Journal of Biological Sciences 9 (4): 357-361, 2009
ISSN 1727-3048

Length-Weight Relationship and Growth Pattern of *Sepioteuthis lessoniana* Lesson 1830 (Cephalopoda:Teuthida) from the Jaffna Lagoon, Sri Lanka

K. Sivashanthini, G.A. Charles and W.S. Thulasitha
Department of Zoology, University of Jaffna, Jaffna, Sri Lanka

Abstract: In the present study, length-weight regression equations were derived for male and female *S. lessoniana* collected from the Jaffna lagoon, Sri Lanka in order to find out the regression parameters and growth pattern of this species. *Sepioteuthis lessoniana* (Lesson 1830) are one of the commercially important group of cuttlefishes and becoming an important model system for neurobiological and behavioral research. It appears to be the most adaptable species to the laboratory environment and there exist a need for detail study on length-weight relationship for this species. Such a mathematical equation enables conversion of one parameter in to another as is often required during monitoring field measurements. Regression coefficients were estimated by using the logarithms of the mantle lengths and the corresponding weights and the growth pattern of the species was also noticed. The curvilinear relationships of mantle length-weight relationships for male and female were $TW = 0.200*ML^{2.477}$ and $TW = 0.229*ML^{2.437}$, respectively. Covariance analysis for mantle length-weight relationships of males and females revealed that there is no significant difference ($p>0.05$) between male and female and hence a common formulae of $TW = 0.213* TL^{2.459}$ was derived for *S. lessoniana*. The 'b' values 2.477 and 2.4347 obtained for male and female, respectively indicate that the growth rate significantly differ from the ideal value '3' and its growth said to be negative allometry.

Key words: Length-weight relationship, big fin reef squid, *Sepioteuthis lessoniana,* allometric growth, cube law

INTRODUCTION

Sepioteuthis lessoniana (Lesson 1830) known as big fin reef squids is one of the important species of squid recorded along the coastal areas in the northern part of Sri Lanka (Varoopa and Sivashanthini, 2006). These are one of the commercially important groups of squids inhabiting the Jaffna lagoon (Fig. 1). It is also becoming an important model system for neurobiological and behavioral research (Ikeda *et al*., 2003). S*epioteuthis lessoniana* is classified under family Loliginidae of the order Teuthoidea (De Bruin *et al*., 1994). In a study on diversity of commercially important species of cephalopods from the Jaffna lagoon ten species belonging to four families and seven genera were recorded (Varoopa and Sivashanthini, 2006). The recorded species are *Sepia aculeata*, *Sepia latimanus*, *Sepia pharaonis* and *Sepiella inermis* (Family: Sepiidae), *Euprymna berryi* (Family: Sepiolidae), *Loligo duvauceli* and *Sepioteuthis lessoniana* (Family: Loliginidae), *Cistopus indicus*, *Octopus aegina* and *Octopus vulgaris* (Family: Octopodidae) (Varoopa and Sivashanthini, 2006). Among the recorded species *Sepioteuthis lessoniana* is the most abundant commercially important species and therefore the present study was concentrated on *S. lessoniana.*

The Jaffna lagoon is one of the largest shallow water body of Western region located in the peninsular Northern province of Sri Lanka with an area of 412.8 km^2 and extends from the fort Hammenhill in the East to the elephant pass and extends in the West as a narrow body of water and separating the Jaffna peninsula from the main land and a few neighboring islands (Somasekaram, 1997). The Jaffna lagoon lies between 79° 52' to 80° 38' E longitude 9° 26' to 9° 46' N latitude. Length of the coast is 140 km and generally 1 to 1.5 m in depth, where there are more fishery resources and thus fishing villages are found all along the coast line (Somasundarampillai, 2002).

Squids are captured by various means; mainly caught by sirahu valai. Some fishermen use jiggers and pots to capture these species as small scale fisheries. In general they are caught incidentally along with other food fishes in trawl nets, boat seines and cast nets. During the peak season special squid jiggers with light attracters were used to catch squids and larger species of cuttlefish at night. A Y-shaped pole, long jigger consisting 5 to 6 hooks arranged in granell fashion and baited hooks are commonly used in this method. Even though, these

Corresponding Author: K. Sivashanthini, Department of Zoology, University of Jaffna, Jaffna, Sri Lanka
Tel: 00 94 21 2225925 Fax: 00 94 21 2222685

