



# Rediscovery of Ram's horn squid, *Spirula spirula* (Cephalopoda: Spirulidae), from the Arabian Sea

K. K. Sajikumar<sup>1\*</sup>, M. P. Rajeesh Kumar<sup>2</sup>, P. Laxmilatha<sup>1</sup>, M. Hashim<sup>2</sup>, V. Venkatesan<sup>1</sup> and N. Saravanane<sup>2</sup>

<sup>1</sup>ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala, India.

<sup>2</sup>Centre for Marine Living Resources and Ecology, Kochi-682 050, Kerala, India.

\*Correspondence e-mail: [kksajikumar@yahoo.co.in](mailto:kksajikumar@yahoo.co.in)

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Original Article

## Abstract

This study describes the rediscovery of the largely uncommon, mesopelagic cephalopod, *Spirula spirula*, from the Arabian Sea. This is the first confirmed record of the species from the seas around India after 80 years of its original record. Four specimens were collected from the Arabian Sea from a depth of 450 m, during the fishery surveys onboard the FORV *Sagar Sampada*, using a mid-water trawl net. The dorsal mantle length (DML) of the individuals ranged from 27 to 36 mm. Detailed morphometric measurements and previous distribution records are also provided.

**Keywords:** Arabian Sea, Ram's horn squid, mesopelagic, chambered shell

## Introduction

The species, *Spirula spirula* (Linnaeus, 1758), commonly known as Ram's horn squid, is one of the most inscrutable cephalopods with an internal loosely coiled chambered shell (Lukeneder, 2016). This species is considered monospecific under the genus *Spirula* (Lamarck, 1799) and recent findings from chambered shell structure challenge the monospecific status of the genus but fall short of proving the occurrence of more than one species (Neige and Warnke, 2010; Haring *et al.*, 2012; Lukeneder *et al.*, 2008; Lukeneder, 2016). *Spirula* inhabits subsurface waters of the tropical and subtropical regions with a disjunctive range of geographic occurrence (Nesis, 1998; Lukeneder, 2016). The internal, loosely coiled, chambered shell of *S. spirula* starting from a spherical initial chamber, resembles the external chambered shells of Ammonoidea, the extinct cephalopod subclass that flourished for more than 340 million years from the middle Devonian to the end of the Cretaceous period (Bandel and Bolezky, 1979; Neige and Warnke, 2010). Because of the presence

of an internal chambered shell in this species, it has frequently been used as a model species to investigate the palaeo-biology of fossil coleoids (Ohkouchi *et al.*, 2013).

According to the International Union for Conservation of Nature (IUCN) Red List, *S. spirula* is considered as "Least concern" because of its extensive distribution. However further research is recommended to determine the population size, distribution trend and ecology of the species (Barratt and Allcock, 2012). Earlier Bruun (1943) documented a detailed study on the distribution and biology of *S. spirula* during the Danish research expeditions ("Dana" expeditions). Previous records of this species came from the Indo-Pacific waters of the Banda Sea, west of Sumatra and the Sea of Maldives (Bruun, 1943).

A comprehensive list of cephalopod species of the Arabian Sea and some aspects of their biology were compiled by Silas (1968) and Silas *et al.* (1985). Oceanic cephalopods of the Arabian Sea are poorly understood (Piatkowski and Welsch, 1991). Although in recent years detailed studies were conducted on the taxonomy and systematics of cephalopods from the Arabian Sea (Sreeja *et al.*, 2015; Sajikumar *et al.*, 2016, 2017, 2018) and researchers emphasised the need for more studies on cephalopod diversity from seas around India. Our objective was to understand the distribution and abundance of deep-sea cephalopods in the eastern Arabian Sea, and in this work, we report the presence of the uncommon cephalopod from the oceanic waters of the Arabian Sea.

