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Length-weight relationship, condition factor and sex ratio of *Uroteuthis (Photololigo) duvaucelii* (d'Orbigny, 1848) from Goa, west coast of India

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Original Article

Abstract

The length-weight relationship study on the squid *Uroteuthis duvaucelii* (d'Orbigny, 1848) was determined from Goa waters. The relationship was expressed as $W=0.0875L^{1.6134}$ for male and $W= 0.0330L^{1.6723}$ for female. The test of linearity shows that weight increases significantly with increase in total length of the fish, and growth was allometric. The relative condition factor (Kn) is low for male (0.911 to 1.16) compared to the female (0.911to 1.49). In both male and female, Kn values were highest at low size group 40-80 mm and decreases gradually from 200 to 240 mm size group. Sex ratio was peculiar because the number of males is exceedingly higher than females in 40-80 and 200-240 mm size compared to other size groups. In the whole stock, the percentage of males declines with increase in size. In case of females no pattern was obtained. The male:female ratio for the Goa stock was 1:0.56. Males were dominant in all size group (except 160-200 mm). Sex-ratio varied and differed significantly.

Keywords: *Uroteuthis duvaucelii, Goa coast, allometric growth, condition factor, sex ratio.*

Introduction

The length-weight relationship (LWR) is an ideal indicator of growth. It is an important tool in fish biology, physiology, ecology and fisheries assessment (Prasad and Ali, 2007). The relationship serves three purpose viz. i) to determine the type of the mathematical relationship between two variables so that if one variable is known the other could be computed, ii) the relative condition can be estimated to assess the general well being of the fish and type of growth i.e. isometric or allometric and, iii) it help to estimate the potential yield per recruit in the study of fish population dynamics. *Uroteuthis duvaucelii* is one of the important components of the cephalopod catch in India. Its biology, length weight, condition factor and sex ratio is well documented from various parts along the west and east coast of India (Rao,1988; Meiyappan and Srinath, 1989; Meiyappan *et al.*, 1993; Nair *et al.*, 1996; Mohamed and Rao, 1997; Karnik and Chakraborty, 2001; Thomas and Kizhakudan, 2006). Information is not available on the biology of *U. duvaucelii* from the Goa coast. Thus, a study was designed to determine the length-weight relationship, the relative condition factor and sex ratio with respect to size composition from the coastal waters of Goa.

Material and methods

Samples were collected from different locations between 15°06′ to 15°42′N latitude and 73°37′ to 72°54′ E longitude through routine survey cruises of *MFV Matsya Vishwa* and *MFV Matsya Sagarika* in every three months during December 2004 to November 2005. Samples were obtained from 35 to

200 m depth by demersal trawl (27.5 m) and fish and shrimp (30 m) trawls. Total 378 specimens (242 males and 136 females) were measured for length-weight, condition factor and sex ratio studies. The LWR was calculated by the method of least square employing the equation of Le Cren (1951): $W = a L^b$ Where, W= weight of fish, L= length of fish and 'a' and 'b' are constants. The same in the logarithmic from can be written as: Log W=log a+ b Log L.

Student's t-test was done to determine if regression coefficients differed from the isometric value of 3. Based on empirical length-weight relationship, the relative condition factor (Kn) was computed for all size groups in each sex by the formula, Kn= W/Wc; where, Kn represents relative condition factor, W observed weight and Wc calculated weight. Five different categories were made for all size with 5 class interval. Males and females were counted to record the changes in sex ratio with increase in size. Chi square test was applied to determine significant difference in the sex ratio in different size groups.

Results and discussion

The correlation coefficient shows high correlation between total length and total weight of *U. duvaucelii*; 0.9137 in male and 0.9556 in female. The LWR obtained for male was $W=0.0875L^{1.6134}$ and that of female $W= 0.0330L^{1.6723}$. In the logarithmic form the expression is:

