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Aspects of biology and exploitation of *Sepia aculeata* Orbigny from Mangalore area, Karnataka

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ABSTRACT

Sepia aculeata is the most important component of cuttlefish landings at Mangalore. The major spawning season is October to March. It attains first maturity at a dorsal mantle length of 86 mm. Females are dominant particularly beyond 150 mm length. The fecundity ranges from 206 to 1,568 ova. Relative fecundity is the highest at 94 mm length and progressively declines with increase in length. Significant difference is observed in length-weight relationship between immature and mature cuttlefish in either sex. The fluctuations of gonad, nidamental gland and hepatic indices are correlated to the maturity and spawning habits of *S. aculeata.* The growth parameters are estimated by Gulland and Holt plot as L_∞ = 231 mm K = 0.0041/day and t_0 = -41days. This species reaches a length of 181 mm at the end of one year.

Introduction

Sepia aculeata Orbigny is an important commercial cuttlefish resource of the inshore waters of Karnataka.

At Mangalore it is mainly caught as by-catch of shrimp trawlers. This species forms about 25 % of the cephalopods landed at Mangalore by trawlers. Information on the biological aspects of this species is meagre (Silas *et al.,* 1985) and no information is available from Mangalore area.

Material and methods

The material for this study was collected at weekly intervals from the landings of shrimp trawlers at Bunder, Mangalore from April 1982 to March 1986 (Table 2). Length-weight relationship was determined by least square method separately for males and females. These equations are based on observations of 82 immature and 281 mature males and 66 immature and 396 mature females. The length is expressed as dorsal mantle length (DML) in mm and weight in grams. The abundance of mature specimens was taken into consideration for determining the spawning season. The length (DML) at first maturity was determined by considering the length at which 50 % of the specimens attained maturity. For the purpose of maturity, four stages viz: immature, maturing, mature and spent were considered. The ova in a mature ovary were counted with naked eye to

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determine the fecundity. The relative fecundity (RF) was calculated by the formula:

F

where F = total fecundity and W = weight of female in grams after removing ovary.

The weight of gonad was expressed as percentage of total weight, in calculating the gonadial index (GI). Nidamental gland index (NGI) and hepatic index (HI) were determined following similar procedures. Sex ratio and maturity studies were based on the examination of about 1,000 specimens. Data on catch and effort were collected at birweekly intervals at Bunder (Mangalore) landing centre. Specieswise and boatwise landings were recorded at random and raised to the total units landed on observed days and eventually to the month. For biological studies the data for different years were pooled as differences between years were negligible.

Biology

Size at first maturity

Mature S. *aculeata* were observed from about 60 mm length. Both males and females appear to mature almost at the same size. At 86 mm, mature cuttlefish formed 50 % (Fig. 1). Hence 86 mm may be considered as length at first maturity.

Maturity and spawning

Data on the distribution of mature S. *aculeata* during the southwest monsoon (June-September) were not available due to suspension of trawl fishing. Mature specimens were available during the rest of the months. Mature cuttlefish constituted more than 50 % of

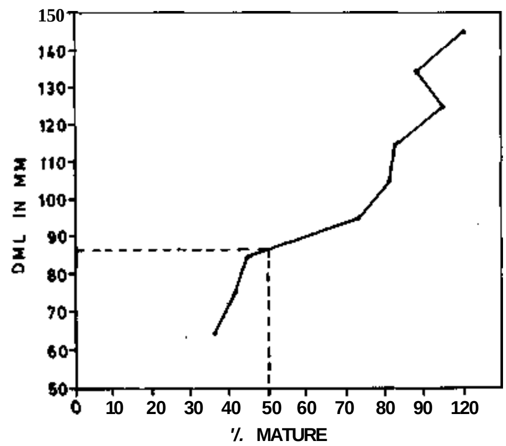

Fig. 1. Length at first maturity in *Sepia aculeata.*

the samples during October-March period (Fig. 2) and around Mangalore this period may be considered as the major spawning season for *S. aculeata*. Analysis of intra ovarian eggs of mature *S. aculeata* revealed uni-modal distribution (Fig. 3). The diameter of mature ova ranged from 1-5 mm and the mean diameter was 3.392 mm. Spent specimens of both the sexes were not found.

