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Research Note

Fecundity of *Sepioteuthis lessoniana* (Cephalopoda: Loliginidae), in the Gulf of Mannar Marine Biosphere Reserve

Mookaiah Kavitha* and Geetha Sasikumar
ICAR-Central Marine Fisheries Research Institute, P. B. No. 1603, Ernakulam North (PO), Kochi - 682 018, Kerala, India

Abstract

Sepioteuthis lessoniana is one of the commercially important species, showing genetic differences among its lineages B (Gulf of Mannar) and C (Palk Bay). This study estimated the average fecundity of *S. lessoniana* from lineages B at 1,043 oocytes, ranging from 308 oocytes in a female, 18.0 cm dorsal mantle length (DML), (11.8 g ovary weight), to 2,563 oocytes in a female, 34.9 cm DML (70.4 g ovary weight). Larger females exhibited higher fecundity, which increased with DML according to the equation Fecundity=0.2266*$DML^{2.5802}$. The fecundity-ovary weight relationship followed the equation: Fecundity=21.379+33.131*ovary weight. These findings contribute to our understanding of *S. lessoniana* stocks from lineage B and their management.

Keywords: Fecundity, *Sepioteuthis lessoniana*, oocyte, Gulf of Mannar

Introduction

Sepioteuthis lessoniana is widely distributed across the Indo-West Pacific waters, from Japan to Northern Australia and New Zealand, as well as the northern Red Sea, Mozambique, Madagascar, Hawaii (Jereb & Roper, 2010; Arkhipkin et al., 2015). It is one of the commercially important squids distributed in the Palk Bay and Gulf of Mannar regions of India. *S. lessoniana*, in addition to its commercial value as an important Loliginidae species, is also of interest for biomedical research (Walsh, Turk, Forsythe, & Lee, 2002). Mitochondrial and nuclear gene analysis (Cheng et al., 2014) has identified three lineages (A, B, and C) of *S. lessoniana* in the Indo-West Pacific region, with lineages B and C corresponding to the Gulf of Mannar and the Palk Bay region of India, respectively (Tomano, Ueda, Kasaoka, & Umino, 2015).

Fecundity is a crucial life-history trait that offers essential information for the conservation and management of marine species. Fecundity estimation is critical in population dynamics studies as well as in predicting the reproductive performance of the species. In recent years, researchers have conducted numerous studies on the reproductive biology of *S. lessoniana,* reporting fecundity between 20 and 1490 (SEAFDEC, 1975; Othman & Ali, 2000; Mhitu, Mgaya, & Ngoile, 2001; Sivashanthini, Thulasitha, & Charles, 2010; Venkatesan & Santhanam, 2013). Studies on fecundity in cultured specimens show considerable variation. Tsuchiya (1981) recorded the lowest fecundity of 86-729, whereas Wada and Kobayashi (1995) reported the highest fecundity of 1024-7780 for this species in Japanese waters. In Palk Bay, the size of the animal is notably less (maximum ML 196 mm), which belongs to lineage C, compared to the species found in the Gulf of Mannar (maximum ML 349 mm), which belongs to lineage B (Kavitha, Sasikumar, Prabu, Laxmilatha, & Sajikumar, 2024). These disparities indicate possible variations in the reproductive characteristics of *S. lessoniana* between the two regions. Venkatesan and Santhanam (2013) examined the fecundity of *S. lessoniana* lineage C

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**Email:* kavifish@gmail.com

from the Palk Bay, while there is no report on the fecundity of *S. lessoniana* belonging to lineage B. Hence, the objective of this study was to focus on the fecundity of *S. lessoniana* in the Gulf of Mannar, which has significant commercial value.

Materials and Methods

The study examined the fecundity of big fin reef squid (*Sepioteuthis lessoniana*) collected from the Gulf of Mannar, southeast coast of India, from January 2018 to December 2020. A total of 1889 specimens were sampled at random from trawls and jigs. Dorsal mantle length (DML), body weight, and ovary weight were measured to the nearest 1 mm, 1 g, and 1 mg, respectively. Gonadal maturity stages were assigned macroscopically as I-immature, II-maturing, III-pre-spawning and IV-spawning, (Gabr, Hanlon, Hanafy, & El-etreby, 1998).

