Cephalopod Biodiversity, Ecology and Evolution
Payne, A. I. L., Lipiński, M. R., Clarke, M. R. and M. A. C. Roeleveld (Eds). *S. Afr. J. mar. Sci. 20: 449–452*
1998

AGE AND GROWTH OF THE SQUID *SEPIOTEUTHIS LESSONIANA* IN N.W. LUZON, PHILIPPINES

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The statoliths of 33 *Sepioteuthis lessoniana* from Bolinao, north-western Luzon, Philippines, were examined microscopically for growth increments. The daily nature of the increments was verified for captive specimens (<6 cm) kept in a tank containing Alizarin solution and fed with shrimps previously soaked in Alizarin solution. The ages ranged from 30–40 days in juveniles (19–33 mm dorsal mantle length *DML*) to 62–132 days in adults (62–315 mm *DML*). The growth rates estimated (0.5 mm·day^{-1} in adults) were much higher than those estimated by length-frequency analysis, but compatible with published estimates based on the statoliths of specimens sampled in Australia and Japan. The discrepancy between the results of length-frequency analysis and statolith ageing is attributed, at least in part, to underestimation of the age of older squid.

The bigfin reef squid *Sepioteuthis lessoniana* (Lesson, 1830) is an important fisheries species throughout much of its range, from central Japan and the Red Sea in the north, through South and South-East Asia, to Queensland, Australia, and North Island, New Zealand, in the south (Roper *et al.* 1984). In the Philippines, *S. lessoniana* is caught mainly by trawl (Hernando and Flores 1981). Regrettably, its contribution to the annual Philippine cephalopod catch of about 10 000 tons (Balgos 1990) is not known, owing to the lack of species-specific data.

The present contribution presents the results of a study on the age and growth of *Sepioteuthis lessoniana* in the north-west of the Philippines (Balgos 1990).

MATERIAL AND METHODS

A total of 13 squid samples was obtained between 26 September 1988 and 10 October 1989 at the wet-fish market at Bolinao, Pangasinan Province. The squid were caught mainly by jigging on reef flats at depths of about 2 m. The samples, consisting of a

Table I: Frequency distribution of dorsal mantle length (*DML* = class midpoint) of *S. lessoniana* caught in Bolinao, north-western Philippines

DML (cm)	Number per collection date												
	28/9/88	15/10/88	21/11/88	20/12/88	17/1/89	20/2/89	25/3/89	14/4/89	16/5/89	17/6/89	22/7/89	18/8/89	10/10/89
7	1	5	4	1				2	2	1	1		7
9	7	39	17	19	7	21	3	15	5	20	17	17	24
11	13	20	23	10	7	32	9	16	19	27	23	35	15
13	19	10	12	8	14	33	18	26	29	17	28	25	21
15	17	14	2	7	13	13	11	20	30	8	25	14	13
17	6	2	4	1		4	3	17	14	12	11	10	16
19	7	4	1	3	2	3	4	6	6	5	4	5	7
21	2	1		2	5	2	3	1	5	6	1	4	
23	1							1	3		1	3	1
25						1	1	1	5	4			
27								1					
29													
31													
Total	73	95	64	51	48	109	52	106	118	101	111	113	104

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Manuscript received: September 1997

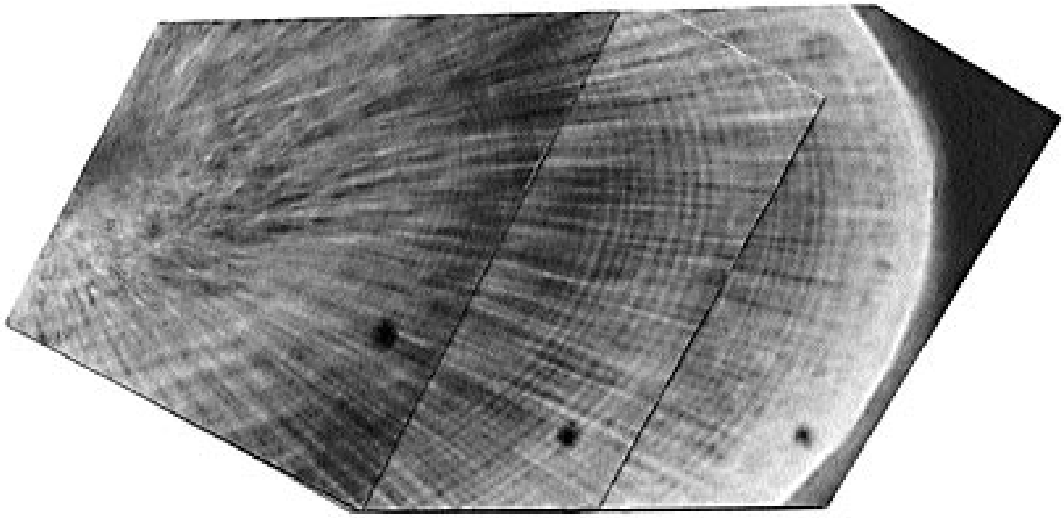

Fig. 1: Ring structures on the ground statolith of a *S. lessoniana* specimen of 6.3 cm *DML*. At such a size, increments appear to be daily

total of 1 145 animals ranging from 2 to 32 cm dorsal mantle length (*DML*, Table I), were used for length-frequency analysis. Statoliths were extracted from 33 squid, cleaned and ground on both sides using 600-grit sandpaper lubricated with mineral oil, washed with acetone, etched with 1% HCl for 15-60 seconds, then rinsed and mounted with Canada balsam.