Male : Log W= -1.05799+1.6134 Log L, $R^2 = 0.9556$

Female : Log W= -1.48149+1.6724 Log L, $R^2 = 0.9137$

A straight line was obtained, when log weights were plotted against log lengths in males and females. The test of linearity by analysis of variance showed that total length was highly significant for increase in total weight of the fish (Table 1). 't'-Stat indicated that growth was significantly allometric (male t =-48.60; female t = -34.59: $t_{0.001\ (1,\ 241)} = 3.291$ $t_{0.001\ (1,\ 135)} = 3.291$). Rao (1988), Meiyappan and Srinath (1989), Nair *et al.* (1996) and Mohammed (1996) also observed allometric growth in *L. duvaucelii*. The present study indicates low value of 'b' for both the male (1.6134) and female (1.6723). Occurrence of low 'b' value is attributed to low size range in male (44 -240 mm) and female (40 -235 mm) than the other studies. Ratana-anan (1978) and Srichanngam (2010) also reported low 'b' value from the Gulf of Thailand and Andaman sea respectively. However, higher 'b' value was recorded from Saurashtra coast (Thomas and Kizhakudan, 2006), Mumbai waters (Kuber, 1987; Karnik and Chakraborty, 2001), Mangalore coast (Mohamed and Rao, 1997), Cochin

Table 1. Statistics of length-weight relationship for *Uroteuthis duvaucelii* in male and female: Analysis of covariance

U. duvaucelii (Male)						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.0875	0.0231	3.7906	0.0002	0.042	0.133
Log L	1.6134	0.0225	71.862	3E-164	1.5691	1.6576
ANOVA		df	SS	MS	F	Significance F
S.S. due to Regression		1	25.17076	25.17076	4353.352	2.1E-155
S.S. Residual		239	1.38188	0.005782		
Total		240	26.55264			
Equation Log W= -1.05799+1.6134 Log L; 1.6134x + 0.0875						
U. duvaucelii (Female)						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.033	0.0477	0.6929	0.4896	-0.061	0.1273
Log L	1.6724	0.0444	37.658	4E-73	1.5846	1.7602
		df	SS	MS	F	Significance F
S.S. due to Regression		1	11.66657	11.66657	1418.113947	3.8E-73
S.S. Residual		134	1.102394	0.008227		
Total		135	12.76896			
Equation Log W= -1.48149+1.6724 Log L; 1.6724x+0.0330						

waters (Meiyappan and Srinath, 1989), Madras coast (Silas *et al*., 1985) and Gulf of Thailand (Chotiyaputta, 1996). The relationship is known to differ among the sexes (Nair *et al*., 1996; Thomas and Kizhakudan, 2006; Sukramongkol *et al*., 2007; Mohamed *et al*., 2009)

The relative condition factor (Kn) expresses the deviation of an individual's weight from average for fish of its length in that population. As such, its use is limited to within population comparison, as for seasonal effects or sexual difference in the growth (Ney, 1999). The Kn ranged between 0.911 to 1.16 for male and 0.911 to 1.49 for female. In males, the Kn gradually decreases from 40-80 mm to 200-240 mm and hence peak occurs in the least size group. In female also Kn is high in the 40-80 mm size group. However, a gradual increase occurs from 0.911 to 0.987 in 80-120 mm to 1.01-1.04 in 160-200 mm size group. Kn of females is higher than males only in 40 - 80 mm size while that of the males in other size groups (Fig. 2). Kn value for *L. duvauceli* ranges between 0.49 to 1.4 from the Indian waters (Silas *et al*., 1985; Rao, 1988; Meiyappan and Srinath, 1989; Meiyappan *et al*., 1993; Mohamed and Rao, 1997; Karnik *et al*., 2003). A narrower range (0.96 to 1.04) was observed for *L. duvaucelii* from the Goa coast.

Studies with respect to size show that the relative condition factor was highest in female for 40-80 mm size compared with 160-200 mm size for the males. Since *L. duvaucelii* attains sexual maturity at 80 mm size, higher Kn for female in 40-80 mm size seems proper. However, higher Kn for male in 160-200 mm size may be due to delayed attainment of sexual maturity. The mature male of *L. duvaucelii* in Mangalore waters are known to range from 70 to 124 mm (Rao, 1988), 50-150 mm and 50-130 mm at Waltair and Madras respectively (Silas *et al*., 1985).

