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Note

Population characteristics and some aspects of the biology of oceanic squid *Sthenoteuthis oualaniensis* (Lesson, 1830)

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Abstract

An analysis of 15 specimens of the oceanic squid *Sthenoteuthis oualaniensis* caught by hooks and lines from the Arabian Sea showed that the growth pattern was isometric with the length-weight relationship $W = 0.0276 L^{3.11}$. The von Bertalanffy growth parameters estimated were L_∞ = 49.1 cm; K = 0.83 yr^{-1} and t_0, -0.06 yr. Other population parameters such as optimum length for exploitation, length at maturity and natural mortality rate were also estimated. Relative fecundity was 125 no. /g body weight. The egg diameter ranged from 0.7 to 0.9 mm. The scope for exploitation of the oceanic squid is discussed.

The purpleback flying squid *Sthenoteuthis* (=*Symplectoteuthis*) *oualaniensis* (Lesson, 1830) is distributed in the tropical and sub-tropical areas of the Pacific and Indian Oceans. The Arabian Sea is considered as one of the richest regions for these oceanic squids in the Indian Ocean (Zuyev *et al.*, 2002; Aravindakshan and Sakthivel, 1973). These squids are pelagic animals living in the open ocean, usually absent over the continental shelves (<200 m), and first appear over continental slopes at depths above 250-300 m (Zuyev *et al.*, 1985). Chesalin *et al.* (1995) termed this species as the *master* of the Arabian Sea due to its high abundance, large size, short life-span, fast growth and near monopoly of the higher trophic niche. However, commercial fishing activity for this resource is still low due to insufficient studies on its abundance and distribution (Chesalin and Zuyev, 2002). Globally, the stock of *S. oulaniensis* has been assessed as 3-4 million tonnes (Zuyev *et al.*, 1985) and 25000-50,000 t in oceanic Indian waters (Silas, 1986).

Materials and methods

The study is based on15 specimens of *S. oualaniensis* caught by hand lines operated from mechanized gillnet boats operating from Cochin Fisheries Harbour. On 5 May 2006, five mechanized gillnet vessels landed 25 kg of these oceanic squids. These 44-60 footer boats operated hooks and lines (No.7/8 hooks) at a depth of 50 m. The depth at station ranged from 1000-1500 m (Lat 11°.10'-11°.49'N; long 71°.51'-72°.05'E). The fishing ground was 450 km west off Cochin near the Lakshadweep Island (off Cheriyam and Kalpeni islands) and the voyage duration was up to 10 days.

All specimens were examined externally and sexed, and then measurements of body proportions, and indices were obtained from the whole body as described by Roper and Voss (1983). Measurements were made in millimeters (mm) and weights were taken to the nearest gram (Table 1). Indices of length were expressed as percentage of dorsal mantle length (ML), *e.g.* HWI (Head Width Index) = HW/ML x 100. Indices of organ weights, viz., gonadosomatic index (GSI), mantle weight index (MWtI), nidamental gland index (NGI) and hepatic (liver) index (HI) were also collected from 2 specimens. The specimens were cut open to examine maturity stage and stomachs were cut open to examine the food contents. The morphological features of the pen or gladius were also examined. The ovary and oviduct of 2 specimens were preserved in formalin to determine the fecundity and ova diameter measurements were also taken.

The length–weight relationship was estimated by using the equation, $W = a L^b$, where W = weight in gram, L = mantle length in centimeter and 'a' and 'b' are constants. The relationship was fitted using the software ABee™ (Pauly and Gayanilo, 1997). The population parameters (asymptotic length, L_∞; growth coefficient, K; t_0, age at zero length; optimum length, L_{opt}; length at first maturity, L_m; natural mortality rate, M) were determined from the maximum length (L_{max}) observed earlier from the region (Nair *et al.*, 1990) using the empirical formulae given by Froese and Binohlan (2000) since maximum length is a good predictor of life history parameters.