The female maturity can be assessed by examining the morphology and size of the oocyte as well as the shape and relative size of gonads (Gabr et al., 1998). The presence of striations on the oocyte surface in different cephalopod species serves as an indicator of the stage of oocyte maturation (Mangold-Wirz, 1963; Boyle & Knobloch, 1983; Gabr et al., 1998). The oocytes in the ovary of all females were separated using a 10% formalin solution, and the measurements of oocyte size were taken on formalin-preserved samples. The oocytes were measured and counted using a binocular dissecting microscope with an ocular micrometre. When oocytes of different sizes were observed in the ovaries, the striations and oocyte sizes were used for grouping them as immature-(I) (small), maturing-(II) (medium with striations), mature (III) (large with striations) and spawning (IV) (large and smooth). Fecundity was estimated by counting the type II, III, and IV oocytes in the ovary and spawning eggs in the oviducts of fully mature females at stage IV (spawning) (n = 333), with the assumption that the immature oocytes (type I) would not be spawned. As females in the present study were producing eggs in batches, the batch fecundity was estimated by counting type II, and III oocytes in the ovary of fully mature females at stage IV (spawning). The dorsal mantle length (DML)-fecundity relationship was computed using the non-linear regression equation, Fecundity = $aDML^b$ (Laptikhovsky, 2000), while the ovary weight-fecundity relationship was estimated by fitting the linear equation, Fecundity = a+b*ovary weight, where a and b are parameters to be estimated. SPSS version 20.0 was used for statistical analysis. The one-way analysis of variance (ANOVA) was used to evaluate the significant difference in the size (DML) of females with fecundity using Tukey's honestly significant post-hoc test at the significance level of $P<0.001$. The analysis was carried out by grouping the squids above minimum size at maturity of 12 cm into 5 different size frequencies based on their DML (12.0-15.0 cm, 15.1-20.0 cm, 20.1-25.0 cm, 25.0-30.0 cm and 30.1-35.6 cm) to assess the significant difference in the size (DML) of females with fecundity.

Results and Discussion

Immature (I) small oocytes without striation measured 0.1 to 2.0 mm; maturing (II)-oocyte with less striation categorised as medium ranged-2.0-3.5 mm in diameter; mature (III)-large oocyte with distinct striations, size range was 3.5-5.5 mm; and spawning (IV)-large and smooth transparent oocyte; size range- 5.5-8.0 mm. The number of oocytes in pre-spawning females ranged from 195 (ML-18.0 cm) to 1,250 (ML-21.0 cm) with types I to III of oocytes within the ovary. Spawning females exhibited types I to IV oocytes, with counts ranging from 404 (ML-14.4 cm) to 2,777 (ML-34.9 cm). The fecundity of *S. lessoniana* ranged from 308 (18.0 cm ML; 11.8 g ovary weight) to 2,563 (34.9 cm ML; 70.4 g ovary weight). The estimated average fecundity of *S. lessoniana* was 1,043. The batch fecundity of *S. lessoniana* ranged from 146 (19.8 cm ML; 15 g ovary weight) to 2,445 (29.5 cm ML; 60 g ovary weight) with an average of 895. The fecundity of *S. lessoniana* increased significantly with mantle length ($P < 0.001$). The dorsal mantle length (DML)-fecundity relationship showed an increasing trend following the equation Fecundity = $0.2266*DML^{2.5802}$; $R^2 = 0.5719$ (Fig. 1**)** indicating that the larger females were more fecund than the smaller ones. The relationship between the number of oocytes and ovary weight showed similar results (Fecundity=21.383+33.131*ovary weight; $R^2 = 0.838$) which demonstrates an apparent increase in fecundity with increasing ovary weight (Fig. 2).

According to the current findings, *S. lessoniana* from the Gulf of Mannar is comparatively more fecund than in other areas. In Palk Bay, southeast coast of India, Venkatesan & Santhanam (2013) observed 180–1054 (497) oocytes. Other than the Indian Coast, Mhitu et al. (2001) from Tanzania reported 180-1180 (680) oocytes from *S. lessoniana*. Similarly, Othman & Ali (2000) indicated a fecundity value of 123-1470

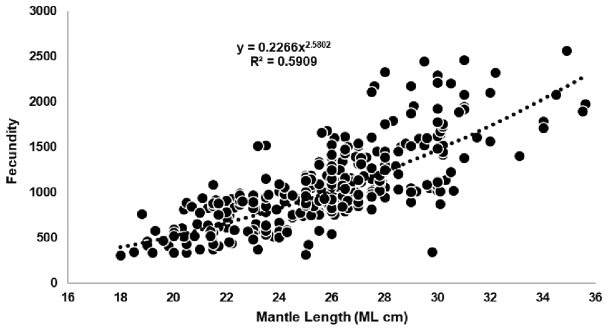

Fig. 1. Relationship between Dorsal Mantle Length (mm) and fecundity of *Sepioteuthis lessoniana* from the Gulf of Mannar

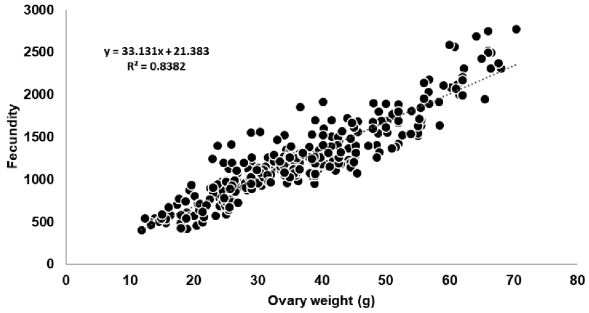

Fig. 2. Relationship between ovary weight (g) and fecundity of *Sepioteuthis lessoniana* from the Gulf of Mannar