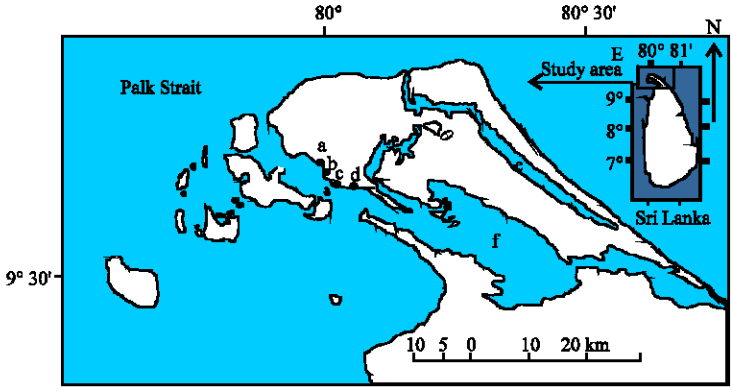

Fig. 1: Map showing the collection sites (a-d) of Jaffna lagoon, Sri Lanka. (a) Kakkaithevu, (b) Navanthrai, (c) Kurunagar, (d) Pasaioor, (e) Thondaimannar logoon and (f) Jaffna lagoon

species are available throughout the year, the major fishing season is from December to March. While, investigating it was observed that *Sepioteuthis lessoniana* and other cuttlefishes are caught in large numbers during full moon days and fog season.

The knowledge of length-weight relationship plays a vital role in the fisheries biology and population dynamics. It helps in estimating the standing stock or biomass and thereby establishing the yield by converting one variable into the other as is often done during field studies (Petrakis and Stergiou, 1995). Length-weight relationship parameters are useful to the fish farmers and farm managers in predicting the yield of the cultured fish from the equation. In the field it is easier to measure the length of fish than the weight and therefore the biomass or the stock could be computed only by measuring the length of the fishes. Compared to other loliginid squid species, *Sepioteuthis lessoniana* appears to be the most adaptable species to the laboratory environment (Hanlon *et al*., 1991) and there exist a need for detail study on length weight relationship for on these species. Various studies on length weight relationship of squids were studied by different authors in world water (Flamigni and Giovanardi, 1984; Gonzalez *et al*., 1992; Karnik and Chakraborty, 2001; Krstuloviæ Šifner, 2000; Manfrin Piccinetti and Giovanardi, 1984; Marano, 1993).

No studies have been performed on mantle length-weight relationship of *Sepioteuthis lessoniana* from the Jaffna lagoon, so far. Therefore, the present study is an attempt to understand information on size distribution, mantle length-weight relationship parameters, a comparison between regression lines of male and female mantle length-weight relationships and growth pattern of *S. lessoniana* from the Jaffna lagoon.

MATERIALS AND METHODS

Random weekly samples of squids were obtained from different landing centers from the commercial squid fishery from Pasaiyoor, Kurunagar, Kakkaiteevu and Navanthurai from May 2007 to April 2008. Twelve field visits were made to each landing centers in the mornings between 7 a.m. and 11 a.m. A total of 413 specimens were analyzed, among those 125 specimens were collected from Pasaiyoor, 101 specimens from Kuruagar, 77 from Kakkaiteevu and 110 from Navanthurai. Mantle Length (ML) was measured to the nearest 5 mm with the measuring board. The specimens were cleaned with tap water and plant parts or fish scales attached with suckers were removed. Then it was mopped with blotting sheet to remove the external moisture and weighed to the nearest 0.01 g on a top loading electrical balance (AND FY 300) and recorded. Measured mantle length data for all male and female *S. lessoniana* were classified in to 5 cm class interval and the mantle length frequency distribution was calculated for each length group.

According to Bagenal and Tesch (1978) and Ricker (1975), the relationship between total body weight (TW) and Mantle Length (ML) typically takes the form:

$$TW = a\ Ml^{b}$$

or in the liner form:

$$\text{Log } TW = \log a + b * \text{Log } ML$$

where, 'a' and 'b' are constants. The parameters 'a' (proportional constant or intercept) and 'b' (exponent) were estimated for male and female separately by using the logarithmic transformation. The regression line was

computed by the method of simple least square regression analysis.

The 'b' values obtained for male and female *S. lessoniana* were tested by Students' t-test to see whether the 'b' values differ significantly from '3' or not (Zar, 1996). Students' t-test was employed by dividing the difference between 'b' and '3' by standard error of 'b'. The regression lines of male and female *S. lessoniana* were then analyzed further for significant differences by General Linear Model Analysis of Covariance (GLMANCOVA) using MINITAB (Version 14) statistical software in the computer.