## Material and methods

The cephalopod specimens (3 male and 1 female) were collected from the Arabian Sea, off the Maldives by the Exploratory surveys

of Fishery Oceanographic Research Vessel, *Sagar Sampada* (FORV *SS*), owned by the Centre for Marine Living Resources and Ecology (CMLRE), Ministry of Earth Sciences (MoES), Kochi, India. Mesopelagic trawl net (49.5 m Cosmos trawl) was used for operation at a depth of 450 m. The station depth was 3948 m. The water column profile was measured using CTD (Sea Bird) and documented.

The specimens were preserved in a 5% formaldehyde solution immediately after collection. Photographic images of the specimens were taken using Nikon Camera and microscope (Nikon SMZ-5). In the laboratory, the morphometric measurements such as the dorsal mantle length (DML), ventral mantle length (VML), mantle width (MW), fin length (FL) head length (HL), head width (HW), arm length (right arm/ left arm I-IV), tentacle length (TL), tentacular club length (TCL), funnel length (FuL) and free funnel length (FFL) of preserved specimens were recorded to the nearest millimetre (mm), as recommended by Roper and Voss (1983).

The specimens were identified as *Spirula spirula* following Reid (2005) and deposited in CMLRE Referral Centre under the accession numbers IO/SS/CEP/00001a, b, c and IO/SS/CEP/00002. Localization of the present sampling station along with previous distribution records is shown in Fig. 1. Morphometric measurements and counts are presented in Table 1. The materials examined were IO/SS/CEP/00001a, b & c: Three live specimens, ♂, DML 34, 35 and 36 mm respectively; IO/SS/CEP/00002: One specimen, ♀, DML-27.4 mm. South-eastern Arabian Sea, Latitude 5.13° N,

Longitude 69.05° E; Cruise no. 344; Cosmos trawl; Depth 450 m; time of operation 06:00 h; 11<sup>th</sup> September 2015.

## Results

### Taxonomy

Phylum : Mollusca Linnaeus, 1758  
 Class : Cephalopoda Cuvier, 1797  
 Subclass : Coleoidea Bather, 1888  
 Superorder : Decapodiformes Young, Vecchione and Donovan, 1998  
 Superfamily : Spiruloidea Rafinesque, 1815  
 Family : Spirulidae Rafinesque, 1815  
 Genus : *Spirula* Lamarck, 1799  
 Species : *Spirula spirula* (Linnaeus, 1758)

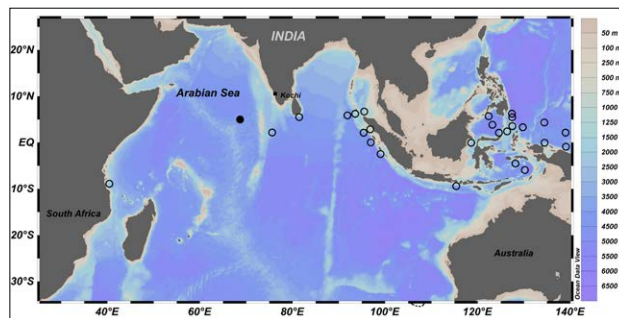


Fig. 1. Map showing the location of new distribution records (Closed circle) of *S. spirula* and the earlier distribution records (Open circle). Map modified from Bruun (1943)

Table 1. Morphometric measurements of *S. spirula* from the Arabian Sea

Measurements (mm)	IO/SS/CEP/00001a	IO/SS/CEP/00001b	IO/SS/CEP/00001c	IO/SS/CEP/00002
Dorsal mantle length	34	35	36	27
Ventral mantle length	32	35	36	25
Mantle width	14	14	14	12
Head length	12	12	13	9
Head width	16	16.3	16	12
Fin length	8	10.2	11	7
Arm I (Right/Left)	8/7.9	8/8.1	8.2/8	7.9/7.2
Arm II (Right/Left)	8.2/8	9/8.8	11/9	6.8/7.8
Arm III (Right/Left)	9/9	12.3/11.2	11.2/10	8.5/8.8
Arm IV (Right/Left)	12/14	12/13	12/13	10.6/9.7
Tentacle length (Right/Left)	58/35	28/26	42/70	26/63
Tentacular club length (Right/ Left)	7.8/7.3	10/9	10/10	7.4/7.8
Funnel length	13	13	12	8
Free Funnel length	5	4.7	4.6	4.2
Tentacular club sucker number (Right /Left)	265/275	272/281	182/198	171/189
Sex	Male	Male	Male	Female
Total weight (g)	5.2	3.9	6.6	5.5