The sex ratio revealed interesting pattern. The number of males is exceedingly higher than females in 40-80 and 200-240 mm size compared to other size groups (Fig. 1). The share of male was high in all size groups except in 160-200 mm size group (Fig. 3).The male:female ratio for the Goa stock was 1:0.56. The sex ratio was significantly different in the 40-80 and 80-120 mm and 200-240 mm size groups (Table 2). Mohamed (1993) also found that the number of male squid is much higher than female (M-1: F 0.25). Thomas and Kizhakudan (2006) observed that females were dominant during January, March, May and December, whereas males were dominant in other months in Gujarat waters and reported a ratio of 1:1.3. However, males was higher than that of females on the east coast (Meiyappan *et al*., 1993). Jackson (1997) found more mature males than females of *Lolliguncula brevis* from the northern Gulf of Mexico off the Texas coast.

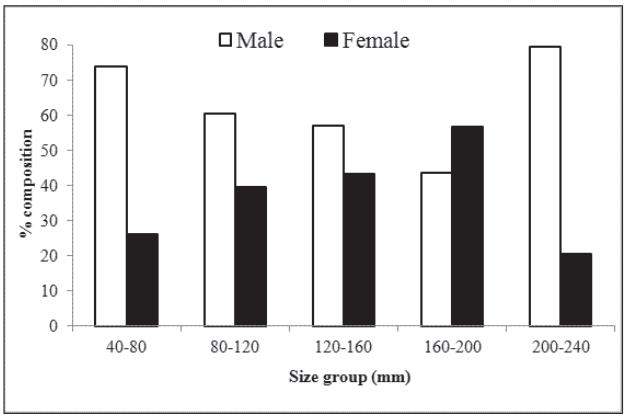

Fig. 1. Percentage composition of male and female in different length group of *U. duvaucelii*

Table 2. Size related variations in sex ratio of *U. duvaucelii*.

Size group (mm)	Number of Male	Number of Female	Sex ratio M:F	$\chi^2 = \Sigma \frac{(O-E)^2}{E}$
40-80	88	31	1:0.35	27.30252101*
80-120	70	46	1:0.65	4.965517241*
120-160	33	25	1:0.75	1.103448276
160-200	20	26	1:1.3	0.782608696
200-240	31	8	1:0.25	13.56410256

*Significant χ^2 0.05 (1) = 3.84

In the higher size groups the ratio differs significantly only in the 160-200 mm size group. Fields (1965) opined that female *L. opalescens* spawn only once and die. Rao (1988) also found evidence of single spawning from the analysis of intra-ovarian eggs in *L. duvaucelii* and suggests the possibility of post-spawning mortality in females. The cannibalistic behaviour in the squids above 80 mm size (Kore and Joshi, 1975) may also contribute to male dominance in the populations. The present investigation supports the theory that the growth is allometric in cephalopods. The number of immature males was high in lower size group and males were dominant over female in higher size group.

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References

Chotiyaputta, C. 1996. Distribution, abundance reproductive biology, age and growth of *Loligo chinensis* and *Loligo duvauceli* in the western Gulf of Thailand. *Proc. seminar on fisheries* 18-20 September 1996. Department of Fisheries, p. 584-589 (in Thai).

Fields, W.G. 1965. The structure, development, food relationships, reproduction and life history of the squid *Loligo opalescens. Fish. Bull. Calif. Dep. Fish game,* 131: 107.

Jackson, G. D., J. W. Forsythe, R. F. Hixon and R. T. Hanlon. 1997. Age, growth and maturation of *Lolliguncula brevis* (Cephalopoda: Loliginidae) in the northwestern Gulf of Mexico with a comparison of length-frequency versus statolith age analysis. *Can. J. Fish. Aquat. Sci*., 54(12): 2907–2919.

Karnik, N.S. and S.K. Chakraborty, 2001. Length –weight relationship and morphometric study on the squid *Loligo duvauceli* (d'Orbigny) (Mollusca/ Cephalopoda) off Mumbai (Bombay) waters west coast of India. *Indian J. Mar. Sci*., 30(4): 261-263.

Karnik N.S., S.K.Chakraborthy, A.K. Jaiswar, R.P. Swamy, R. Rajaprasad, S. Boomireddy and A. F. Rizvi, 2003. Growth and mortality of Indian squid, *Loligo duvauceli* (d' Orbigny) (Mollusca/ Cephalopoda/ Teuthoidea) from Mumbai waters, India. *Indian J. Mar. Sci*., 32 (1): 67-70.

Kore, B.A. and M.C. Joshi 1975. Food of the squid *Loligo duvauceli. Proc. Indian Acad. Sci*., 81B (1): 20-28.

