



# A checklist of chaetognaths along the eastern Arabian sea

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Received: 19 January 2024 / Accepted: 5 July 2024 / Published online: 2 August 2024

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## Abstract

Chaetognatha, the second-most abundant zooplankton in the marine ecosystem, is a connecting link between copepods and organisms of the higher trophic level. The present checklist provides detailed information on the morphology and distribution of chaetognaths in the eastern Arabian Sea (northeastern Arabian Sea, southeastern Arabian Sea, and Laccadive Sea). It includes five families under two orders with 34 species belonging to 15 genera and recorded from both shelf, oceanic and deep sea waters of the eastern Arabian Sea, creating a first line data on chaetognaths of the Arabian Sea.

**Keywords** Chaetognatha · Eastern Arabian Sea · Laccadive Sea · Apheroglossa · Phragmophora

## Introduction

Chaetognaths, commonly called the arrow worms (due to their darting motion) or glass worms (due to their transparent or translucent body in water), is the phylum of marine invertebrates with torpedo-shaped worm-like organisms, which are bilaterally symmetrical coelomate animals. The word "chaetognatha" arises from the Greek words "*chaeto*," which means "bristle," and "*gnathos*," which means "jaws" (Johnson 2005; Srichandan et al. 2015). Chaetognaths are the second most abundant marine zooplankton after copepods (Nair 1977; Peter and Nair 1978). They are ferocious carnivores that eat other chaetognaths, small crustaceans, and fish larvae. Although they consume a variety of planktonic species, copepods are their preferred food source (Feigenbaum and Maris 1984). Chaetognaths play a significant part in ocean flux (Terazaki 1995), transportation of energy from copepods to higher trophic levels (Bone et al. 1991) and are an effective indicator of water mass due to their strong association with certain environmental variables and their species-specific horizontal and vertical dispersion and their pattern of distribution is connected to hydrographic

events like upwelling (Bieri 1959; Cheney 1985; Terazaki 1989).

Chaetognaths are mesozooplankton organisms with a body length generally between 2–105 mm (Sieburth et al. 1978) and divided into three distinctive regions: head, trunk, and tail. Their body consists of two pairs of lateral fins and a caudal fin, built around a hydroskeleton that plays an important role in locomotion along with four longitudinal muscles (Duvert and Salat 1979). They can be recognized by their distinctive features, which include bilateral symmetry, long, transparent streamlined bodies with horizontal protruding fins and two clusters of flexible, cuticularized clasping bristles for catching prey at the frontal end (Harzsch et al. 2015). These hermaphrodite carnivores have their male and female gonads in different body parts. The seminal vesicles and testes are located on the tail, whereas the posterior region of the trunk contains the ovaries, one on each side. Chaetognaths frequently exhibit protandry, with the most common mode of fertilization being cross-fertilization (Alvarino 1965, 1967; Reeve and Cosper 1975), however, self-fertilization has also been documented in some species (Reeve 1970a, b). Historically, chaetognaths are connected to deuterostomes based on embryology and anatomy, however, this has been questioned by genetic studies (Helfenbein et al. 2004; Papillon et al. 2004) and molecular analyses (Telford and Holland 1993; Wada and Satoh 1994; Halanych 1996). Chaetognaths are either sisters to all protostomes or to the Lophotrochozoa, according to new molecular phylogenomic research

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(Szaniawski 2002; Marlétaz et al. 2006), although the conclusive proof for their phylogenetic position is still pending.

Chaetognaths have a wide distribution in the deep sea, open oceans, estuaries, tidal pools, coastal lagoons, marine caves, and polar waters (Bone et al. 1991). The phylum consists of about 209 species recorded in international waters (Bieri 1991; Vega-Pérez and Schinke 2011), however, along Indian waters, five families including 15 genera and only 34 species have been identified (Chandra and Raghunathan 2022). Doncaster (1903) initially researched chaetognaths in the Indian Ocean. Studies on the distribution, community structure, abundance, and systematics of chaetognaths of the Indian Ocean were done by John (1933), Varadarajan and Chacko (1943), George (1949), Ganapati and Rao (1954), Silas and Srinivasan (1968, 1970), Nair and Rao (1973a, b), Nair (1976), Nair et al. (2002), Kusum (2012), Kusum et al. (2011, 2014). The present report puts forward a compiled checklist of the chaetognaths that have been recorded from the eastern Arabian Sea.

## Materials and methods

The list of species presented was compiled based on the previous literature on Chaetognatha of the eastern Arabian Sea. Databases were used to update the names and status of the species, such as WoRMS 2014. All names found to be incorrect were corrected, and an updated checklist was created.

## Results

A total of five families under two orders and 34 species belonging to 15 genera were recorded from both oceanic and deep seas waters of the eastern Arabian Sea. The two orders of the phylum Chaetognatha are Aphragmophora and Phragmophora. Families included in the order Aphragmophora are Krohnittidae, Pterosagittidae, and Sagittidae. Order Phragmophora includes Eukrohnidae and Spadellidae.

Images of the few chaetognath species of the eastern Arabian Sea are presented in Fig. 1. Only species having valid names are included in the checklist (Table 1).

## Check list

**Phylum:** Chaetognatha

**Class:** Sagittoidea

**Order:** Aphragmophora

**Family:** Krohnittidae

**Genus:** *Krohnitta*

*Krohnitta pacifica* Aida, 1897

**Description.** Has a single pair of lateral fins. The tail segment does not contain a digitate adhesive organ. Either side of the head contains one set of teeth. Collarite is absent or not well developed. Spatula shaped tail. The lateral fin extends midway between the tail segment and the ventral ganglion. Teeth are placed in the form of a cone. Normal lateral fin with well-defined rays except the internal anterior part. Ovaries extend up to ventral ganglion in matured species. Ova are arranged as single rows in the ovary (Silas and Srinivasan 1970).