Sex ratio

Females were dominant during

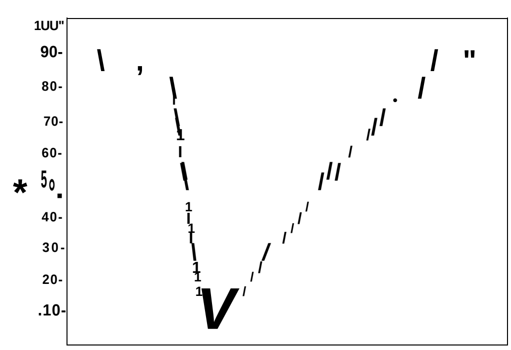

Fig. 2. Seasonal abundance of mature S. *aculeata* (broken line indicates absence of data).

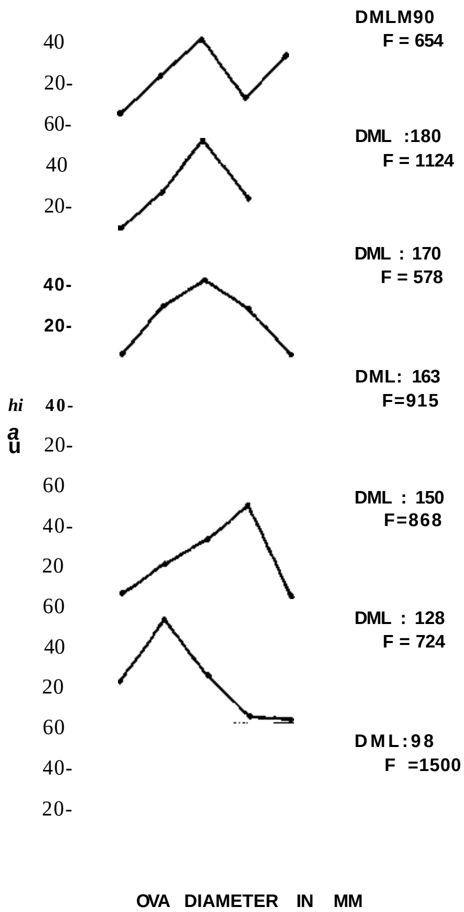

Fig. 3. Ova diameter frequency of mature *S. aculeata* at different lengths (mm) with fecundity (F).

November-December and February-April, whereas males were dominant in other months except June. It may be pointed out that female dominance during the peak landing season was pronounced (Table 1). The overall male to female ratio was 1 : 1.3. Analysis of length-wise sex ratio indicated that there was a marked female dominance beyond 150 mm. The number of males beyond 170 mm length was negligible. The largest male and female specimens recorded measured 205 mm.

TABLE 1. *Variation in the sex ratio of* S. aculeata *during 1982 - 86 (pooled)*

Month	Males	Females	Total	
Jan.	98	80	178	1.82
Feb.	42	84	126	14.00*
Mar.	15	36	51	8.64*
Apr.	24	38	62	3.16
May	28	14	42	4.66*
Jun.	1	6	7	3.57
Oct.	8	2	10	3.6
Nov.	86	118	204	5.02*
Dec.	105	144	249	6.10*
Total	407	522	929	14.2*

* Significant at 5 %

Fecundity

The number of ova in the mature ovaries of *S. aculeata* ranged from 206 to 1,568, with an average of 587. Fecundity for different length groups was pooled based on 96 observations and the relation between length and fecundity was derived by the least square method. The equation was:

Log Fecundity = -1.5334496634 + 0.58951667 log length (r=0.5689, Df : 95).

The curve of actual mean values of fecundity at different length groups was superimposed over the length-fecundity regression line (Fig. 4A). The curve of mean values has shown first peak, almost coinciding with the length at first maturity and thereafter it showed peaks and troughs. The correlation between the length and fecundity was poor. However, a good correlation (0.8016) has been observed between the length and ovary weight as indicated below:

Log ovary weight = -3.929314 + 2.324186

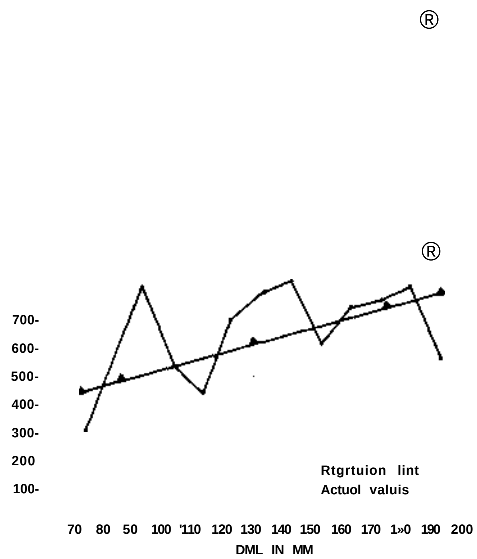

Fig. 4. Length-fecundity (A) and relative fecundity (RF) relationship (B) in S. *aculeata.*

log length

Relative fecundity

The relative fecundity ranged from 8.6 to 1.5 eggs per gram. The values of RF peaked at length of 94 mm which is close to the length at first maturity. The RF values showed a gradual decline towards the higher lengths (Fig. 4).

