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Mated Shiny bird squid, *Ornithoteuthis volatilis* Sasaki, 1915 (Cephalopoda: Ommastrephidae), in the southeastern Arabian Sea

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Original Article

Abstract

Shiny bird squid is a nerito-oceanic species of squid distributed in the Indo-West Pacific oceans. Two individuals of female Shiny bird squid, *Ornithoteuthis volatilis,* from the Arabian Sea collected by trawl catch are reported. The dorsal mantle length of the individuals was 148 mm and 76 mm, with a body weight of 46 g and 28 g, respectively. The maturing female had 13 implanted spermatangium, located on the aboral surface of the third left arm. The length of the implanted spermatangium ranged from 1.10 to 1.38 mm. The current study proposes additional research to better understand the species population and fisheries potential in the Arabian Sea.

Keywords: *Spermatangium, Arabian Sea, Spawning ground, Mating, Oceanic squid*

Introduction

The genus *Ornithoteuthis* Okada, 1927 presently consists of two closely related species: *Ornithoteuthis volatilis* (Sasaki, 1915) and *Ornithoteuthis antillarum* Adam, 1957. The Shiny bird squid *O. volatilis* is a tropical and sub-tropical species which is widely distributed in the Indo-Pacific Oceans (Wormuth, 1976) including, off western and eastern Australia (Lu and Dunning, 1982; Dunning and Brandt, 1985), South China Sea (Khromov, 1990), Indian Ocean (Okutani and Tsukada, 1988), Arabian Sea (Nesis, 1987) and the southeast Atlantic (Villanueva and Sanchez, 1993). They are mesopelagic species and rarely occur above 100 m (Wormuth, 1976; Nesis and Nigmattulin, 1979). It is a larger species than its Atlantic congener, *O. antillarum* (Young and Vecchione, 2014). The mean instantaneous biomass for harvest-sized *O. volatilis* is estimated to be 1 million tonnes (Roper *et al.*, 2010) in tropical Indo-West Pacific waters. This species is reported to spawn throughout the year in tropical waters (Dunning, 1988).

In the last few decades, studies on the distribution and abundance of oceanic cephalopods from the Indian Ocean are scarce, and only limited studies have been documented from the Arabian Sea. However, recent advances in the knowledge of the diversity of cephalopods (Sreeja, 2013; Joseph *et al.*, 2015; Sajikumar *et al.,* 2016, 2017, 2018, 2023; Venkatesan *et al.,* 2023) of India argue for more comprehensive studies.

Sperm storage is reported in many cephalopods (Sato *et al.,* 2010; Fernandez-Alvarez *et al.,* 2018). Male cephalopods pack their sperm into complex spermatophores that are transferred to the females during mating (Fernandez-Alvarez *et al.,* 2018). The position of the seminal receptacles and implanted spermatangia varies among species (Nesis, 1995; Norman and Lu, 1997; Hoving *et al.*, 2004; Jackson and Jackson, 2004; O'Shea *et al.*, 2007). Implanted spermatangia have never been reported for *O. volatilis*. Therefore, here we report a mated maturing female *O. volatilis* from the Arabian Sea.

Material and methods

Uncommon mesopelagic squid specimen was collected from the Central Arabian Sea and off Maldives by the exploratory surveys of

Fishery Oceanographic Research Vessel *Sagar Sampada* (FORV *SS*) of the Centre for Marine Living Resources and Ecology (CMLRE), Ministry of Earth Sciences (MoES), Kochi, India. A mesopelagic trawl net (COSMOS Krill mid-water net, length: 49.5 m; cod end mesh size 10 mm) was used for operation at a depth of 100 m.

The specimens were preserved in 5% formaldehyde solutions immediately after collection. The species identification was done according to Dunning (1998). In the laboratory, morphometric measurements such as dorsal mantle length (DML), ventral mantle length (VML) mantle width (MW), fin length (FL) head length (HL), head width (HW), arm length (A1, A2, A3, and A4), tentacle length (TL), tentacular club length (TCL) and funnel length (FUL) of preserved specimens were recorded to the nearest mm by using a scale, as recommended by Roper and Voss (1983). Sexual maturity was assessed using the maturity scale in Lipinski and Underhill (1995). Images of specimens were taken by using a Nikon Coolpix Camera and microscope (Nikon SMZ-5). Indices of length were expressed as a percentage of dorsal mantle length.