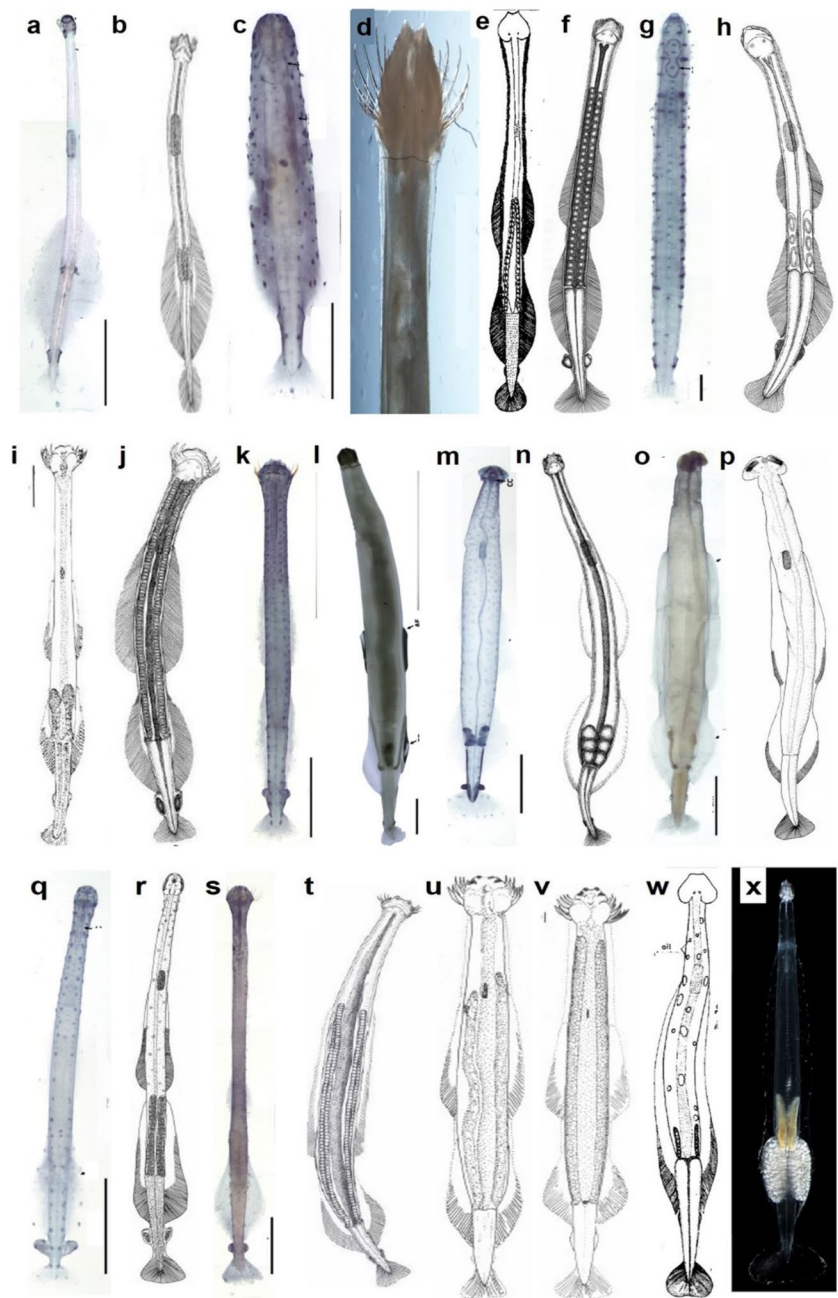
**Distribution.** *Krohnitta pacifica* is an epipelagic cosmopolitan species, and it has been recorded from the west coast of India and the Laccadive Sea (Silas and Srinivasan 1968; Srinivasan 1974, 1988, 1996). It is more frequent in the oceanic region than in the shelf region. This species has been recorded within the lagoon and water surrounding the Kavaratti and Kalpeni atolls during the winter monsoon season (Nair and Rao 1973b). Nair (1977) observed the presence of this species on the southwest coast of India, with the maximum abundance along the coastal region or inner shelf region off Alleppy and Quilon from February to April. *K. pacifica* was observed during early winter monsoon in the eastern Arabian Sea (Kusum et al. 2011; Balamurugan et al. 2011). Kusum (2012) and Kusum et al. (2014) recorded the occurrence of this species from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon. During the summer monsoon, this species was dominant in the surface upwelling region of the eastern Arabian Sea, and it was more abundant up to 300 m in the water column. Nair et al. (2015) recorded this species during the summer monsoon in the depth range of 0 – 1000 m in the eastern Arabian Sea.

***Krohnitta subtilis* Grassi, 1881**

**Description.** A single pair of lateral fins. The tail segment does not contain a digitate adhesive organ. Either side of the head contains one set of teeth. Collarite is absent or not well developed. The lateral fin extends midway between the tail segment and the ventral ganglion. Teeth are placed in the form of a cone. Lateral fins are broader and without rays except the margin. In matured species, the ovary extends up to the origin of the anterior fin and does not go beyond it. Ova is arranged as two rows in the ovary (Silas and Srinivasan 1970).

**Distribution.** *Krohnitta subtilis* is a cosmopolitan epipelagic species recorded from both oceanic and shelf waters of the west coast of India and the Laccadive Sea (Silas and Srinivasan 1968; Nair 1977; Srinivasan 1974, 1988, 1996). *Krohnitta subtilis* was observed during the early winter monsoon in the northeastern Arabian Sea and was found at a depth range of 0 – 1000 m. Mature populations of this species are more abundant at mixed layer depth (MLD) (Kusum et al. 2011). The species was observed in the eastern Arabian Sea during the summer

**Fig. 1** Few Chaetognath of eastern Arabian Sea. **a** *Krohnia subtilis* (scale bar: 5000  $\mu$ m), **b** *K. pacifica*, **c** *Pterosagitta draco* (scale bar: 5000  $\mu$ m), **d** *Sagitta bipunctata*, **e** *Sagitta bombayensis*, **f** *Aidanosagitta neglecta*, **g** *Aidanosagitta regularis* (scale bar: 1000  $\mu$ m), **h** *A. bedfordii*, **i** *Decipisagitta decipiens* (scale bar: 1 mm), **j** *Ferosagitta ferox*, **k** *Ferosagitta robusta* (scale bar: 5000  $\mu$ m), **l** *Flaccisagitta hexaptera* (scale bar: 5000  $\mu$ m), **m** *Flaccisagitta enflata* (scale bar: 5000  $\mu$ m), **n** *Mesosagitta minima*, **o** *Pseudosagitta lyra* (scale bar: 1 cm), **p** *Pseudosagitta maxima*, **q** *Serratosagitta pacifica* (scale bar: 5000  $\mu$ m), **r** *Serratosagitta tasmanica*, **s** *Zonosagitta bedoti* (scale bar: 5000  $\mu$ m), **t** *Zonosagitta pulchra*, **u** *Solidosagitta planc-tonis*, **v** *Solidosagitta zetesios*, **w** *Eukrohnia minuta*, **x** *Eukrohnia hamate*. **Picture Courtesy:** Fig. a, c, g, k, l, m, o, q, s (Choo et al. 2022), Fig. e, w (Silas and Srinivasan 1967, 1968), Fig. x (Kosobokova and Hopcroft 2021), Fig. b, d, f, h, i, j, n, p, r, t, u, v (Conway et al. 2003)



monsoon, fall inter-monsoon, and winter monsoon (Balamu-rugan et al. 2011; Kusum 2012; Nair et al. 2015). During the summer monsoon, the species was dominant in the surface upwelling site in the eastern Arabian Sea and was more abundant, up to 300 m in the water column (Kusum et al. 2014).

**Family: Pterosagittidae**

**Genus: Pterosagitta**

***Pterosagitta draco* Krohn, 1853**

**Description.** Only one pair of lateral fins is present, and it is seen in the tail segment. Absence of digitate adhesive organ on the tail segment. Either side of the head contains

two sets of teeth. Collarrette extends from the head-to-tail region as a clear band (Silas and Srinivasan 1970).

**Distribution.** *Pterosagitta draco* is a planktonic species recorded from the west coast of India, Eastern Arabian Sea and the Laccadive Sea (Silas and Srinivasan 1968; Srinivasan 1974, 1988, 1996; Nair and Rao 1973b; Nair 1977) in both oceanic and shelf waters with more frequency in oceanic waters. *Pterosagitta draco* is quite sparsely distributed during the southwest monsoon period (June–August), but it is substantially represented during the pre-monsoon (February–April) and post-monsoon (October–December) (Srinivasan 1974). *Pterosagitta draco* has been observed