Results and discussion

On the basis of the dorsal photophore and gladius morphology five intraspecific forms of *S. oualaniensis* have been described (Nesis, 1995). Accordingly, the

specimens examined presently belong to Type 4 which is a middle-sized late-maturing form with dorsal photophore and with double lateral axes of the galdius (Fig.1). This is the most common form in Indian and Pacific oceans (Zuyev *et al.*, 2002). All the squids obtained were females with the dorsal mantle length ranging from 220-268 mm and a wet body weight range of 406-811 g. Based on the size these animals can be placed in the Vth ontogenetic phase out of a total of VI phases (Zuyev *et al.*, 2002); which is a middle-sized adult of nektonic habit. All the animals had empty stomachs, although they are known to be active predators with a wide mesopelagic food spectrum. The preponderance of empty stomachs may be due to the fast digestion rates in the stomach of this squid (8-10 h in middle-sized squids; Chesalin *et al.*, 1995).

All the animals sampled were in fully mature condition with the oviduct full of mature eggs and well developed nidamental glands. Fecundity was estimated as more than 100,000 eggs in each specimen (relative fecundity 125 no. /g body weight) and the egg diameter varied between 0.7 and 0.9 mm. Zuyev *et al.* (2002) reported that middle-sized *S. oualaniensis* had a potential fecundity varying from 100,000 to 500,000 eggs and had egg diameters varying between 0.65 and 0.85 mm. Compared to neretic squids, the fecundity of *S. oualaniensis* is high and therefore, these animals can be considered as *r*-strategists as opposed to *k*-strategy of the neretic squids. All animals were also in mated condition as evident from the presence of spermatophores in the buccal region. Since all the squids were mated and in mature condition, it can be concluded that May is a peak spawning period in the southeastern Arabian Sea. Earlier reports (Silas, 1969; Okutani and Tung, 1978) also suggest that *S. oualaniensis* spawning occurs throughout the year with peak in March to May (summer) in the Arabian Sea.

Most length indices were in conformity with those observed by earlier workers from other regions of the world (Nateewathana *et al.*, 2001), except that of tentacle length index (TLI). The TLI was considerably lesser in *S. oualaniensis* from the South China Sea (Vietnamese waters). This may be because the specimens examined by Nateewathana *et al.* (2001) were considerably smaller and therefore could belong to the dwarf form of *S. oualaniensis*. The maturity index (GSI) is reported to vary from 11-15 to 25-30 for *S. oualaniensis* and the orangeback flying squid *S. pteropus* worldwide (Zuyev *et al.*, 2002). In the present case the GSI of fully mature females was estimated to be 11, which is close to the lower maximal range.

Table 1. *Mean indices of length and weight of female* S. oualaniensis *together with standard deviation (SD) and range*

Indices measured	Mean	SD	Range
Mantle Width Index - MWI	29.7	2.2	27.5-33.6
Arm Length Index - ALI	58.8	7.9	40.0-73.1
Tentacle Length Index - TLI	167.4	24.2	130.4-207.7
Club Length Index - CLI	44.2	3.2	40.0-49.0
Head Length Index - HLI	22.5	0.6	21.6-23.1
Head Width Index - HWI	21.2	0.7	20.4-22.4
Fin Length Index - FLI	42.0	2.3	38.0-44.8
Fin Width Index - FWI	80.4	1.3	78.4-82.4
Mantle Weight Index - MWtI	47.8	-	47.0-49.0
Gonadosomatic Index - GSI	11.0	-	11.0-11.0
Nidamental Gland Index - NGI	5.98	-	5.9-6.1
Hepatic Index - HI	4.63	-	4.5-4.7

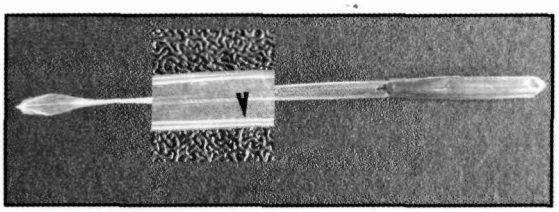

Fig. 1. Ventral view of the gladius of *S. oulaniensis*. Inset shows detail of the central region and arrowhead shows the double lateral axes of the gladius

The length-weight relationship was found to be $W = 0.0276\ L^{3.1056}$. The b value close to 3 indicates the isometric growth pattern of the squid (Table 2). The values compare well with *S. oualaniensis* from Hawaii (Suzuki *et al.*, 1986) and central Arabian Sea (Chesalin, 1993). In contrast, in most neretic squids the growth pattern is

Table 2. *Estimated parameters of the length-weight relationship of* S. oualaniensis.