## Description

The mantle is cylindrical, thin and muscular (Fig. 2A and B). The anterior region of the dorsal mantle with one and the ventral posterior region with two tongue-like projections. The funnel locking apparatus is simple. The first pair of the arm is short and



Fig. 2. Dorsal (A) and ventral (B) view of *S. spirula* (DML 35 mm male) collected from the Arabian Sea (Scale bar = 10mm)

the fourth pair of the arm is the longest with small suckers (tetraserial) and wide web except for the fourth pair. The tentacles are long and slender. Eyes are large, without cornea (Fig. 3A). The mantle is fusiform and the whole mantle is covered with regularly aligned collagen fibres (Fig. 3B). Both ventral arms are modified as hectocotyzed (Fig. 4). Left hectocotyzed arm with two finger-like outgrowths at the distal tip (Fig. 4A). The right hectocotyzed arm grooved with a pointed tip and with 2 finger-like outgrowths (Fig. 4B). The tentacular club has similar sized small suckers (Fig. 5A). Curvature present on the

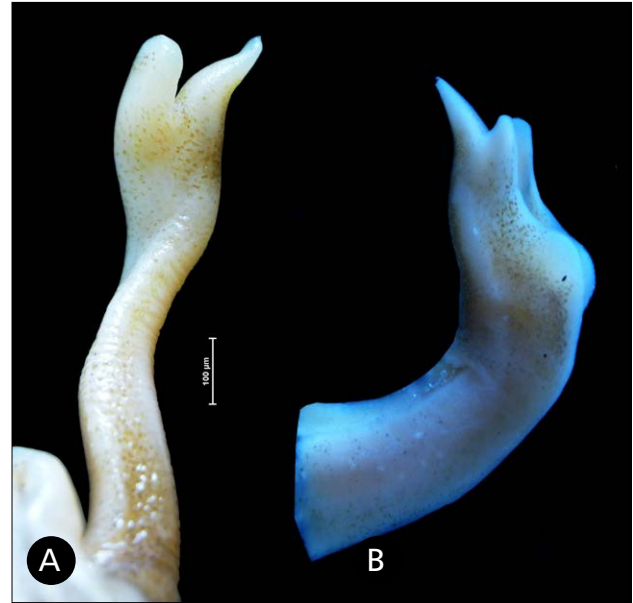


Fig. 4. Hectocotyzed arm of male *S. spirula* collected from Arabian Sea (A = ventral view of left hectocotyzed arm and B = lateral view of right hectocotyzed arm)