Table 1 Checklist of Chaetognatha from the eastern Arabian Sea

Species	Area	Season	Reference
<i>Eukrohnia fowleri</i>	NEAS, southwest coast of India, Laccadive sea	Summer monsoon, fall Inter monsoon, winter monsoon, Feb–April, north-east monsoon	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Nair (1977); Silas and Srinivasan (1968); Nair and Rao (1973a); Balamurugan et al. (2011)
<i>Eukrohnia hamata</i>	Eastern Arabian Sea	summer monsoon, Fall inter monsoon	Nair et al. (2015); Kusum (2012); Kusum et al. (2014)
<i>Eukrohnia minuta</i>	NEAS, Eastern Arabian Sea	SM, FIM, WM, early winter monsoon	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Silas and Srinivasan (1968)
<i>Krohnhitta pacifica</i>	NEAS, Southwest coast of India, Eastern Arabian Sea, lagoons of Lakshadweep islands (Kavaratti, Kalpeni)	SM, FIM, WM, early winter monsoon, pre-monsoon, monsoon, post-monsoon, Feb–April	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Srinivasan (1974, 1996, 1988); Nair (1977); Nair and Rao (1973b); Silas and Srinivasan (1968); Balamurugan et al. (2011)
<i>Krohnhitta subtilis</i>	NEAS, Eastern Arabian sea, eastern Arabian sea	SM, FIM, WM, early winter monsoon, pre-monsoon, monsoon, post-monsoon, Feb–April	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Srinivasan (1974, 1996, 1988); Nair (1977); Silas and Srinivasan (1968); Balamurugan et al. (2011)
<i>Pterosagitta draco</i>	SEAS, NEAS, Eastern Arabian Sea, south west coast of India, lagoons of Lakshadweep islands (Kavaratti, Kalpeni)	SM, FIM, early winter monsoon, pre-monsoon, monsoon, post-monsoon, Feb–April	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Purushothaman et al. (2021); Srinivasan (1974, 1996, 1988); Nair (1977); Nair and Rao (1973b); Silas and Srinivasan (1968); Balamurugan et al. (2011)
<i>Sagitta bipunctata</i>	NEAS, eastern Arabian sea, south west coast of India, lagoons of Lakshadweep islands (Kavaratti, Kalpeni and Minitoy)	SM, FIM, WM, early winter monsoon, pre monsoon, monsoon, post monsoon, Feb–April	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Jima et al. (2015); Nair (1977); Nair and Rao (1973b); Balamurugan et al. (2011)
<i>Aidanosagitta neglecta</i>	Eastern Arabian sea, NEAS, lagoons of Lakshadweep islands (Kavaratti, Kalpeni and Minitoy), south east coast of India,	SM, FIM, WM, Early winter monsoon, pre monsoon, monsoon, post monsoon, Feb–April	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Jima et al. (2015); Srinivasan (1996, 1988); Nair (1977); Nair and Rao (1973a, b); Balamurugan et al. (2011)
<i>Aidanosagitta regularis</i>	Arabian sea, Eastern Arabian sea, NEAS, lagoons of Lakshadweep islands (Kavaratti, Kalpeni and Minitoy), south east coast of India	SM, FIM, WM, Early winter monsoon, Pre monsoon, monsoon, post monsoon, Feb–April	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Jima et al. (2015); Srinivasan (1974, 1996, 1988); Nair (1977); Nair and Rao (1973b); Silas and Srinivasan (1968); Balamurugan et al. (2011)
<i>Caecosagitta macrocephala</i>	Arabian sea, Eastern Arabian sea, (09° 57'N., 75° 27'E)	SM, FIM	Nair et al. (2015); Kusum (2012); Kusum et al. (2014); Srinivasan (1971)
<i>Decipisagitta decipiens</i>	Arabian sea, Eastern Arabian sea, NEAS, south west coast of India	SM, FIM, early winter monsoon, pre monsoon, monsoon, post monsoon, Feb–April,	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Jima et al. (2015); Srinivasan (1974, 1996, 1988); Nair (1977); Nair and Rao (1973a); Silas and Srinivasan (1968); Balamurugan et al. (2011)
<i>Ferosagitta ferox</i>	Arabian sea, eastern Arabian sea, NEAS, south west coast of India, lagoons of Lakshadweep islands (Kavaratti, Kalpeni)	SM, FIM, WM, early winter monsoon, pre monsoon, monsoon, post monsoon, Feb–April	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Srinivasan (1974, 1996, 1988); Nair and Rao (1973b); Nair (1977); Balamurugan et al. (2011)

Table 1 (continued)

Species	Area	Season	Reference
<i>Ferosagitta robusta</i>	Arabian sea, eastern Arabian sea, NEAS, lagoons of Lakshadweep islands (Kavaratti, Kalpeni and Minicoy), south west coast of India	SM, FIM, WM, pre monsoon, monsoon, post monsoon, early winter monsoon, Feb-April	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Srinivasan (1974, 1996, 1988); Nair (1977); Nair and Rao (1973b); Silas and Srinivasan (1968); Balamurugan et al. (2011)
<i>Flaccisagitta hexaptera</i>	Arabian sea, eastern Arabian sea, NEAS, south west coast of India, lagoons of Lakshadweep islands (Kavaratti, Kalpeni)	SM, FIM, WM, early winter monsoon, pre monsoon, monsoon, post monsoon, Feb- April	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Srinivasan(1974, 1996, 1988); Nair (1977); Nair and Rao (1973b); Balamurugan et al. (2011)
<i>Mesosagitta minima</i>	Arabian sea, eastern Arabian sea, NEAS	SM, FIM, WM, early winter monsoon	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Balamurugan et al. (2011)
<i>Pseudosagitta lyra</i>	Arabian sea, oceanic region of AS,	SM, FIM,	Nair et al. (2015); Srinivasan (1988); Silas and Srinivasan (1968); Balamurugan et al. (2011)
<i>Pseudosagitta maxima</i>	Arabian sea, eastern Arabian sea, NEAS,	SM, FIM, WM, early winter monsoon,	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Balamurugan et al. (2011)
<i>Serratosagitta pacifica</i>	Arabian sea, Eastern Arabian sea, NEAS, SEAS, south west coast of India, lagoons of Lakshadweep islands (Kavaratti, Kalpeni)	SM, FIM, WM, early winter monsoon, pre monsoon, monsoon, post monsoon, Srinivasan	Nair et al. (2015); Kusum et al. (2011, 2014); Kusum (2012); Purushothaman et al. (2021); Srinivasan (1974, 1996, 1988); Nair (1977); Silas and Srinivasan (1968); Nair and Rao (1973b); Balamurugan et al. (2011)
<i>Zonosagitta bedoti</i>	Arabian Sea, Eastern Arabian Sea, lagoons of Lakshadweep islands (Kavaratti, Kalpeni, and Minicoy), southwest coast of India,	SM, FIM, pre-monsoon, monsoon, post-monsoon, Feb- April	Nair et al. (2015); Kusum et al. (2014); Kusum (2012); Jima et al. (2015); Srinivasan (1974, 1996, 1988); Nair (1977); Silas and Srinivasan (1968); Nair and Rao (1973a, b); Balamurugan et al. (2011)
<i>Zonosagitta pulchra</i>	Arabian Sea, Eastern Arabian Sea, NEAS, southwest coast of India, lagoons of Lakshadweep islands (Kavaratti, Kalpeni)	SM, FIM, WM, early winter monsoon, pre-monsoon, monsoon, post-monsoon, Feb- April	Nair et al. (2015); Kusum et al. (2014); Kusum (2012); Srinivasan (1974, 1996, 1988); Nair (1977); Silas and Srinivasan (1968); Nair and Rao (1973b); Balamurugan et al. (2011)
<i>Eukrohnia bathypelagica</i>	Eastern Arabian sea, NEAS,	FIM, SM, WM, early winter monsoon	Kusum et al. (2011, 2014); Kusum (2012)
<i>Aidanosagitta beaffordii</i>	Eastern Arabian sea, NEAS	FIM, SM, WM, early winter monsoon	Kusum et al. (2011, 2014); Kusum (2012)
<i>Flaccisagitta enflata</i>	Eastern Arabian sea, NEAS, SEAS, lagoons of Lakshadweep islands (Kavaratti, Kalpeni, and Minicoy), southeast coast of India	FIM, SM, WM, early winter monsoon, pre-monsoon, monsoon, post-monsoon, Feb-April	Kusum et al. (2011, 2014); Kusum (2012); Purushothaman et al. (2021); Jima et al. (2015); Srinivasan (1974, 1996, 1988); Nair (1977); Nair and Rao (1973b); Silas and Srinivasan (1968); Balamurugan et al. (2011)
<i>Aidanosagitta oceania</i>	Eastern Arabian sea,	FIM, SM,	Kusum et al. (2014); Kusum (2012); Ramaiah and Nair (1993)
<i>Solidosagitta planctonis</i>	Eastern Arabian sea, NEAS	FIM, SM, WM, early winter monsoon,	Kusum et al. (2011, 2014); Kusum (2012)
<i>Decipisagitta sibogae</i>	Eastern Arabian Sea,	SM	Kusum et al. (2014); Kusum (2012)
<i>Solidosagitta zetesios</i>	Eastern Arabian sea, NEAS	FIM, SM, WM, early winter monsoon	Kusum et al. (2011, 2014); Kusum (2012); Balamurugan et al. (2011)
<i>Serratosagitta tasmanica</i>	NEAS, Arabian sea	early winter monsoon, FIM, SM, WM	Kusum et al. (2011); Kusum (2012)