Gonad (GI), Nidamental gland (NGI) and Hepatic (HI) indices

These indices for mature specimens showed peak values in April and low values from October to March (Fig. 5); the low values coinciding with peak spawning season. In the case of immature specimens the GI showed high values during February and March, NGI in March and April and HI only in February. The GI in relation to length showed its first decline around 80 mm and thereafter, it showed peaks and troughs. NGI also indicated its first trough at 80 mm and thereafter the values fluctuated. Similarly HI also showed first decline at 80 mm and then almost steady with a peak around 130 mm (Fig. 6).

Length-weight relationship

The length-weight relationship for immature and mature S. *aculeata* was calculated separately for males and females. The following equations describe the length-weight relationship :

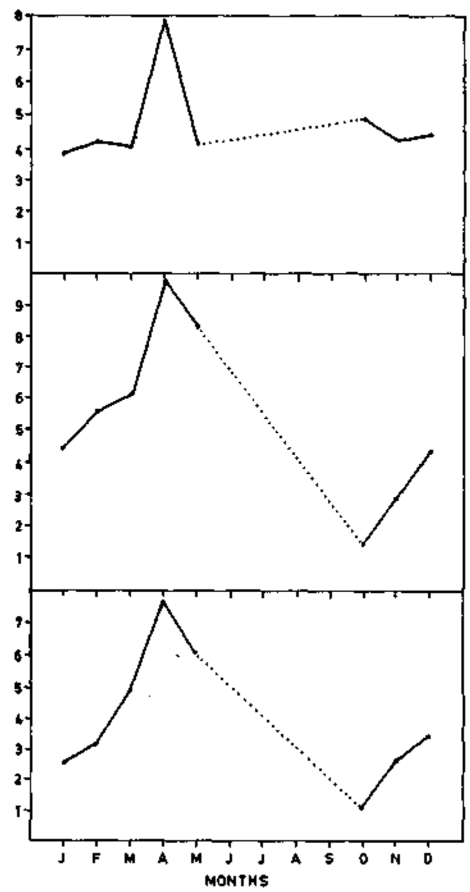

Fig. 5. Length-weight relationship in *S. aculeata.*

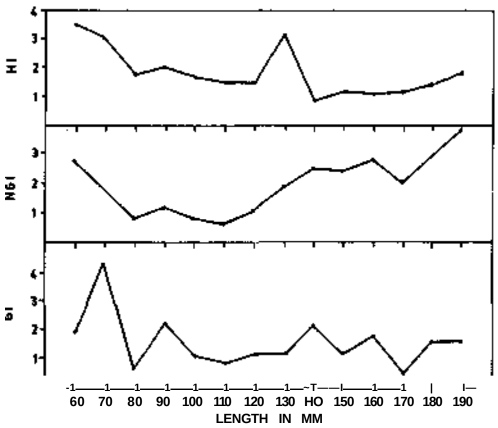

Fig. 6. Seasonal variations in the gonadial, nidamental gland and hepatic indices of mature S. *aculeata* (No data during June-September).

1. Immature: Males : log W = -3.765117429 + 2.911936407 log length (r = 0.94341)

Females : log W = -4.18059529 + 3.207482485 log length (r=0.9644)

b. Mature males : log W = -2.700583283 + 2.38521028 log length (r = 0.9678)

Females : log W = -3.21338178 + 2.503340692 log length (r=0.9836)

Analysis of covariance indicated that there was significant difference at 5 % level between the regression equations of immature and mature specimens of the same sex. The regression equations showed high degree of correlation between length and weight.

Age and growth

For the purpose of growth studies, the length measurements were grouped into 2 mm class intervals. It was not possible to trace the broods continuously over the whole length range of the species due to irregular shifting of modes and absence of data over the monsoon period (June-September). Hence Gulland and Holt (1959) method was applied which allows the tracing of growth at short and irregular intervals of time at different length ranges. Each mode in a length-frequency distribution is taken as the average length of one group (brood) of fish:

$$\frac{\Delta L}{\Delta t} = a - K.\bar{L}$$

The above equation may be written as

$$\frac{\Delta L}{\Delta t} = K\left(L_\infty - \frac{L_1 + L_2}{2}\right)$$

where L_1 = Length of cuttlefish at any mode of mode chain,

L_2 = Length of cuttlefish at the following mode of mode chain,

$t_2 - t_1$ = Interval in days between the two modes, K = catabolic growth coefficent and L_∞ = asymptotic length of cuttle fish.