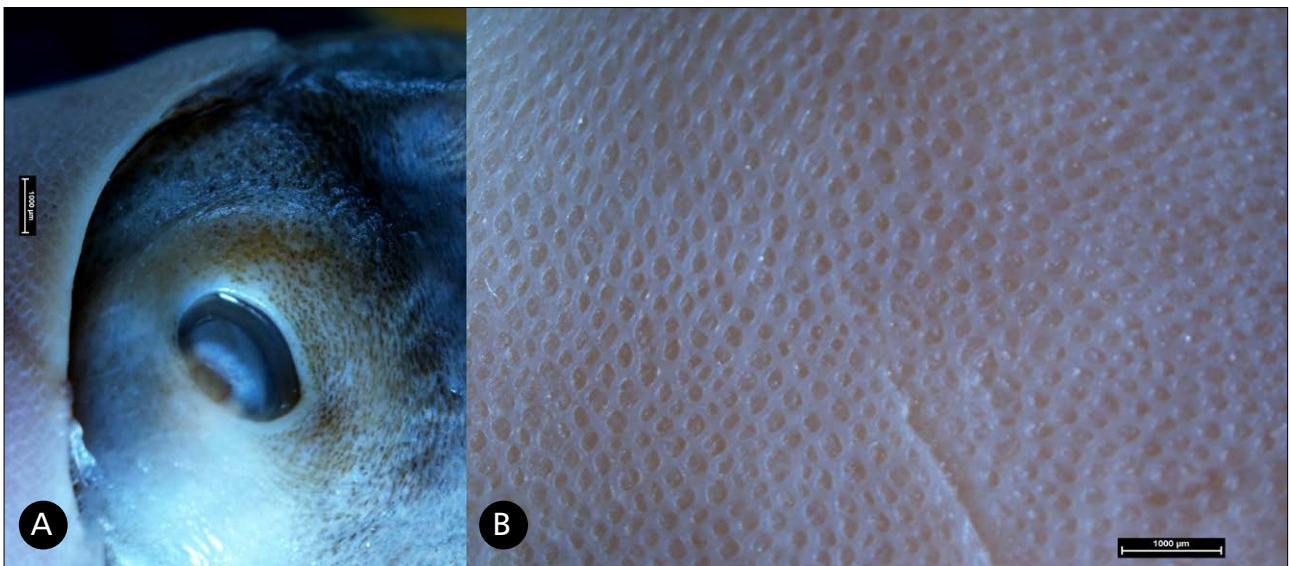


Fig. 3. The eye (without cornea) of the species (A) and mantle covered with regularly aligned collagen fibres (B) of *S. spirula* collected from the Arabian Sea

aboral tentacular club (Fig. 5B). The number of suckers on the tentacular club ranged from 171 to 281 (Table 1). The individuals have a photophore at the posterior end of the mantle, which is surrounded by a pair of small round fins (Fig. 6). Spirally coiled internal shell present. Colour in fresh form was not recorded; in the preservative, it is uniform creamy-white with retention of light brown colour on the head and arm portions. The water temperature at collection depth was 10.8 °C, salinity was 35.19 PSU and dissolved oxygen had the value of 1.03 ml/l.

## Discussion

Compared to other seas, the studies on the cephalopod diversity of the Arabian Sea are few and need a comprehensive investigation for a better understanding of the distribution and

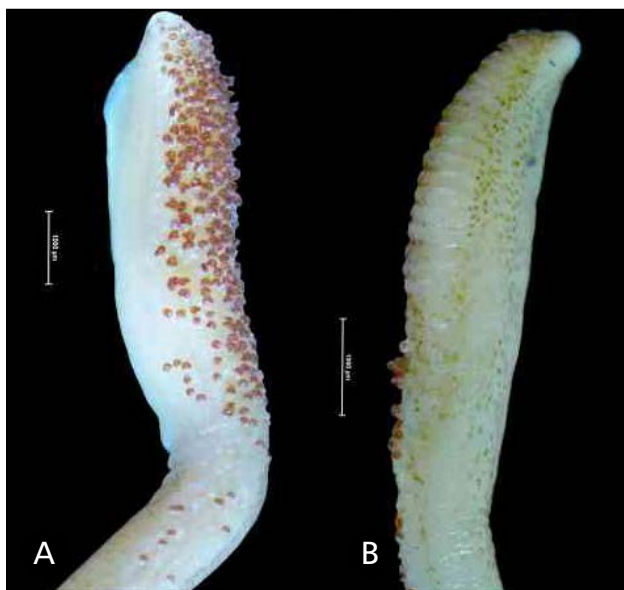


Fig. 5. Dorsal (A) and aboral with dorsal curvature (B) view of tentacular club of *S. spirula* from the Arabian Sea