Table 1 (continued)

Species	Area	Season	Reference
<i>Ferosagitta madhupratapi</i>	Lagoons of Lakshadweep islands (Kavaratti, Kalpeni, and Minicoy)	pre-monsoon, monsoon, post-monsoon	Casanova and Nair (1999); Jima et al. (2015)
<i>Sagitta bombayensis</i>	The southeastern part at 10° S–75° E	SW monsoon	Lele and Gae (1936); Nair and Rao (1973a); Silas and Srinivasan (1967)
<i>Spadella angulata</i>	Lagoons of Lakshadweep islands (Kavaratti, Kalpeni)	Oct & Dec	Nair and Rao (1973b)
<i>Ferosagitta hispida</i>	west coast of India & Laccadive sea	Pre-monsoon, monsoon, post-monsoon	Srinivasan (1974); Silas and Srinivasan (1968)
<i>Aidanosagitta septata</i>	Laccadive sea	Dec-Jan. 10 & april	Doncaster (1902)
<i>Aidanosagitta nairi</i>	near Agatti Atoll in the Arabian Sea	winter monsoon	Casanova and Nair (2002)

during the early winter monsoon in the northeastern Arabian Sea (Kusum et al. 2011; Balamurugan et al. 2011). The species was reported from the western part of the EEZ of India, i.e., the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon (Kusum 2012; Nair et al. 2015). This species was abundant up to 300 m depth during the summer monsoon (Kusum et al. 2014). *Pterosagitta draco* was obtained from upwelled waters of the southeastern Arabian Sea during the summer monsoon (Purushothaman et al. 2021).

#### Family: Sagittidae

##### Genus: *Sagitta*

##### *Sagitta bipunctata* Quoy and Gaimard, 1827

**Description.** The body is slender, tapering towards the tail and slightly tapering as it moves towards the head. The head is small. Rounded tail fin and well-separated anterior and posterior fins. Long posterior fin. The anterior fin is narrower and shorter than the posterior fin and does not reach the ventral ganglion. The jaw is strong and curved in the distal half. Anterior teeth: 4–7. Posterior teeth: 8–18 (Fowler 1905).

**Distribution.** *Sagitta bipunctata* is an epipelagic species. The species was recorded from the water surrounding Kavaratti and Kalpeni atolls (Nair and Rao 1973b) and the southwest coast of India from Feb–April (Nair 1977). *Sagitta bipunctata* has been observed during the early winter monsoon in the northeastern Arabian Sea with an abundance of up to 300 m depth (Kusum et al. 2011). The species was reported along the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon (Balamurugan et al. 2011; Kusum 2012; Nair et al. 2015). This species was recorded from surface upwelling sites during the summer monsoon (Kusum et al. 2014). Jima et al. (2015) recorded this species from the lagoons of Lakshadweep islands (Kavaratti, Kalpeni, and Minicoy) during pre-monsoon, monsoon, and post-monsoon periods.

##### *Sagitta bombayensis* Lele and Gae, 1936

**Description.** Elongated and slender body. The collarite is well-developed and starts from the head to just behind the middle of the posterior fin. Large head containing pigmented eyes. The posterior fin is longer compared to the anterior fin. In fully mature species, ovaries are shorter and do not reach beyond the ventral ganglion. Seminal vesicles become anteriorly spout-shaped during discharging. Hooks: 9–10. Anterior teeth: 9–10. Posterior teeth: 18–23 (Silas and Srinivas 1967).

**Distribution.** Lele and Gae (1936) first described this species from Bombay Harbor. Later, Silas and Srinivas (1967) recorded this species from Bombay Harbor. This species has been recorded from the northwest coast of India during the northeastern monsoon period (Nair and Rao 1973a).

##### Genus: *Aidanosagitta*

***Aidanosagitta neglecta* Aida, 1897**

**Description.** Collarlette is seen around the neck. The anterior fin starts from the posterior end of the ventral ganglion. The posterior fin is longer compared to the anterior fin. The posterior fin divides equally on the trunk and tail segment and is wider at the level posterior to the trunk-tail septum. Rays are present in both fins. The ovary reaches the anterior end of the posterior fin during medium maturity. The seminal vesicle is located close to the posterior fin's rear end. Eye pigment is oval-shaped (Tokioka 1959).

**Distribution.** *Aidanosagitta neglecta* is an epipelagic species. Srinivasan (1988, 1996) and Nair and Rao (1973a, b) recorded this species from the eastern Arabian Sea and observed it to be more abundant in the oceanic area than in the shelf area. This species has also been reported within the lagoon and water surrounding the Kavaratti and Kalpeni atolls during winter monsoon (Nair and Rao 1973b). Nair (1977) recorded the species along the southwest coast of India from Feb–April, with maximum abundance along the coastal region or inner shelf region of off Cochin. *Aidanosagitta neglecta* has been observed during the early winter monsoon in the northeastern Arabian Sea with an abundance of up to 300 m depth (Kusum et al. 2011; Balamurugan et al. 2011). The species was recorded from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon (Kusum 2012; Kusum et al. 2014; Nair et al. 2015). Jima et al. (2015) recorded this species from the lagoons of Lakshadweep islands (Kavaratti, Kalpeni, and Minicoy) during pre-monsoon, monsoon, and post-monsoon periods.

***Aidanosagitta regularis* Aida, 1897**

**Description.** Rigid and opaque body. Intestinal diverticula present. Two rows of stout teeth arranged in a comb shape. Two pairs of lateral fins completely rayed. Hooks 6. Anterior teeth are 3–4, and posterior teeth are 5–6. Head small, triangular shaped. Collarlette expanding to seminal vesicles. Corona ciliata begin from the neck to the anterior of the ventral ganglion. The anterior fins begin at the posterior of the ventral ganglion. Posterior fins are not connected to anterior fins, and both anterior and posterior fins are completely rayed. Caudal fin fully rayed. Seminal vesicles longitudinally elongated along the body (Choo et al. 2022).