(657) from Malaysian waters and Yakoh, Kaewmanee, Leartkaitratchata, Tes-a-sen, and Intharasuwan (2013) reported 189-1382 (573) oocytes from Thailand. Fecundity of *S. lessoniana* from the Sri Lankan Coast ranged from 20-793 (Sivashanthini et al., 2010). Furthermore, the present study suggests that animal size is a significant factor in fecundity estimation, as the dorsal mantle length of *S. lessoniana* from the Gulf of Mannar is greater than that reported in other studies. The captive-rearing studies of *S. lessoniana* reported fecundity between 49 and 7780 egg cases/female. The fecundity of *S. lessoniana* displays considerable variability across different geographical locations (Table 1), likely due to varying spawning periods, which can be either shorter or longer, in specific locations (Mhitu et al., 2001).

Table 1. The fecundity of *Sepioteuthis lessoniana* reported from captive and wild-caught squids

Study area	ML (cm)	Fecundity (av.)	Method	References
Philippines	—	292-757	–	SEAFDEC (1975) *
Malaysia	—	123-1470 (657)	Gravimetry (Potential fecundity)	Othman & Ali (2000) *
Tanzania	14.0-24.1	180-1180 (680)	Gravimetry (Batch fecundity)	Mhitu et al. (2001) *
Sri Lanka	7.0-26.0	20-793	Gravimetry (Potential fecundity)	Sivashanthini et al. (2010) *
India	12.0-19.6	180-1054 (497)	Gravimetry (Potential fecundity)	Venkatesan & Santhanam (2013) *
Thailand	12.0-30.5	189-1382 (573)	-	Yakoh et al. (2013) *
Japan	—	1500-2000	Egg case/female	Choe & Oshima (1961) **
Japan	—	86-729	Egg case/female	Tsuchiya (1981) **
Japan	20.0-25.0	500-1734 (986)	Egg case/female	Segawa (1987) **
Japan	14.8-23.0	305-3294 (1543)	Egg case/female	Lee, Turk, Yang, & Hanlon (1994) **
Japan	18.9-30.0	1024-7780	Egg case/female	Wada & Kobayashi (1995) **
Thailand	11.4-21.3	1000	Egg case/female	Nabhitabhata (1996) **
Thailand	—	1490	Egg case/female	Thapanand & Phetchsuthi (1998) **
Japan	14.6-22.4	49-1785 (509)	Egg case/female	Walsh et al. (2002) **
Japan	18.8-22.2	972-1360	Egg case/female	Ikeda, Ueta, Anderson, & Matsumoto (2009) **
India	18.0-34.9	308-2563 (1043)	(fecundity)	Present study

* wild capture *S. lessoniana*; ** captive reared *S. lessoniana*

The oocyte numbers and ovary weight of *S. lessoniana* showed a strong correlation, and the fecundity of *S. lessoniana* increased significantly with mantle length. Larger squids have a greater potential for producing more offspring in the next generation compared to smaller individuals. The relationship holds true in various loliginid squid species, *S. lessoniana* (Mhitu et al., 2001; Sivashanthini et al., 2010; Venkatesan & Santhanam, 2013); *Loligo vulgaris* (Laptikhovsky, 2000); *L. gahi* (Laptikhovsky, Arkhipkin, Middleton, & Butcher, 2002) and *Uroteuthis duvaucelii* (Rao, 1988; Choi, 2007). However, among females of similar sizes, there might be variations in the quantity of eggs and weak relationship obtained between the mantle length and fecundity may result from some females of similar size that have already laid different numbers of eggs. This is likely due to different spawning histories, since all these individuals appeared to be in spawning condition. Similar findings have been reported in *S. lessoniana* (Pecl, 2001; Mhitu et al., 2001; Sivashanthini et al., 2010; Venkatesan & Santhanam, 2013); *S. australis* (Pecl, 2001) and *U. duvaucelii* (Choi, 2007).

Conclusion

The fecundity of *S. lessoniana* stocks belonging to lineage B, from the Gulf of Mannar, exhibits greater oocyte counts compared to the fecundity of *S. lessoniana* lineage C reported from Palk Bay. This suggests differences in the reproductive output of the two lineages of *S. lessoniana*. The observation of the reproductive capacity of these stocks in nearby geographical areas is the first of its kind to be documented along the southeastern coast of India. Such variability in reproductive capacity is an important factor in assessing the intrinsic rebound potential, which is crucial for the management of this commercially important species. As these species have different reproductive performances in terms of fecundity, this study will be more beneficial and robust in planning the stock management strategies and aquaculture potential of these short-lived commercially important species.

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