The processed statoliths showed very fine alternating dark and light bands, as in otoliths and other statoliths. Statoliths with clearly identifiable rings along the longest axis from the focus to the edge of the lateral dome were examined. From the focus to about 116.5 µm, the increments had a mean width of 17.94 µm. Thereafter, to about 233 µm, increments were relatively thinner. Then followed an area where increments had irregular widths that gradually became narrow towards the edge of the lateral dome. Increment counts were

Table II: Observations on the left and right statoliths of five specimens of *S. lessoniana* fed on 29 September 1989 with shrimps soaked in Alizarin red solution

DML (cm)	Survival (days)	Rings beyond Alizarin marks	
		Right	Left
5.4	12	10	11
7.3	24	23	21
5.2	13	10	10
5.9	24	21	22
5.7	24	14	15

Table III: Apparent ages of *S. lessoniana* from Bolinao, Philippines, based on statolith ring counts

DML (cm)	Sex	Statolith length (µm)	Apparent age (days)
1.9	Juvenile	239	30
2.4	Juvenile	330	45
3.3	Juvenile	288	68
6.2	F	546	85
6.3	M	426	61
8.8	F	486	73
9.5	F	511	78
10.6	M	575	91
11.2	F	551	86
11.3	F	588	94
11.5	F	554	86
11.9	F	544	84
12.4	F	572	90
12.5	F	607	98
13.4	F	596	96
13.5	F	594	95
14.3	M	602	97
14.5	M	567	89
14.6	F	613	99
15.4	M	630	103
15.7	F	639	104
15.9	M	588	94
16.0	M	630	103
18.0	F	693	115
18.9	F	648	106
19.0	F	657	108
19.3	F	778	132
21.8	M	742	125
23.5	M	647	106
24.0	M	752	127
25.1	M	741	125
27.5	M	796	136
31.5	M	679	112

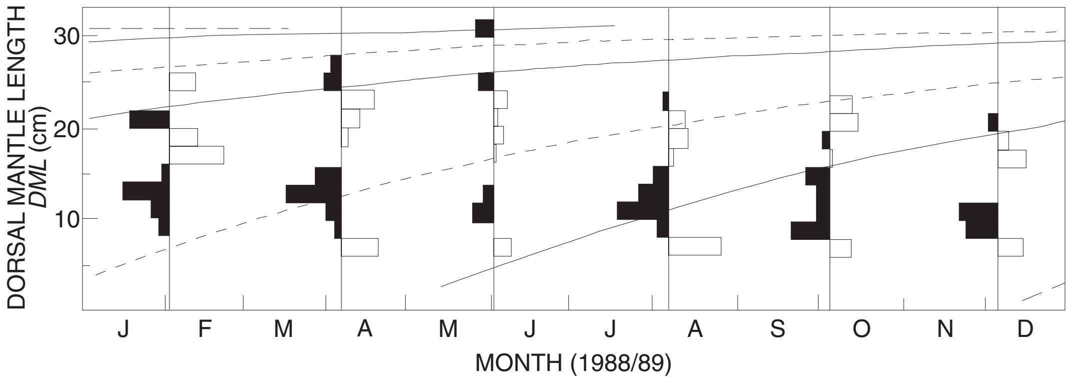

Fig. 2: Von Bertalanffy growth curve (with L_∞ = 32 cm *DML* and K = 1·year^{-1}) superimposed on the length-frequency data of Table I, regrouped into bimonthly samples, and re-expressed as positive points (black) representing modes, and negative points, representing the troughs between modes. The curve shown is that which passes through, and accumulates, the most positive points, while avoiding troughs. The fit is not particularly convincing, presumably as a result of gear selection against small squid

taken from 150 segments of 23.3 μm each, following the method of Ralston (1985).

Five live squid, kept in a 230 l aquarium containing Alizarin solution, and fed *Acetes* shrimps previously soaked in Alizarin red solution, survived long enough to validate whether observed statolith increments were daily.

The length-frequency analyses, initially performed using the Compleat ELEFAN software (Balgos 1990), were repeated using the recently released FiSAT software (Gayanilo *et al.* 1996). A rapid evaluation of a wide range of parameter combinations of von Bertalanffy growth equation can be obtained with this equation.