RESULTS AND DISCUSSION

The size Mantle Length (ML) of *S. lessoniana* ranged from 3.8 to 25.5 cm (mean±SD = 13.73±3.98 cm). Males ranged from 5.5 to 25.5 cm ML (mean±SD = 13.89±4.51 cm) while females ranged from 3.8 to 24.8 cm ML (Mean±SD = 13.58±3.32 cm). The values for mean weight by sex were simply compared by two-sample t-test. The results show that females were larger than males but there is no significant difference ($p>0.05$) between males and females (Table 1). The mantle length (size) frequency distribution of male and female *S. lessoniana* individuals is shown in Fig. 2. Highest percentage of frequency (i.e., 54%) was observed for *S. lessoniana* individuals of 11-15 cm mantle length class interval.

The estimates of the regression parameters of mantle length-weight relationship for male and female, obtained by regression analysis are shown in Table 2. The equations of mantle length-weight relationship and their logarithmic transformation are given in Table 3. The 'b' values 2.477 and 2.437 obtained for male and female, respectively indicate that the fish follows the cube law, its growth is proportionally three-dimensional (n = 194, $r^2 = 0.931$, 95% CL a = 0.1561 to 0.2576, 95% CL b = 2.380 to 2.573 and CV = 0.00237 for males; n = 219, $r^2 = 0.957$, 95% CL a = 0.191 to 0.274, 95% CL b = 2.368 to 2.506 and CV = 0.00223 for females). That is, with increasing age, rate of growth in terms of weight in this squid becomes slower than that of its length. Correlation coefficients (r) 0.965 for male and 0.978 for female were found to be significant ($p<0.01$) in both instances indicate good correlation bet ween mantle length and weight.

The significance of variation in the estimates of 'b' for *S. lessoniana* from the expected value for the ideal fish (3.0) was tested by Students' t-test (Snedecor, 1963; Jayaprakash, 2001). Students' t-test was employed by dividing the difference between 'b' and '3' by standard error of 'b' (Zar, 1996). The results are as follows:

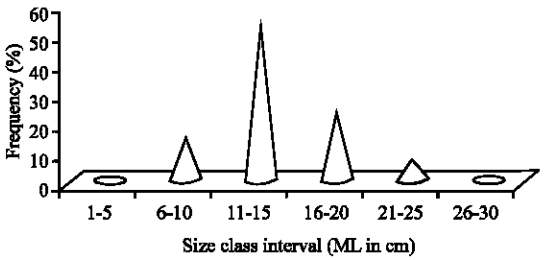

Fig. 2: Percentage frequency of size Mantle Length distribution of male and female *S. lessoniana*

Table 1: Parameters obtained from two-sample t-test for mean weight of male and female *S. lessoniana* collected from the Jaffna lagoon, Sri Lanka

Statistical parameters	Female	Male
Mean	166.10	147.33
Variance	20613.33	9058.57
Observations	194	219
Hypothesized Mean Difference	0	
df	328	
t-statistic	1.545	
P (T≤t) (one-tail)	0.062	
t-critical (one-tail)	1.65	
P (T≤t) (two-tail)	0.12	
t-critical value (two-tail)	1.97	

Table 2: Length-weight relationship parameters of *S. lessoniana* collected from Jaffna lagoon, Sri Lanka

Sex	R	N
Male	0.965	194
Female	0.978	219
Pooled	0.970	413

Table 3: Relationship between total length and weight of male, female and pooled sexes of *S. lessoniana*

Sex	Length-weight relationship	Logarithmic transformation
Male	$W = 0.200*L^{2.477}$	Log W = -0.698+2.477*LogL
Female	$W = 0.229*L^{2.437}$	Log W = -0.641+2.437*LogL
Pooled	$W = 0.213*L^{2.459}$	Log W = -0.672+2.459*LogL

Male: (2.477~3.0)/0.0488 = 10.717 Significant
(computed $t_{\alpha(2),0.05,193}>1.960$)

Female: (2.437-3.0)/0.0351 = 16.039 Significant
(computed $t_{\alpha(2),0.05,218}>1.970$)

Pooled: (2.459-3.0)/0.0303 = 17.854 Significant
(computed $t_{\alpha(2),0.05,412}>1.965$)

The above result shows that the 'b' values of male, female and pooled *S. lessoniana* significantly differ ($p<0.05$) from the ideal value '3' and exhibit negative allometric growth in all instances.