**Distribution.** *Aidanosagitta regularis* is a tropical–equatorial species restricted to the Pacific and Indian Oceans. It is an epipelagic species and has been recorded from the west coast of India, the Eastern Arabian Sea and the Laccadive Sea (Silas and Srinivasan 1968; Srinivasan 1974, 1988, 1996) with occurrence in both oceanic waters and shelf waters, however, higher abundance in oceanic waters. This species has been observed within the lagoon and water surrounding the Kavaratti and Kalpeni atolls during the winter monsoon season (Nair and Rao 1973b). Nair (1977) recorded this species along the southwest

coast of India from Feb–April, with the maximum abundance in the coastal or inner shelf region off Aleppy. *Aidanosagitta regularis* has been reported during the early winter monsoon in the northeastern Arabian Sea (Kusum et al. 2011; Balamurugan et al. 2011). Kusum (2012) and Nair et al. (2015) recorded this species from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon. During the summer monsoon, the species occupied the lower subsurface upwelling sites in the eastern Arabian Sea (Kusum et al. 2014). Jima et al. (2015) recorded this species from the lagoons of Lakshadweep islands (Kavaratti, Kalpeni, and Minicoy) during pre-monsoon, monsoon and post-monsoon periods.

***Aidanosagitta bedfordii* Doncaster, 1902**

**Description.** The tail region constitutes 34% of the entire body length. The body is covered by alveolar tissue from the neck down to the level of the subenteric ganglion's posterior margin. Conspicuous intestinal diverticula, 9–12 hooks, 1–3 slender posterior teeth and 2–3 needle-like anterior teeth on each side of the head. Mature ovary extend anteriorly to the middle of the ventral ganglion (Tokioka 1942; Michel 1995; Kasatkina and Selivanova 2003).

**Distribution.** *Aidanosagitta bedfordii* has been observed during the early winter monsoon in the northeastern Arabian Sea with an abundance of up to 300 m depth (Kusum et al. 2011). The species was recorded from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon (Kusum 2012; Kusum et al. 2014).

***Aidanosagitta oecania* Grey, 1930**

**Description.** The anterior fin starts from the posterior end of the ventral ganglion. The posterior fin is longer than the anterior fin and divides equally on the trunk and caudal segment, and it is wider at the level posterior to the trunk-tail septum. Rays are present in both fins but sparse in a small area near the frontal end. Large pigmented round eyes. Collarlette absent. The seminal vesicles are closer to the posterior fin than the caudal fin. The ovaries extend further than the posterior end of the anterior fin (Tokioka 1959). The tail region constitutes 32% of the entire body length. Alveolar tissue is absent (Kasatkina and Selivanova 2003).

**Distribution.** *Aidanosagitta oecania* has been recorded from the eastern Arabian Sea during pre-monsoon, monsoon and post-monsoon periods (Ramaiah and Nair 1993). This species was recorded from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon (Kusum 2012; Kusum et al. 2014).

***Aidanosagitta septata* Doncaster, 1903**

**Description.** The fins of the 1st pair are longer than the fins of 2nd pair. The anterior margin of the fins of the 1st pair is located behind the level of the posterior margin of subenteric ganglion and the alveolar tissue covers the body from the neck to the level of the subenteric ganglion. The

ratio between the tail and trunk parts in the 2nd pair of fins equals or less than 1.2 (Kasatkina and Selivanova 2003).

**Distribution.** Doncaster (1902) recorded this species from the Laccadive archipelago.

***Aidanosagitta nairi* Casanova and Nair, 2002**

**Description.** The body is transparent, slender and slightly rigid, with a maximum length of 5.2 mm (small). A tail without a tail fin constitutes 28.5 – 30.2% of the total body length. The head contains fan-shaped anterior teeth, which are numerous (11–14) compared to posterior teeth (11–12). Hooks: 7–8. Large pigmented round eyes. Two intestinal diverticula at the beginning of the gut. Large ventral ganglion constitutes 11% of body length. The anterior fin begins at the level of the ventral ganglia's posterior end. The posterior fin lies more on the tail than the trunk without reaching the seminal vesicles. Small and elongated seminal vesicles (Casanova and Nair 2002).

**Distribution.** Casanova and Nair (2002) recorded this species for the first time from the Laccadive Sea (Agatti lagoon) during the winter monsoon.

**Genus: *Caecosagitta***

***Caecosagitta macrocephala* Fowler, 1904**

**Description.** Muscular slender body. The head is wider than the body, and the region of the genital septum is not constricted. Body length up to 21 mm long. The caudal end of the body does not taper. On each side of the body, anterior teeth range from 6–10 and posterior teeth from 17–33. Spines: 10–12. Eyes are without pigment spots (Kasatkina 2003). The anterior fin starts very far back from the ventral ganglion and is smaller than the posterior fin. The anterior fin is fully rayed, whereas the posterior fin is wider and rayless. Collarette and intestinal diverticula are absent. The seminal vesicle is located closer to the posterior fin. Ova is arranged in four rows in the ovary (Srinivasan 1971).

**Distribution.** Srinivasan (1971) recorded this species from deep waters of the west coast of India during December. This species has been recorded during the summer monsoon and fall inter-monsoon from the eastern Arabian Sea (Kusum 2012; Kusum et al. 2014; Nair et al. 2015).

**Genus: *Decipisagitta***

***Decipisagitta decipiens* Fowler, 1905**

**Description.** Body slender, transparent and firm. It tapered towards both ends but became thicker after the middle of its length. The neck is not well-defined, and the collarette is very slight. The anterior and posterior fin are about the same length. The anterior fin is not reaching the ventral ganglion. The posterior fin is more triangular-shaped. Corona is absent. Prominent ventral ganglion. Short and opaque ovary extending to the anterior end of the posterior fin. Slender and curved jaw. Posterior teeth are longer, while anterior teeth are shorter and have a triangular shape. The vestibular ridge with a thick cuticle is present. Anterior teeth up to 10 and posterior teeth up to 18 (Fowler 1905).

**Distribution.** *Decipisagitta decipiens* is a cosmopolitan mesoplanktonic species. It has been recorded from the west coast of India, the southern coast of India and the Laccadive Sea (Silas and Srinivasan 1968; Nair and Rao 1973a; Nair 1977). *Decipisagitta decipiens* is an oceanic epipelagic species observed in oceanic and shelf waters during monsoon and post-monsoon periods and used as an indicator of upwelling along the southwest coast of India (Srinivasan 1974, 1988, 1996). This species has been observed during the early winter monsoon in the northeastern Arabian Sea and was found at a depth range of 0 – 1000 m (Kusum et al. 2011; Balamurugan et al. 2011). Kusum (2012), Kusum et al. (2014) and Nair et al. (2015) recorded this species from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon. Jima et al. (2015) recorded this species from the lagoons of Lakshadweep islands (Kavaratti, Kalpeni, and Minicoy) during pre-monsoon, monsoon, and post-monsoon periods.

***Decipisagitta sibogae* Fowler, 1906**

**Description.** Non-serrated hooks. Intestinal diverticula present. Eyes big with large t-shaped pigmentation spot. The body is slender with a maximum length of up to 30 mm. Seminal vesicles touching the tail fin and apart from the posterior fin. Ovaries are of medium length (Pierrot-Bults 2020).

**Distribution.** Kusum (2012) and Kusum et al. (2014) recorded this species from the eastern Arabian Sea during the summer monsoon.