The growth ranges derived at diferent mean lengths were utilised to get the regression equation (Fig. 7) by the least square method:

Growth rate (Y) = 0.9459 - 0.0041 length (x)

The intercept a and slope b provide values of K and L through the relationships:

K = -b = 0.0041/day

and $L_\infty = \frac{a}{k}$ = 231 mm

For estimation of t_0 in the von Bertalanffy growth equation :

$L_t = L_\infty (1 - e^{-K(t - t_0)})$

The method suggested by Pauly (1978) was followed as given below:

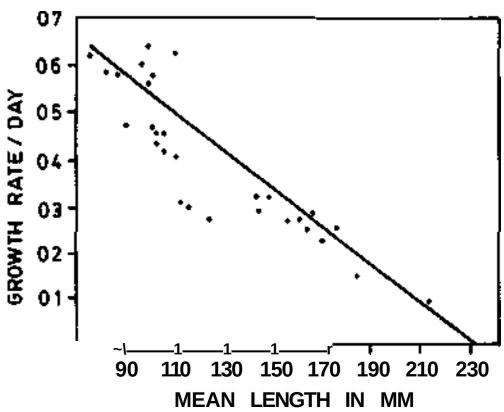

Fig. 7. Regression of instantaneous growth rates on mean lengths of S. *aculeata.*

Log_{10} $(-t_0)$ = -0.3922-0.2752 log_{10} L -1.038 $log_{10}K$

This relation gave the t_o value of S. *aculeata* as -41 days. Hence the von Bertalanffy growth equation for S. *aculeata* may be expressed as:

231 (1. e-' (t+41)\

where the estimated K and t_0 are per day and in days respectively. According to the above growth equations S. *aculeata* grows to 96 mm in 3 months, 137 mm in six months 166 mm in 9 months and 181 mm at the end of one year (Fig. 8).

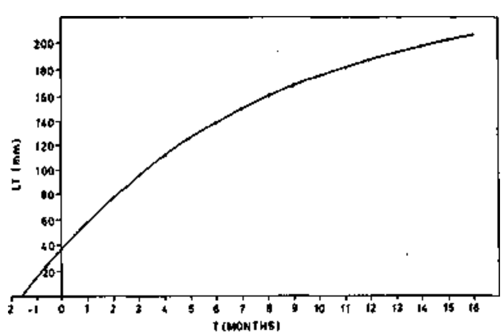

Fig. 8. Growth curve of *S. aculeata* obtained by fitting von Bertalanffy equation.

Fishery

Details of trawl fishing at Mangalore were presented by Rao (1988). The catches of *S. aculeata* ranged between 104 t in 1983 and 184 t in 1982 (Table 2). Although *S. aculeata* was observed in most of the months, the major fishery season is from November to January, when more than 75 % of the annual catches were landed. The average catch per unit effort during these three months were 12.25, 11.03 and 3.83 kg respectively. The monthly contribution of *S. aculeata* to the total cephalopod catch varied from 10.1 to 84 %. The dorsal mantel length of *S. aculeata* in the landings ranged from 60 to 205 mm. Other species of cuttlefish that contributed to the fishery on a minor scale are *Sepia pharaonis* and *Sepiella inermis.*

Discussion

Though *S. aculeata* is distributed throughout the Indo-Pacific region (Chikuni, 1983), information on biological aspects of this species is very scanty. From the von Bertanlanffy growth equation it is estimated that *Sepia aculeata* reaches a length of 181 mm at the end of the first year of its life ie., a growth rate of 15 mm/month. According to Silas *et al.* (1985) this species reaches 138.9 mm at the end of one year at Madras and Bombay which gives a growth rate of 11.6 mm/month in the first year. However, Mangold (1963) observed a growth rate of 14 mm/month and Richard (1966) recorded 18 mm/month for *Sepia officianalis hierredda.* Nabitabhata (1994) observed very high growth rates in S. *pharaonis* and *Sepioteuthes lessoniana* under culture system. The largest specimen recorded in the present study was 205 mm which is close to the value of L obtained. It is well known

TABLE 2. *Catch (kg) details of cephalopods during 1982-'86 at Mangalore by trawls*