The GLMANCOVA showed the slopes 'b' of males and females not to exhibit significant interaction (computed $F_{412}<3.86$, $p>0.05$). Further, comparison of

Table 4: The parameters of length-weight relationship of squids from different regions of the world

Species	Place	Type of relation ship	Sex	a	b	Author
Illex illecebrosus	Georges bank.	ML-Wt	M+F	0.2192	1.782	Chojnacki (1973)
Loligo pealei	Georges bank	Ml-Wt	M+F	0.5144	2.056	Chojnacki (1973)
Sepia officinalis (Linnaeus, 1758)	Baltic Sea	ML-Wt	M+F	0.2204	2.773	Manfrin Piccinetti and Giovanardi (1984)
Loligo vulgaris	Gulf of Guinea	TL-Wt	M+F	0.4703	2.788	Flamigni and Giovanardi (1984)
			M+F	0.113	2.511	Marano (1993)
			M	0.008	2.3501	Krstuloviæ Šifner (2000)
Eledone cirrhosa (Lamarck, 1798)	Adriatic Sea	ML-Wt	M+F	0.394	2.713	Marano (1993)
Eledone moschata (Lamarck, 1798)	Atlantic	ML-Wt	M+F	0.858	2.389	Marano (1993)
Illex coindetii	Galician waters	ML-Wt	M	1.496×10^{-5}	3.163	Gonzalez *et al.* (1992)
			F	3.901×10^{-5}	2.910	Gonzalez *et al.* (1992)

ML: Mantle Length; TL: Total Length; Wt: Weight

regression co-efficient of males and females using GLMANCOVA for the regression of log weight on log mantle length of males and females showed the 'b' values not to show significant differences ($p>0.05$). The confidence intervals of 'a' for male and female overlap with each other and therefore there is no significant differences between the intercepts, too. Hence, the following common formulae were derived for males and females:

Parabolic equation: $TW = 0.213^* ML^{2.459}$

Logarithmic equation: $\log TW = -0.672 + 2.459 * \log ML$

The values of 'a' and 'b' differ not only in different species but also in the same species depending on sex, maturity stage, feeding intensity etc. According to Hile (1936) and Martin (1949) the value of exponent 'b' usually range between 2.5 and 4.0. The reasons for this variation are said to be due to seasonal fluctuations in environmental parameters, physiological conditions of the fish at the time of collection, sex, gonadal development and nutritive conditions of the environment of the fishes (Froese, 2006).

The length weight relationship parameters estimated for this species by previous studies expressed 'a' = 0.0005 and 'b' = 2.255 (Mhitu *et al*., 2001). The 'b' value obtained for *S. lessoniana* in the present study is slightly higher than the recorded value for this species. However, the growth pattern remains the same as that of previous studies.

Comparison of the relationship between mantle length-ML (mm) and total weight-TW (g) in different regions of the Mediterranean and Eastern Atlantic, as well as comparison of different years indicated an allometric length-weight relationship which is positive in males ($b>3$) and negative in females ($b<3$) (Ragonese and Jereb, 1992; Gonzalez *et al*., 1992).

Length-weight relationship and morphometric study for squids from Mumbai water, West coast of India was studied by Karnik and Chakraborty (2001). Chojnacki (1973) described the length-weight relationship for squids *Illex illecebrosus* and *Loligo pealei* from Georges Bank. It was observed that the 'b' values obtained for these species exhibit negative allometry with high correlation coefficient value. This result is in consistent with the reported values for 'b' in the present study. In a study on *Illex coindetii* in Galician waters, Gonzalez *et al*. (1992) reported mature males had a greater body weight at the same length than the rest of the animals and the regression coefficient was significantly higher than 3 and mature females showed a negative allometry. This result slightly differs from the present study in that negative allometry was observed in both cases, i.e., males and females. Some of the earlier results on length-weight relationship for squids in world waters are summarized in Table 4. Deviation in growth pattern i.e., allometric growth, in the present study may be the due to variations in ecology of the geographical locations, food availability and different environmental conditions. The present study reveals important parameters which are useful in the culture systems as well as in understanding the growth pattern of this species that would definitely lead to successful management and information for successful culture of *S. lesoniana* in Sri Lankan waters.

ACKNOWLEDGMENTS

Authors are grateful to the authorities of National Science Foundation for the financial assistance (Research grant No. RG/MS/2006/01). Authorities of University of Jaffna, Sri Lanka deserve grateful thanks for the facilities during this study.

REFERENCES

Bagenal, T.E. and F.W. Tesch, 1978. Age and Growth. In: Methods for Assessment of Fish Production in Freshwater. IBP Handbook No. 3, Bagenal, T. (Ed.). Blackwell Scientific Publications, Oxford and Edinburgh, pp: 101-136.

Chojnacki, J., 1973. Length weight relationship for squids-*Illex illecebrosus* Lesueur and *Loligo paelei* (Lesueur). Acta Ichthyol. Pisca., 2: 99-103.