**Genus *Ferosagitta***

***Ferosagitta ferox* Doncaster, 1902**

**Description.** Collarette extends from head to tail region but is thicker from head to ventral ganglion and, beyond that, is thinner. There are no serrations on the concave internal margins of hooks. Seminal vesicles touch both the tail fin and posterior fins. Gut diverticula present. The number of posterior teeth and hooks ranges from 10–15 and 5–8, respectively. The anterior fin begins opposite the centre of the ventral ganglion and is longer than the posterior fin. Ova is arranged as two rows in the ovary (Silas and Srinivasan 1970).

**Distribution.** *Ferosagitta ferox* has been recorded within the lagoon of Kalpeni atoll during winter monsoon (Nair and Rao 1973b) and from the Eastern Arabian Sea and the Laccadive Sea (Srinivasan 1974, 1988, 1996). It was observed in both oceanic and shelf waters with abundance in shelf waters. Nair (1977) recorded it along the southwest coast of India from Feb–April, with maximum abundance in the coastal zone or inner shelf region off Cochin. The species has been observed during the early winter monsoon in the northeastern Arabian Sea (Kusum et al. 2011; Balamurugan et al. 2011). The species was reported from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon,



and winter monsoon (Kusum 2012; Kusum et al. 2014; Nair et al. 2015).

***Ferosagitta robusta* Doncaster, 1902**

**Description.** Opaque body with strong longitudinal muscles. The head is broader, and the collarete extends from the head to the origin of the anterior fins, where its width decreases and reappears just above the seminal vesicles. Large pigmented eyes. Intestinal diverticula clove-shaped. A large rectangular ventral ganglion is located at the beginning of the anterior fins. The posterior fin is longer than the anterior fin. In fully mature species, the ovaries extend ahead of the ventral ganglion and the seminal vesicles are differentiated into a voluminous sperm sac. Hooks: 7–8. Anterior teeth: 6–9. Posterior teeth: 10–15 (Silas and Srinivas 1967).

**Distribution.** *Ferosagitta robusta* is a tropical–equatorial species restricted to the Pacific and Indian Oceans. It is an epipelagic species recorded in both oceanic waters and shelf waters along the west coast of India, the Eastern Arabian Sea and the Laccadive Sea (Silas and Srinivasan 1968; Srinivasan 1974, 1988, 1996) with abundance in oceanic waters. This species is found in the lagoon and water surrounding the Kavaratti and Kalpeni atolls during the winter monsoon (Nair and Rao 1973b). Nair (1977) recorded this species along the southwest coast of India from February to April, with an abundance in the middle zone or outer shelf region. *F. robusta* has been observed during the early winter monsoon in the northeastern Arabian Sea and was found at a depth range of 0–1000 m (Kusum et al. 2011). The species was reported from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon (Balamurugan et al. 2011; Kusum 2012; Kusum et al. 2014; Nair et al. 2015).

***Ferosagitta madhupratapi* Casanova and Nair, 1999**

**Description.** Body firm with length ranging from 6.6 to 9.5 mm. Elongated head with snake-like appearance. 4–6 anterior teeth on each side of the head, and the number of posterior teeth ranges from 8 to 10. Hooks (6–7) bent at their tips and smooth. They had rounded pigmented eyes. A tail without a tail fin constitutes 24.5 to 28.8% of the total body length. Collarete starts from the neck to the beginning of the ventral ganglion and again appears on the anterior portion of the tail fin. Two intestinal diverticula are present in the neck region. The anterior fin starts just after the ventral ganglion's posterior end. In the case of matured organisms, ovaries containing ova reach up to the neck region, and tail segments are filled with sperm. Seminal vesicles are located after the posterior fin and touch the tail fin (Casanova and Nair 1999).

**Distribution.** Casanova and Nair (1999) recorded this species from Agatti lagoon during the winter monsoon for the first time. Later on, Jima et al. (2015) reported the species from the Kavaratti, Kalpeni, and Minicoy lagoons of

Lakshadweep islands during pre-monsoon, monsoon, and post-monsoon periods.

***Ferosagitta hispida* Conant, 1895**

**Description.** Have two pairs of lateral fins. Collarete present and starts from the head and extends up to the ventral ganglion. There are no serrations on the concave internal margins of hooks. Seminal vesicles extend up to the posterior fin. The gap between the seminal vesicles and the tail fin is wider. The posterior fin occupies trunk and tail segments. The tail segment constitutes 26 to 34% of the total body length. The number of posterior and anterior teeth ranges from 6–18 and 4–10, respectively. Oval or spherical-shaped ova arranged in a single row as a regular compact series. Hispid condition is conspicuous (Silas and Srinivasan 1970).

**Distribution.** *Ferosagitta hispida* is a tropical–equatorial epi planktonic species restricted to the Indian and Atlantic Oceans and recorded from the west coast of India, Eastern Arabian Sea and the Laccadive Sea (Silas and Srinivasan 1968; Srinivasan 1974). It was observed in both oceanic waters and shelf waters with abundance in oceanic waters.

**Genus *Flaccisagitta***

***Flaccisagitta hexaptera* d'Orbigny, 1836**

**Description.** Two pairs of lateral fins are present. The sac-like gelatinous substance is present at the base of the lateral fins. Corona ciliata is situated at the level of the eye or higher level. No intestinal diverticula (Kassatkina 2007). Maximum total length of body 70 mm. The tail constitutes 16–20% of the total body length. The anterior fin is short and partially rayed. Hooks are not serrated. Round or ovoid seminal vesicles. Seminal vesicles touching the tail fin and away from the posterior fin. Ovaries are long (Pierrot-Bults 2020).

**Distribution.** *Flaccisagitta hexaptera* is an epipelagic species recorded from the Eastern Arabian Sea and the Laccadive Sea in both oceanic waters and shelf waters with more abundance in oceanic waters (Srinivasan 1974, 1988, 1996). This species has been obtained within the water surrounding the Kavaratti and Kalpeni atolls and within the lagoon of Kalpeni during winter monsoon (Nair and Rao 1973b). Nair (1977) recorded this species along the southwest coast of India from February to April, with maximum abundance in the outer zone or slope region. *Flaccisagitta hexaptera* has been reported from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon (Balamurugan et al. 2011; Kusum 2012; Kusum et al. 2011; 2014; Nair et al. 2015).

***Flaccisagitta enflata* Grassi, 1881**

**Description.** The total maximum length of the body is up to 25 mm. The tail constitutes 14–17% of the total body length. Flaccid body. Separate anterior fin and posterior fin. Hooks are not serrated. The anterior fin is partially rayed and short. Round or ovoid seminal vesicles, touching the tail

fin and away from the posterior fin. The ovary is too short (Pierrot-Bults 2020).

**Distribution.** *Flaccisagitta enflata* is a cosmopolitan epipelagic species recorded from both oceanic and shelf waters of the west coast of India, the Eastern Arabian Sea and the Laccadive Sea (Silas and Srinivasan 1968; Srinivasan 1974, 1988, 1996) with abundance in shelf waters. This species is found in the lagoon and water surrounding the Kavaratti and Kalpeni atolls during the winter monsoon (Nair and Rao 1973b). Nair (1977) recorded the species along the southwest coast of India with the maximum abundance from the coastal zone or inner shelf region off Cochin from February to April. *Flaccisagitta enflata* has been observed during the early winter monsoon in the northeastern Arabian Sea and was found at a depth range of 0–1000 m (Kusum et al. 2011). The species has been reported from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon (Balamurugan et al. 2011; Kusum 2012; Kusum et al. 2014; Nair et al. 2015). Jima et al. (2015) recorded this species from the lagoons of Lakshadweep islands (Kavaratti, Kalpeni, and Minicoy) during pre-monsoon, monsoon, and post-monsoon periods. *Flaccisagitta enflata* was suggested to indicate upwelled waters along the southeastern Arabian Sea during the summer monsoon (Purushothaman et al. 2021).