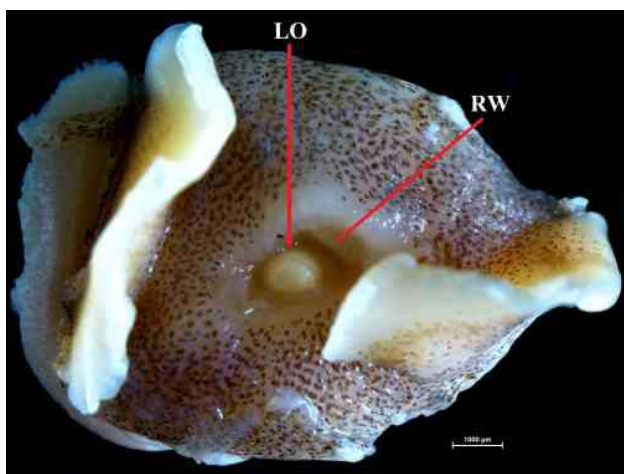


Fig. 6. Large photophore (LO) and ring wall (RW) on the posterior region of the mantle of *S. spirula* from the Arabian Sea

status (Sajikumar *et al.*, 2018). Much earlier, Chun (1910) reported the *Spirula* sp. from "Valdivia" expedition of the Indian Ocean. Following this, Bruun (1943) studied the distribution and biology of the species from Indo-Pacific waters. Recent investigations for understanding cephalopod distribution in the Arabian Sea failed to record this species (Silas, 1968; Aravindakshan and Sakthivel, 1973; Piatkowski and Welsch, 1991; Sajikumar *et al.*, 2017, 2018). The specimens of this species are rare due to their deep-dwelling habits and small size. The DML of the specimen of *S. spirula* from Indo Pacific waters ranged from 14.5 to 44.2 mm (Bruun, 1943).

The most distinctive feature of the species is the presence of the internal chambered shell, which acts as a buoyancy organ (Bruun, 1943; Hoffman *et al.*, 2018) and the presence of a light organ in the posterior part of the mantle (Herring *et al.*, 1981). The purpose of the large, upward-facing light organ is unknown (Norman, 2003). Recently, a video of *Spirula* sp. in its natural habitat at 861 m depth showed, they floated heads upwards, so the light organ points downwards and helped the animal to camouflage for predators coming from below (Lindsay *et al.*, 2020). The taxonomic status of the species is unresolved Neis (1998) and Neige and Warnke (2010) suggested using a molecular key to distinguish between the intra and interspecific differences. The current specimen, preserved in formaldehyde, constrained molecular investigation. A recent study from two distinct morphological clusters of *Spirula* sp. from the Atlantic and Indo-Pacific suggested potentially representing two pseudo cryptic species or two populations undergoing divergence (*i.e.* in the process of speciation) (Hoffmann *et al.*, 2021).

The nearest confirmed record was from the near Maldives (Bruun, 1943), about 400 nautical miles away from the present record. Live animals drift in a vertical position with their head and arms hanging down, which can retract into their mantle cavity (Norman, 2003). The specimen found from a depth of 300 m support the vertical distribution of *S. spirula* from a depth of more than 200 m (Bruun, 1943). This species has a very wide geographic and depth distribution (from 300 to 1750 m) (Reid, 2005) with diurnal migration (550-1000 m during the day and 100-300 m during the night) (Clarke, 1970; Hoffmann and Warnke, 2014).

Mature males have modified ventral arms that lack suckers and are tipped with finger-like outgrowths (Norman, 2003; Reid, 2005). Previously *S. spirula* from Atlantic and Indo-Pacific waters have 5-10 small finger-like structures in the left hectocotylized arm is showing the difference in the present observation (Bruun, 1943). Earlier Neige and Warnke (2010) studied the characteristics of the *S. spirula* adult shell morphometry from different geographic locations and challenge the monospecific status of the genus and they suggested the need for molecular

investigation. The water temperature at collection depth is also similar to the previous report, that 10 °C or warmer (Reid, 2005) water is preferred for the species.

The Arabian Sea is considered one of the richest areas for cephalopods in the Indian Ocean (Aravindakshan and Sakthivel, 1973). However, in the last few decades, studies on the distribution and taxonomy of cephalopods from this area are few. The present work describes new findings on the distribution of an uncommon mesopelagic squid and also argued for more detailed studies.

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