Kuber, V.D. 1987. A study on cephalopod of Bombay waters. Ph.D. Thesis University of Bombay, 262 pp.

Le Cren, E.D. 1951. Length-weight relationship and seasonal cycle in gonad weight and condition in perch (*Perca fluvitialis*). *J. Ani. Ecol*., 20: 201-219.

Meiyappan, M.M. and M. Srinath, 1989. Growth and mortality of the Indian squid (*Loligo duvauceli*) off Cochin, India. In: S.C. Venema, and N.P. VanZallnge (Eds.) *Contributions to tropical fish stock assessment in India*. FAO, Rome p. 157.

Meiyappan, M. M., M. Srinath, K.P. Nair, K.S. Rao, R. Sarvesan, G. S. Rao, K.S. Mohamed, K. Vidyasagar, K.S. Sundaram, A.P. Lipton, P. Natarajan, G. Radhakrishnan, K. A. Narasimham, Balan, V. Kripa and T. V. Sathianandan . 1993. Stock assessment of the Indian squid. *Loligo duvauceli* Orbigny. *Indian J. Fish*., 40 (1&2): 74-84.

Mohamed, K.S., 1993. Spawning congregations of the Indian squid *Loligo duvauceli* (Cephalopoda: Loliginldae) in the Arabian sea off Mangalore and Malpe. *Indian J. Mar. Sci*., 22: 172-175.

Mohamed, K.S. 1996 Estimates of growth, mortality and stock of the Indian squid *Loligo duvauceli* Orbigny, exploited off Mangalore, south west coast of India. *Bull. Mar. Sci*., 58 (2): 393- 403.

Mohamed, K.S. and G.S. Rao. 1997. Seasonal growth, stock recruitment and prediction of yield of Indian squid *Loligo duvauceli* (d' Orbigny) exploited from from Karnataka coast. *Indian J. Fish*., 44 : 319-329.

Mohamed, K.S., M. Joseph, P. S. Alloycious, G. Sasikumar, P. Laxmilatha, P. K. Asokan, V. Kripa, V. Venkatesan, S. Thomas, S. Sundaram and G. S. Rao. 2009. Quantitative and qualitative assessment of exploitation of juvenile cephalopods from the Arabian Sea and Bay of Bengal and determination of minimum legal sizes. *J. Mar. Biol. Ass. India,* 51 (1) : 98 - 106.

Nair, K.P., M.M. Meiyappan, P.S. Kuriakose, R. Sarvesan, A.P. Lipton, S.K. Mohamed, P.K. Asokan, M. Joseph and D. Nagaraja. 1996. Biology of squids. In Exploratory Squid Jigging in India with notes on Biology of Squids *Bull 23, Fishery Survey of India, Bombay*. p. 24-42.

Ney, J.J. 1999. Practical use of biological statistics. In: C.C. Kohler and W.A. Hubert (Eds.) *Inland Fisheries Management in North America*. 2nd Edition, American Fisheries Society, Maryland, USA. p. 167-191.

Prasad, G. and P.H. Anvar Ali. 1997. Length-weight relationship of a cyprinid fish *Puntius filamentosus* from Chalakudy river, Kerala. *Zoos' Print J.* 22(3) : 2637-2638.

Rao, G.S. 1988. Biology of inshore squid *Loligo duvauceli* Orbigny, with a note on its fishery off Mangalore. *Indian J. Fish*., 35(3) : 121 – 130.

Ratana-anan, T. 1978. Biological studies of *Loligo duvauceli* in the Gulf of Thailand. Annual report (Invertebrate fisheries subdivision Marine Fish Div Bangkok, Thailand.

Silas, E.G., R. Sarvesan, K.P. Nair, M. Srinath and K.S. Rao 1985. Stock assessment of squids and cuttlefish at selected centres. *Bull. Cent. Mar. Fish Res. Inst*., 37: 71-79.

Srichanngam, S. 2010. Age and growth determination and stock identification using statolith microstructure of Indian squid, *Loligo duvauceli* Master thesis for Fisheries biology and management program, University of Bergen, 100 pp.

Thomas, S. and S. J. Kizhakudan. 2006. Cephalopod fishery and population dynamics of *Loligo duvauceli* (Orbigny) off Saurashtra region, Gujarat. *Indian J. Fish*., 53(4) : 425-430.