Results

Material examined- Two female specimens, Accession no- IO/SS/CEP/00033, DML-148 mm, Central Arabian Sea, Lat- 15.9° N Lat-65.5° E, Cosmos trawl, collection depth 100 m, station depth- 3714m, 10-02-2016, 19:20. IO/SS/CEP/00037, DML-76 mm, off the Maldives, Arabian Sea Lat-6.4° N Lat-67.07° E, Cosmos trawl, collection depth-100 m, station depth- 3943 m, 10-09-2015, 08:05. Specimens were deposited in CMLRE Referral Center.

Systematic accounts

Class : Cephalopoda Cuvier, 1795
Family : Ommastrephidae Steenstrup, 1857
Subfamily : Ornithoteuthinae Nigmatullin, 1979
Genus : *Ornithoteuthis* Okada, 1927
Species : *Ornithoteuthis volatilis* Sasaki, 1915
Holotype : Museum of the Science College, University of Tokyo, Japan, mature male, 213 mm DML, collected off Atami, Sagami Province, Honshu, Japan, 24 Jun 1906.
Paratype : 3 female and 1 male collected off Atami, Sagami Province, Honshu, Japan
Syntype : None nominated

Diagnosis

Mantle narrow, fin long, sagittate and pointed tail. Funnel groove smooth, with faveola and side pockets. Two viscera photophore present; a large round photophore near the anus and a small oval photophore in the posterior end of the intestine. Tentacular club with very large medial manal suckers.

Description

Two individuals of *O. volatilis* were collected from the Arabian Sea (Fig.1). The specimens with a DML of 148 mm and 76 mm weighed 46 g and 28 g respectively. The specimen had a narrow muscular mantle with a long-pointed tail (Fig. 2 A, B). The faveola without longitudinal folds and side pockets. The length of the fin is 57 % of the DML and the fin width is

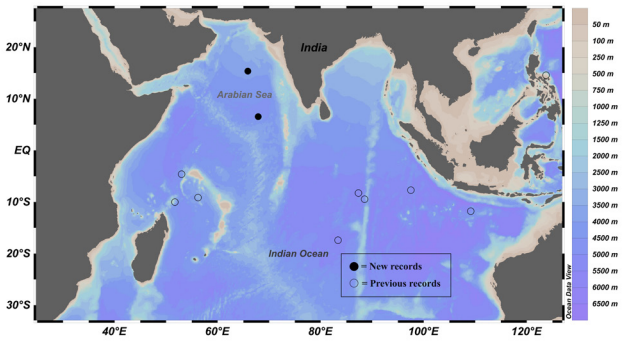

Fig. 1. Map showing the location of earlier distribution records of *Ornithoteuthis volatilis* (Open circle) and the new distribution records (Closed circle). Data sources: GBIF (https://www.gbif.org/occurrence/search?q=Ornithoteuthis%20volatilis); OBIS (https://obis.org/taxon/220322)

Fig. 2. Dorsal (A) and ventral (B) view of shiny bird squid *Ornithoteuthis volatilis* (DML=148 mm) from the Arabian Sea (Scale=5 cm)

Table 1. Morphometric measurements and indices of Shiny bird squid *Ornithoteuthis volatilis* from the Arabian Sea

Variables (mm)	IO/SS/CEP/00033	Indices	IO/SS/CEP/00037	Indices
Dorsal mantle length	148	100	76	100.0
Ventral mantle length	140	94.59	73	96.1
Mantle width	27	18.24	12	15.8
Head length	30	20.27	19	25.0
Head width	24	16.21	16	21.1
Funnel length	18	12.16	12	15.8
Fin length	85	57.43	45	59.2
Fin width	72	48.64	42	55.3
Right arm 1	62 (38)*	41.89	36(35)	47.4
Right arm 2	80 (51)	54.05	42(38)	55.3
Right arm 3	78 (63)	52.70	38(40)	50.0
Right arm 4	72 (68)	48.64	33(43)	43.4
Left arm 1	60	40.54	32	42.1
Left arm 2	73	49.32	36	47.4
Left arm 3	78	52.70	32	42.1
Left arm 4	67	45.27	32	42.1
Tentacle length	147	99.32	73	96.1
Tentacular club length	75 (85)	50.67	32(52)	42.1
Sex	Female	-	Female	-
Stage	Maturing	-	Immature	-

