | | | | | |
| Total | 10,174 | 0.41 | 3,87,457 | 9.75 | 4,85,374 | 10.78 | 4,97,369 | 43.39 | 6,00,959 | 26.31 |

CPUE = Catch per unit effort.

DISCUSSION

Although *Loligo duvancelii* is abundantly distributed in Indo-Pacific region (Chikuni, 1983), information on its biology is very scanty.

The present study indicated that females are dominant and they spawn during December-May period. According to Silas *et al.* (1985) females are dominant along Vizhinjam, and males along Cochin. However, along Bombay coast the sexes are equally distributed with the peak spawning during January-May.

According to Bakhayokho (1983), high gonad index (GI) and nidamental gland index (NGI) suggest conditions favourable to gonad maturation. In *Loligo duvancelii* high GI and NGI were observed below 100 mm and the estimated size at first maturity in females was 108 mm (100-109 mm length group). In Vizhinjam, Cochin and Bombay areas of west coast, female *L. duvancelii* reaches maturity at sizes of 110, 128 and 107 mm respectively, whereas for males

the size at first maturity along the former two areas are 108 and 122 mm (Silas *et al.*, 1985). Thus it appears that females of the Mangalore area reach maturity, almost at the same size as along Bombay area, but slightly at a smaller size than Cochin and Vizhinjam areas.

Junaico (1983) and Schuldt (1979) suggested that the males of some species of squids would continue producing spermatozoa, once maturity is reached and the spent stage would not exist in these animals. According to Summers (1968) male *Loligo peali* survive after first spawning season and may live more. Similarly in *L. duvancelii*, mature male specimens were present till their observed maximum size, indicating that they also spawn continuously after attaining maturity. In *Loligo opalescens* and *Todarodes pacificus* dead or exhausted specimens were found in the spawning areas (Grieb, 1976; Grieb and Beeman, 1978; Kripe and Beeman, 1978). Post-spawning death process in *Todarodes pacificus* has been described by Hambe (1963) and Hayashi (1971). Fields (1965) opined that female *Loligo opalescens* spawn only

BIOLOGY OF *LOLIGO DUVAUCELII*

once and die. In *L. duvaucelii* also the evidence of single spawning is found from the analysis of intra-ovarian eggs (Fig. 2). The steep decline in the proportion of mature *L. duvaucelii* beyond 150 mm suggests that it may be due to post-spawning mortality.

Although the process of post-spawning mortality is expected as in some other species of squids, so far even tentative evidence has not been established in *L. duvaucelii*. The evidence of post-spawning mortality in female *L. duvaucelii* may contribute to the proper evaluation and management of squid resources along the Karnataka coast.

Silas *et al.* (1985) recorded a maximum length of 190 mm for females and 285 mm for males. Higher maximum sizes have been recorded in the present study.

Cephalopods are highly opportunistic species, capable of rapidly expanding the population size and occupy the niches left by other resources (Caddy, 1983). There are considerable fluctuations in the composition of different species of fish, after the introduction of purse-seines around Mangalore area (Silas *et al.*, 1980; Narayana Rao *et al.*, 1982). Hence the recent spurt in the catches of squids may be viewed against this background.

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