Months	1982					1983					1984					1985					1986				
	Squids	*S.a*	Others	Total	CPUE	Squids	*S.a*	Others*	Total	CPUE	Squids	*S.a*	Others@	Total	CPUE	Squids	*S.a*	Others@	Total	CPUE	Squids	*S.a*	Others@	Total	CPUE
Jan.	No data	-	Nil	No data	-	45,176	21,713	Nil	66,889	9.80	53,692	17,430	Nil	71,122	10.14	96.117	51,470	1,577	1,49,164	15.4	73,452	28,356	7,745	1,09,553	14.50
Feb.	No data	Nil	No data	-	71,411	10,046	Nil	81,457	15.44	70,638	17,284	Nil	8,79,922	4.50	96,411	10,217	700	1,07,328	14.0	1,55,546	30,209	21,874	2,07,629	23.90	
Mar.	No data	-	Nil	No data	-	1,12,881	7,745	Nil	1,20,624	17.05	95,298	17,108	Nil	1,12,406	4.00	39,808	8,052	482	48,342	7.3	3,71,961	23,314	12,908	4,08,183	61.44
Apr.	4,343	Nil	Nil	4,343	0.74	1,04,395	1,04,395	4,410	-	1,08,805	16.12	74,184	3,540	Nil	77,724	13.90	73,311	4,843	1,101	79,255	11.4				
May.	4,069	Nil	Nil	4,069	0.75	2,91,946	14,938	-	44,884	7.59	98,692	1,776	Nil	1,00,468	17.40	52,549	3,433	Nil	55,982	11.2					
Jun.	1,000	Nil	Nil	1,000	2.34	9,975	675	-	10,650	11.35	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF					
Jul.	NF	Nil	-	-	NF	NF	-	NF	-	NF	NF	NF	NF		NF		NF		NF		NF	NF	NF		
Aug.	NF	NF	NIL	-	-	NF	NF	-	NF	-	NF	NF	NF	NF	NF	NF	NF								
Sep.	463	NIL	NIL		483	0.24	NL	NL	-	NL	-	NIL	NIL	NIL	NIL	NIL	NF	NF	NF	NF	NF				
Oct.	NIL	NIL	NIL	-	-	NL	NL	-	NL	-	2,813	1,779	NIL	4592	2.90	164	801	42	1,007	2.96					
Nov.	279	1,13,018	Nil	1,13,297	20.69	2,140	2,134	15,613	39,093	13.41	28,037	16,377	NIL	44,414	12.60	13,084	21,000	6,686	40,770	19.41					
Dec.	NIL	71,044	NIL	71,044	12.47	11,533	23,240	5,921	40,694	10.06	61,962	76.251	5824	1,44,057	15.20	1,25,925	34,369	1,364	1,61,658	32.03					
Tot.	10,174	184062	NIL	1,94,236	-	3,87,457	1,04,107	21,534	5,13,098	-	5,05,336	151,545	5824	6,42,705	-	4,97,369	1,34,185	11,962	6,43,506	-	600,959	81,879	42,527	7,25,365	-

NF - No fishing S.a - *Sepia aculeata* * - *Sepiella inermis* @ - *Sepia pharaonis*

that in short lived species the K value is high (Beverton and Holt, 1957). Considering the above points the presently estimated growth parameters appear to be reasonable.

According to Silas *et al.* (1985), this species reaches first maturity at different lengths between 77 and 130 mm at different places. Mangold (1963), Garcia Cabrera (1968) and Bakhayokho (1983) also observed different lengths for first maturity in *Sepia offtcianalis hierredda* from different regions. Silas *et al.* (1985) observed difference between the regression equations of males and females. In this study significant difference was observed between regression equations of immature and mature specimens in both males and females. On the other hand Bakhayokho (1983) observed no significant difference in the length-weight relationship of S. (o.) *hierredda.* Silas *et al.* (1985) and Bakhayokho (1983) found prolonged spawning season in *S. aculeata* and S. (o.) *hierredda* respectively. In this study also spawning season was found to be prolonged between October and March. The observed fecundity range (206-1,568) of S. *aculeata* is comparable to that of S. (o.) *hierredda* (250-1,400). The relative fecundity (RF) is the highest at 94 mm, almost coinciding with the length at first maturity. The first peak of the gonad and nidamental gland indices almost coincide with the length at first maturity. Fluctuation in the gonad index, nidamental gland index (Fig. 7) and fecundity (Fig. 4) beyond the length at first maturity suggests that *S. aculeata* spawns more than once during the spawning season. The poor correlation observed between the length and fecundity (Fig. 4) may be due to this spawning habit.

Acknowledgments

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