**Genus: *Mesosagitta***

***Mesosagitta minima* Grassi, 1881**

**Description.** Corona ciliata situated below the eye level and occasionally on the neck. Hooks are not serrated. Gut diverticula present. In all stages of mature animals, most of the posterior fins are placed in the trunk region (Kassatkina 2007). Flaccid body with a small head. The entire body length is 10 mm. Ovaries are short and contain large eggs in few numbers. Seminal vesicles with knob and touches the tail fin (Pierrot-Bults 2020).

**Distribution.** *Mesosagitta minima* has been observed during the early winter monsoon in the northeastern Arabian Sea with an abundance of up to 300 m depth (Kusum et al. 2011). The species were recorded from the eastern Arabian Sea during the summer, fall inter-monsoon, and winter monsoon (Balamurugan et al. 2011; Kusum 2012; Kusum et al. 2014; Nair et al. 2015).

**Genus: *Pseudosagitta***

***Pseudosagitta lyra* Krohn, 1853**

**Description.** Two pairs of lateral fins are present. Between the anterior and posterior fin, there is a sac-like gelatinous structure. No intestinal diverticula. Corona ciliata are situated at the level of the eye or higher level (Kassatkina 2007). Flaccid body. The total maximum length of the body is 42 mm. The tail fin constitutes 15–17% of the total body length. Anterior and posterior fin with fin bridge. Collarette is absent (Pierrot-Bults 2020).

**Distribution.** *Pseudosagitta lyra* is a meso planktonic species recorded from the west coast of India and the Laccadive Sea (Silas and Srinivasan 1968). Srinivasan (1988) recorded this species from the Eastern Arabian Sea, but its presence was only recorded in oceanic areas. Balamurugan et al. (2011) and Nair et al. (2015) recorded this species from the eastern Arabian Sea during the summer monsoon and early winter monsoon, respectively.

***Pseudosagitta maxima* Conant, 1896**

**Description.** Total body length ranges from 33 to 36 mm, including the tail fin. Body transparent and flaccid. A distinct neck separates the head and body. The width of the head is more than its length and consists of pigmented oval eyes. Number of anterior teeth two and posterior teeth 2–3. Hooks: 4. Collarette and intestinal diverticula absent. The anterior fin is narrower and longer than the posterior fin and starts just above the middle of the ventral ganglion. The fin bridge connects both the anterior and posterior fins. The elongated ovary and seminal vesicles are oval-shaped and closer to the posterior fin (Srinivasan 1971).

**Distribution.** *Pseudosagitta maxima* has been observed during the early winter monsoon in the northeastern Arabian Sea at a depth range of 500–1000 m (Kusum et al. 2011). Species recorded from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon (Balamurugan et al. 2011; Kusum 2012; Kusum et al. 2014; Nair et al. 2015).

**Genus: *Serratosagitta***

***Serratosagitta pacifica* Tokioka, 1940**

**Description.** Collarette present. Serrated hooks with concave internal margins. Seminal vesicles with 4–10 chitinous teeth. Ova is arranged as a single row in the ovary. (Silas and Srinivasan 1970).

**Distribution.** *Serratosagitta pacifica* is a tropical–equatorial epipelagic species, restricted to the Pacific and Indian Oceans, recorded from the west coast of India, the Eastern Arabian Sea and the Laccadive Sea (Silas and Srinivasan 1968; Srinivasan 1974, 1988, 1996) in both oceanic and shelf waters with high abundance in oceanic waters. This species has been obtained within the lagoon and water surrounding the Kavaratti and Kalpeni atoll during winter monsoon (Nair and Rao 1973b). Nair (1977) recorded this species along the southwest coast of India with maximum abundance along the middle zone or outer shelf region. *Serratosagitta pacifica* has been observed during the summer monsoon, fall inter-monsoon, and winter monsoon in the Eastern Arabian Sea (Kusum et al. 2011, 2014; Balamurugan et al. 2011; Kusum 2012; Nair et al. 2015). This species was also obtained from upwelled waters of the southeastern Arabian Sea during the summer monsoon (Purushothaman et al. 2021).

***Serratosagitta tasmanica* Thompson, 1947**

**Description.** Separate anterior fin and posterior fin. Body needle-like. Hooks with serration. Maximum total length up to 30 mm. Number of posterior teeth ranges from 9 to 15. Seminal vesicle knob with protuberance. Transversal musculature absent (Pierrot-Bults 2020).

**Distribution.** *Serratosagitta tasmanica* has been obtained during the early winter monsoon in the northeastern Arabian Sea (Kusum et al. 2011). Kusum (2012) recorded this species from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon.

**Genus: *Zonosagitta***

***Zonosagitta bedoti* Béraneck, 1895**

**Description.** Ovary extends up to the posterior end of the anterior fin. The front end of the intestine is a little swollen and may appear whitish or opaque. The space between the eyes is relatively wide (Tokioaka 1959).

**Distribution.** *Zonosagitta bedoti* is a tropical–equatorial, epi planktonic species, restricted to the Pacific and Indian Ocean, recorded from the west coast of India, the Eastern Arabian Sea and the Laccadive Sea (Silas and Srinivasan 1968; Srinivasan 1974, 1988, 1996) with high abundance in shelf waters. The species has been reported within the lagoon and water surrounding the Kavaratti and Kalpeni atoll during winter monsoon (Nair and Rao 1973b). Nair (1977) recorded this species along the southwest coast of India from Feb–April with maximum abundance from the coastal zone or inner shelf region. The species has been reported from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon and winter monsoon (Balamurugan et al. 2011; Kusum 2012; Kusum et al. 2014; Nair et al. 2015). Jima et al. (2015) recorded the species recorded from the lagoons of Lakshadweep islands (Kavaratti, Kalpeni, and Minicoy) during pre-monsoon, monsoon, and post-monsoon periods.

***Zonosagitta pulchra* Doncaster, 1902**

**Description.** Collarette present. There are no serrations on the concave internal margins of hooks. Seminal vesicles touch the tail fin, and a wide gap separates seminal vesicles and the posterior fin. Intestinal diverticula absent. The number of posterior teeth ranges from 8–16. The base of the lateral fin without ray. Anterior fin is twice the length of the posterior fin. Ova is arranged as three rows in the ovary (Silas and Srinivasan 1970).

**Distribution.** *Zonosagitta pulchra* is a tropical–equatorial species restricted to the Pacific and Indian Oceans. It is an epi planktonic species recorded from the west coast of India, the Eastern Arabian Sea and the Laccadive Sea in both oceanic and shelf waters (Silas and Srinivasan 1968; Srinivasan 1974, 1988, 1996). This species is found in the lagoon and water surrounding the Kavaratti and Kalpeni atolls during the winter monsoon (Nair and Rao 1973b). Nair (1977) recorded the species along the southwest coast of India with maximum abundance from the middle zone or outer shelf region. Balamurugan et al. (2011), Kusum (2012), Kusum

et al. (2014), and Nair et al. (2015) recorded this species from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon.

**Genus: *Solidosagitta***

***Solidosagitta planctonis* Steinhaus, 1896**

**Description.** Corona ciliata situated below the eye level and occasionally on the neck. In all stages of mature animals, the majority of the posterior fins are located in the trunk region. Rays are present in the fins. Non-serrated hooks. Intestinal diverticula present. The greater size of the inner nuclear eye zone than the peripheral one (Kassatkina 2007).