Mantle length range (mm)	*a* value	*b* value	Goodness of fit(R^2)	Authors
200-472	0.0276 ± 0.011	3.1056 ± 0.107	0.985	Present study
100-297	0.000018	3.150	0.959	Suzuki *et al.* (1986)
150-300	0.082	2.699	-	Chesalin (1993)
Above 300	0.005	3.506	-	Chesalin (1993)

clearly allometric, with the value of b closer to 2 than 3 (Meiyappan *et al.*, 2000).

The von Bertalanffy parameter L_∞ was determined as 49.1 cm (SE range 41.4-58.3) and K as 0.83 (Table 3). The average life span of the animal is estimated to be around 2 years. Considerable work has been done on the age and growth of various intraspecific forms of *S. oualaniensis* in the Arabian Sea by Soviet investigators using recordings on the gladius (Zuyev *et al.*, 2002). Generally females grew faster than males and the growth pattern was either slightly sigmoid or linear depending on the maturity stage.

The length at first maturity (L_m) was estimated as 27.6 cm. Nair *et al.* (1990) estimated the L_m as 11 cm for females of *S. oualaniensis* from the Indian EEZ. Although the present estimate is an empirical one, the large difference could be because the latter estimate may be primarily based on the dwarf intraspecific form of *S. oualaniensis* available in the Indian Ocean. The ratios of L_{max}/L_∞, L_m/L_∞, L_{opt}/L_∞ and M/K are all well within the limits of an unexploited population. The present mean length of the catch (24.3 cm) is close to the estimated L_{opt} (30.8 cm), which is the length at which highest biomass of this unfished population is available.

S. oualaniensis form large shoals of up to 1000 individuals in the open ocean. They are attracted to light and undertake diurnal migrations rising to the epipelagic layer at night for feeding and descending up to 800-1200 m depth in the morning. The present catch of squids using small hook and lines was obtained as incidental catch by fishermen who were targeting tunas and sharks during dusk and night. Fishermen reported that in Lakshadweep waters, the lights from the boats attracted the squids, and below the dense mass of squids, tunas and sharks were present to feed on them. According to Chesalin *et al.* (1995), the most promising region to develop a fishery for these squids is the Arabian Sea, where the squid biomass reaches several tonnes per km^2. The estimated squid stock in the Arabian Sea varies in the range 0.9-1.6 million t (Zuyev *et al.*, 2002). At present the fishermen do not bring back the squid catch from these voyages due to the lack of market demand and appreciable price structure. The prospects for developing a new fishery for oceanic squids in the Arabian Sea based from west coast fishing ports, either by hook and line or squid jigging, is substantial, taking into account the relatively huge magnitude of the unexploited resource. For this, a concerted effort through the formation of an oceanic squid task force with fishery biologists, fish processors, market developers and planners is recommended.

Table 3. *Estimated population parameters with standard error (SE range) of* S. oualaniensis *caught from Arabian Sea*

Population parameter		SE range
L_{max} (cm)	47.2	
L_∞ (cm)	49.1	41.4-58.3
L_{max}/L_∞	0.96	
L_m (cm)	27.6	20.6-36.9
L_m/L_∞	0.56	
L_{opt} (cm)	30.8	26.0-36.4
L_{opt}/L_∞	0.63	
K yr^{-1}	0.83	
t_0 yr	-0.0607	
M yr^{-1}	1.34	
M/K	1.61	

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