*sucker count

48 %. The arm formula of the individual was 2<3<4<1 (Table 1). The number of arm suckers ranged from 38 to 68. The highest number of suckers (68 and 43) was found in the ventral arm (fourth arm) and the lowest number count in the first arm (38 and 35). The tentacular clubs are around half (50.7 %) of the length of the tentacles, they have 12 suckers in the carpal region (Fig. 3 A) and 13 suckers on the manus each of which has 21-25 conical teeth set (Fig. 3 B). There are three visceral photophores, an oval, anal photophore; a posterior intestinal photophore and an elongated posterior visceral photophore (Fig. 4 A). The largest arm suckers have 10-14 teeth all of which are sharply pointed and closely set, with long teeth and short teeth alternately (Fig. 4 B). The colour of the fresh specimen could not be observed and preserved specimen was dark yellowish. The maturing female (148 mm DML) has implanted spermatangia. A total of 13 spermatangia were implanted on the aboral surface of the third left arm (Fig. 5 A). The size of the spermatangia ranged from 1.10 to 1.38 mm. The spermatangia have a 'drop' shaped sperm mass (Fig. 5 B).

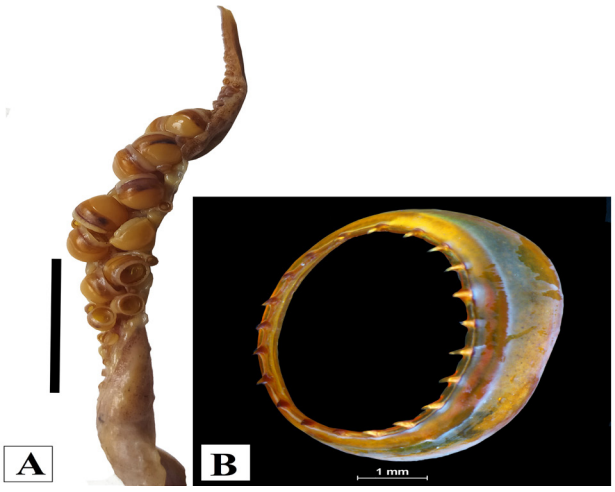

Fig. 3. View of tentacular club (A) and enlarged view of tentacular club sucker (B) of shiny bird squid *Ornithoteuthis volatilis* (DML=148 mm) from the Arabian Sea

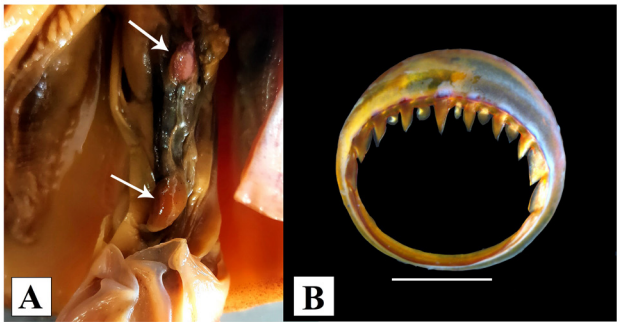

Fig. 4. Mantle cavity showing the visceral photophores (indicated by the arrow mark) (A) and enlarged view of arm sucker ring of (scale bar= 1 mm) squid *Ornithoteuthis volatilis* (DML=148 mm) from the Arabian Sea