De Bruin, G.H.P., B.C. Russell and A. Bogusch, 1994. FAO Species Identification Field Guide for Fishery Purposes. The Marine Fishery Resources of Sri Lanka. FAO, Rome, Italy, pp: 440.

Flamigni, C. and O. Giovanardi, 1984. Biological data collected during the Pipeta expeditions, on the squid *Loligo vulgaris* Lam. FAO Fish. Rep., 290: 143-146.

Froese, R., 2006. Cube law, condition factor and weight-length relationships: History, meta analysis and recommendations. J. Applied Ichthyol., 22: 241-253.

Gonzalez, A.F., G.C. Bernardino and A. Guerra, 1992. Age and growth of the short-finned squid *Illex coindetii* in Galician waters (NW Spain) based on statolith analysis. ICES J. Mar. Sci., 53: 802-810.

Hanlon, R.T., P.E. Turk and P.G. Lee, 1991. Squid and cuttlefish mariculture: An updated perspective. J. Ceph. Biol., 2: 31-40.

Hile, R., 1936. Age and growth of the cisco, *Leucichthys ardeti* (Le Sueur), in the lakes of the north-eastern highlands. Wisconsin. Bull. US. Bur. Fish., 48: 211-317.

Ikeda, Y., I. Sakurazawa, Y. Sakurai and G. Matsumoto, 2003. Initial trials on squid rearing, maintenance and experimentation at the Brain Science Institute of RIKEN. Suisanzoshoku, 51: 391-400.

Jayaprakash, A., 2001. Length weight relationship and relative condition in *Cynoglossus macrostomus* Norman and *C. arel* (Schneider). J. Mar. Biol. Assoc. Ind., 43: 148-154.

Karnik, N. and Kr. 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. Ind. J. Mar. Sci., 30: 261-263.

Krstuloviæ Šifner, S., 2000. Prilog poznavanju biologije i ekologije lignje, *Loligo vulgaris* (Lamarck, 1798) u Jadranu. Master Thesis, Sveuèilište u Zagrebu. pp: 98.

Manfrin Piccinetti, G. and O. Giovanardi, 1984. Données sur la biologie de *Sepia officinalis* L. dans l'Adriatique obtenues lors de expéditions pipeta. FAO Fish. Rep., 290: 135-138.

Marano, G., 1993. Valutazione delle risorse demersali dell'Adriatico meridionale dal promotorio del Gargano al capo d'Otranto: Relazione finale triennio '90-'93. Min. Mar. Mer., Roma.

Martin, W.R., 1949. The mechanics of environmental control of body forms in fishes. Univ. Toronto Stud. Biol. 58. Publ. Ont. Fish. Res. Lab., 70: 1-91.

Mhitu, H., Y. Mgaya and M. Ngoile, 2001. Western Indian Ocean Marine Science Association, Zanzibar (Tanzania) and Institute of Marine Sciences, Zanzibar (Tanzania) University of Dar es Salaam. In: Growth and Reproduction of the Big Fin Squid, *Sepioteuthis lessoniana*, in the Coastal Waters Of Zanzibar, Richmond M.D. and J. Francis (Eds.). IMS/WIOMSA, Zanzibar, pp: 289-300.

Petrakis, G. and K.I. Stergiou, 1995. Weight-length relationships for 33 species in Greek water. Fish. Res., 21: 456-469.

Ragonese, S. and P. Jereb, 1992. Length-weight relationships of *Illex coindetii* Veranv, 1839 (Mollusca: Cephalopoda) in the Sicilian Channel. Obelia, 28: 17-24.

Ricker, W.E., 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board. Can., 191: 1-382.

Snedecor, G.W., 1963. The Comparison of Two Groups. In: Statistical Methods. Chapter 4, The IOWA State College Press, Ames, IOWA, USA., pp: 534.

Somasekaram, T., 1997. Arjuna's Atlas of Sri Lanka. Arjuna Consulting Company Ltd., Dehiwela, Sri Lanka, pp: 220.

Somasundarampillai, A., 2002. Introduction of Sri Lanka Fisheries Exploitation and Development. Ampalam Publications, Wattala, pp: 1-2.

Varoopa, P. and K. Sivashanthini, 2006. Taxonomy and species diversity of cephalopodos (Phylum: *mollusca*) from the jaffna lagoon, Sri Lanka. Proceedings of International Symposium of Sabaragamuwa, Jul. 4-8, University of Sri Lanka, pp: 291-291.

Zar, J.H., 1996. Biostatistical Analysis. 3rd Edn., Prentice-Hall, Inc., USA., ISBN: 0-13-084542-6, pp: 662.