RESULTS AND DISCUSSION

Figure 1 shows the increments in the statoliths of a *S. lessoniana* of 6.3 cm *DML*. Table II shows that, in specimens of about 6 cm *DML*, rings appear to be deposited daily. Table III suggests that specimens of about 10 cm *DML* (statolith length ± 550 m) are about 3 months old, roughly compatible with the length-based estimates in Figure 2. However, the data in Table III are also suggestive of rapid growth thereafter, 30 cm *DML* being reached at about 4 months of age. The corresponding growth rates (Table IV) match those estimated by Jackson (1990), based on *S. lessoniana* samples taken off Townsville, Australia.

The results differ radically from those derived from length-based analysis, and suggest either:

(i) that length-based analysis seriously underestimates the growth rate of larger specimens of *S. lessoniana*; or

(ii) that ring counts in larger squid underestimate their true age.

Which of these two options is correct cannot be decided on the basis of the available data; either analysis may be flawed. Therefore, the length-frequency data at hand cannot be as straightforwardly interpreted as those in Figure 10.10 of Longhurst and Pauly (1987), pertaining to *S. lessoniana* in Palk Bay, India (which grew roughly as suggested in Fig. 2). On the other hand, it is possible for the rings in Table III to be daily in the small sizes (<6 cm), for which they were subject to at least some validation, but to represent longer intervals in larger, mature specimens.

Table IV: Comparison of length at age and growth rate between *S. lessoniana* specimens from Bolinao, Philippines (this study) and specimens from Townsville, Australia (after Jackson 1990), based on statolith analyses

Stage	*n*	Age (days)	*DML* (cm)	Growth rate (mm·day^{-1})
Juveniles				
Bolinao	3	30–45	1.9–3.3	0.54
Townsville	5	34–40	2.9–3.5	0.71
Females				
Bolinao	17	73–132	6.2–19.3	1.70
Townsville	9	60–188	7.5–18.4	1.34
Males				
Bolinao	13	62–136	6.3–31.5	1.32
Townsville	9	58–153	7.5–21.3	1.42

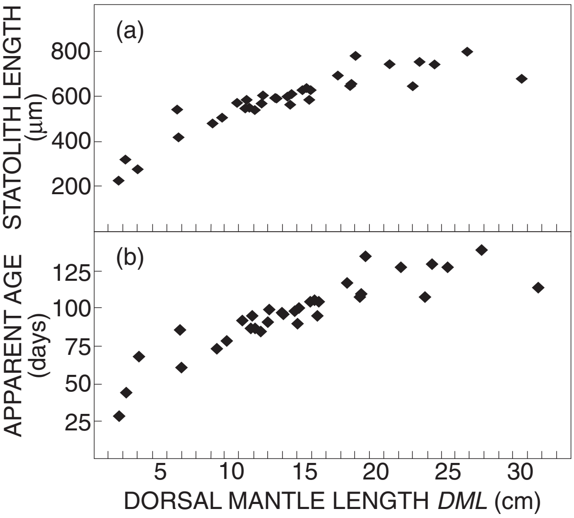

Fig. 3: Relationships between dorsal mantle length and (a) statolith length, and (b) apparent age of *S. lessoniana* specimens from Bolinao, Philippines

In view of the extremely rapid growth implied by the data in Tables III and IV (see also Fig. 3), it is felt that the age of the large squid may have been underestimated in this study. Massive underestimates of true age are known for adult fish (see Pauly 1998). Morales-Nin (1988) describes the problem as follows:

"When the otolith increments in adult fishes are studied with light microscopy, areas with unclear increments are found. Ralston (1985) attributed these areas to imperfect sample preparations, and proposed the use of a method based on increment thickness to determine growth rate and interpolate age based on increment measurements. However, in *Lutjanus kasmira* from Hawaii, it has been shown that these areas are composed of very thin increments and are below the detection power of the light microscope. Thus, if growth is determined by Ralston's method, only the clearer and thicker increments, laid down in the periods of active growth, will be employed."

This interpretation may explain the results obtained in this study, because the "ages" in Table III were obtained using the method of Ralston (1985). It must be stressed again that:

- validation was performed for small, immature specimens only;
- blurred statoliths were not employed, which resulted in only fast-growing, relatively young specimens being included in ring counts, whereas older, non-growing, but relatively small specimens were excluded;
- occulting crystals in statoliths of larger, mature squid complicated the grinding procedure, suggesting a change in the chemistry of the process leading to statolith growth.

Jackson (1990), using light microscopy, reported structures that he interpreted as subdaily, and concluded that "validation is the only way to conclusively delineate whether less-prominent rings are in fact subdaily rings." This statement is worthy of support, and it is therefore recommended, as did Morales-Nin (1988), that electron scanning microscopy be used to investigate these allegedly subdaily rings.

ACKNOWLEDGEMENTS

We thank Ms M. L. 'Deng' Palomares (ICLARM) for her help in assembling the exhibits in this contribution, and Dr V. Christensen (ICLARM) for his comments. MB thanks Dr J. McManus (ICLARM) for his supervision of the work upon which this contribution (ICLARM No. 1446I; University of the Philippines Marine Science Institute No. 292) is based. Inputs from two reviewers of the draft manuscript are gratefully acknowledged.

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