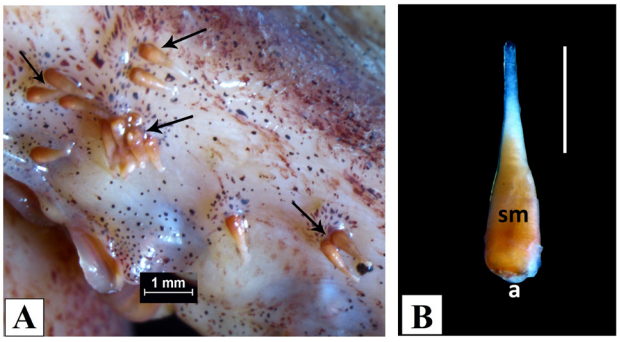

Fig. 5. Attached spermatangia (indicated by the arrow mark) on the aboral surface of third arm (A) enlarged view of single spermatangium (Scale= 500 μm) (B) in shiny bird squid *Ornithoteuthis volatilis* (DML=148 mm) from the Arabian Sea.sm: sperm mass, a: attachment area

Discussion

The Indian Ocean cephalopod fauna is still poorly described and nothing is known about the biology of various species (Paitkowski and Welsch, 1991) and is by far not as well investigated as that of the Pacific and Atlantic Oceans (Nesis,

1970). Recently, cephalopod fauna of the Arabian Sea was investigated by Silas (1968), Silas *et al.* (1985), Aravindakshan and Sakthivel (1973), Piatkowski and Welsch (1991), Joseph *et al.* (2015), Sajikumar *et al.* (2016, 2017, 2018, 2023), Venkatesan *et al.* (2023). However, all previous Indian studies fail to record the species from the Arabian Sea. The present findings of *O. volatilis* in Indian waters (eastern Arabian Sea) for the first time and the second record of the species from the Arabian Sea. The adult species of *O. volatilis* live in the lower epipelagic and mesopelagic zones (Nesis, 1987). The female mature at a size of 220 DML and 250 mm DML (Nesis and Nigmattulin, 1979; Dunning and Brandt, 1985). According to Nesis and Nigmattulin (1979), *O. volatilis* reaches maturity at larger sizes at higher latitudes.

The presence of implanted spermatangia in the aboral surface of arms indicates that the individual completed the mating process which in turn confirms that the Arabian Sea may be a spawning ground for the species. Earlier, Nigmatullin *et al.* (1995) suggested the spawning ground of a squid species can be identified by the presence of mature, mated squids and the presence of egg masses. Collections of mature females and larvae along the continental slope between 30°S and 33°S and around the Taupo Seamount and predominately near the Ogasawara Islands, south of Japan, near 31° N; 134° E (Wakabayashi *et al.,* 2002) suggest that it spawns in these regions (Dunning and Brandt, 1985).

The mechanism and locations of spermatangium attachments in squids are species-specific (Nesis, 1995; Hoving *et al.,* 2008a). Earlier, up to 10-15, spermatangia attachment over the buccal region of the mature females of congener *O. antillarum* (Arkhipkin *et al.,* 1998) has been reported. Also, the squid belong to the family Ommastrephidae, jumbo squid *Dosidicus gigas* (Fernandez-Alvarez *et al.,* 2018) and *Todarodes pacificus* (Hirohashi *et al.,* 2016) where spermatangium were placed in the buccal area. However, the present individuals have an attachment over the arm base. The fertilization mechanisms in oceanic squid remains unknown (Hoving *et al.,* 2010). Fernandez-Alvarez *et al.* (2018) hypothesise that spermatozoa can actively migrate over the female skin. Multiple spawning has been reported of congener *Ornithoteuthis antillarum* (Arkhipkin *et al.,* 1998). The present mated individual was in a maturing stage, indicating that the mating occurs before reaching sexual maturity. Premature mating has been reported in Jumbo squid *Dosidicus gigas* from Santa, Rosalia, BCS, Mexico (Fernandez-Alvarez *et al.,* 2018).

The shape of squid spermatangia is highly variable, appearing as a teardrop in *T. pacificus* (Takahama *et al.,* 1991), irregularly coiled in *Heteroteuthis dispar* (Hoving *et al.,* 2008b) and in Japanese Pygmy squid (*Idiosepius paradoxus*) have fish hook shaped (Sato *et al.,* 2014). Females can mate with multiple males before laying eggs and can store sperm for up to 10 months in some species (Mangold, 1987).

Conclusion

The preliminary information provided here entails further detailed investigation for understanding distribution, biomass, and the role of ecosystem and population characteristics of *O. volatilis* in the Arabian Sea.

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