**Distribution.** *Solidosagitta planctonis* has been observed during the early winter monsoon in the northeastern Arabian Sea, abundantly up to 300 m depth (Kusum et al. 2011). Kusum (2012) and Kusum et al. (2014) recorded this species from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon.

***Solidosagitta zetesios* Fowler, 1905**

**Description.** Body stout and tapering towards the end. Medium-sized head. Well-marked neck. Collarette present. The tail occupies 25–33% of the total body length. The anterior fin is narrower and longer than the posterior. The posterior fin is triangular-shaped and extends towards the rear end of the ventral ganglion. They have elongated, slender teeth. The size of anterior teeth increases ventrally. The posterior teeth grow longer inwards at first, then decrease in the innermost. The vestibular ridge fully formed and covered by a thin cuticle. Corona ciliata is absent (Fowler 1905).

**Distribution.** *Solidosagitta zetesios* has been observed during the early winter monsoon in the northeastern Arabian Sea (Kusum et al. 2011). This species was recorded from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon (Balamurugan et al. 2011; Kusum 2012; Kusum et al. 2014).

**Order: Phragmophora**

**Family: Eukrohniidae**

**Genus: *Eukrohnia***

***Eukrohnia fowleri* Ritter-Záhony, 1909**

**Description.** Total length ranges from 7.5–23 mm. Eyes are oval shaped and pigments surrounded by ommatidia in rows. Long, stout body with strong longitudinal muscles. Body orange coloured. The number of hooks ranges from 10–13 and are long with straight tips. Lateral fins extend from the anterior part of the ventral ganglion to seminal vesicles. The collarette is seen around the ventral ganglion as a band and becomes thinner as it extends backwards to the tail. It will become thicker behind seminal vesicles (Silas and Srinivasan 1968).

**Distribution.** *E. fowleri* is a cosmopolitan, deep-water (meso- and bathy-planktonic) species recorded from the west coast of India and the Laccadive Sea (Silas and Srinivasan 1968; Nair and Rao 1973a; Nair 1977). The species has been reported as mesopelagic in the Indian Ocean (Nair 1978).

Balamurugan et al. (2011), Kusum (2012), and Nair et al. (2015) recorded this species from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon. They were primarily abundant in 500–1000 m depth during fall inter-monsoon. Because of their mesopelagic nature, in summer monsoon, they were seen in the upper layers only in the upwelling regions along the coastal zones, which is evidence of the usage of this species as an indicator of upwelling in the coastal zones (Kusum et al. 2014).

***Eukrohnia minuta* Silas and Srinivasan, 1969**

**Description.** Opaque, slender body with wavy longitudinal muscles. The total length of the body, including the tail fin, varies from 5.6 to 12.0 mm. From the neck to the posterior end of the ventral ganglion, the transverse muscles are evident as regular, closely spaced rings. Large ventral ganglion. The head is wider and contains closely spaced minute eyes without pigments. Neck fragile. Jaw hooks: 7 to 9 with straight tips. Teeth 8 to 14. Broad and pigmented intestine. Well-defined constriction is the characteristic feature of the tail segment (Silas and Srinivasan 1968).

**Distribution.** *E. minuta* is a mesopelagic species. It is endemic to the Arabian and Laccadive Sea (Silas and Srinivasan 1968). This species has been recorded from the north-eastern Arabian Sea during the early winter monsoon from a depth below 500 m. Their abundance in the southern NEAS supports their affinity for oxygenated water (Kusum et al. 2011). Kusum (2012) and Nair et al. (2015) recorded this species from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon. This species is known to be an indicator of the upwelling phenomenon in the Arabian Sea because of its presence in subsurface layers of upwelling regions (Kusum et al. 2014).

***Eukrohnia hamata* Möbius, 1875**

**Description.** Collarlet present. Number of hooks is less than 11. The tail segment occupies less than 25% of the total body length. In matured species, ova are arranged as four rows in the ovary (Silas and Srinivasan 1968).

**Distribution.** *E. hamata* is a bathypelagic species. Kusum (2012) recorded this species from the eastern Arabian Sea during the summer monsoon, fall inter-monsoon, and winter monsoon. In the summer monsoon, *E. hamata* was seen in depths below 300 m in the eastern Arabian Sea (Kusum et al. 2014). Nair et al. (2015) recorded this species from the depth layer above 1000 m in the eastern Arabian Sea during the summer monsoon.

***Eukrohnia bathypelagica* Alvaríño, 1962**

**Description.** Long ovary constitutes 30% or more in total length. In matured species, ova are arranged as two rows in the ovary. As the ovary matures, it will become coiled as it moves towards the tip. The number of ommatids in the eye is up to 100. Number of teeth ranges from 14–24. The tip of the hooks are curved (Silas and Srinivasan 1968).

**Distribution.** *Eukrohnia bathypelagica* is a bathypelagic species recorded from the north-eastern Arabian Sea during the early winter monsoon at a depth range of 500–1000 m (Kusum et al. 2011). This species was recorded from the eastern Arabian Sea during the summer, fall inter-monsoon, and winter monsoon (Kusum 2012). Kusum et al. (2014) recorded this species from the oxygen-deficient zone of the eastern Arabian Sea during the summer monsoon.

**Family: Spadellidae**

**Genus: *Spadella***

***Spadella angulata* Tokioka, 1951**

**Description.** Length of the body up to 5.8 mm. Number of hooks ranges from 8–9, Anterior teeth: 2–4 and Posterior teeth: 0–1. Intestinal diverticulum present. Five evenly spaced sensory tufts are along the midline along the dorsal side of the tail segment. Seminal vesicles extend to the lateral fin. Matured species have angular-shaped seminal vesicles, while maturing, they appear like a bulb along the tail fin. Ovary around half the length of the trunk. Tail segment has five orange-brown colored rings on the dorsal side (Bieri 1974).

**Distribution.** *Spadella angulata* has been recorded within the Kalpeni lagoon during the winter monsoon season (Nair and Rao 1973b).

## Discussion

The present checklist provides the chaetognatha recorded from the eastern Arabian Sea (northeastern Arabian Sea, southeastern Arabian Sea and Laccadive Sea). This checklist includes five families under two orders and 34 valid species belonging to 15 genera. Within the recorded Chaetognatha orders, the Aphragmophora is the most diverse order, containing about 29 species, and Phragmophora is less diverse. In this study, Sagittidae was recorded as the most dominant family, containing 11 genera. The most diverse genus was *Aidanosagitta*. Almost all of the species in this study have been recorded from both the northeastern Arabian Sea and southeastern Arabian Sea, except *Spadella angulata*, *Ferosagitta madhupratapi* and *Aidanosagitta nairi*. These species have been found only in the Laccadive Sea. In this study, some species have shown a record of endemism. *Ferosagitta madhupratapi* (Casanova and Nair 1999), *Aidanosagitta nairi* (Casanova and Nair 2002) are endemic to Laccadive Sea. Chaetognath, the phylum of glass-like invertebrates, play a significant role in maintaining the ecosystem balance and are considered as an indicator organism of various physical events. Most of the species mentioned in the content here are indicators of upwelling, *Decipisagitta decipiens*, *Eukrohnia minuta*, *E. fowleri*, *Ferosagitta ferox*, *Krohnhitta subtilis* whereas *Flaccisagitta enflata*, *Zonosagitta bedoti*, *Pterosagitta draco*, *Aidanosagitta neglecta*, *Sagitta*

*bipunctata* are indicators of receding upwelling phenomenon. Similarly, few of the chaetognaths, *Pterosagitta draco*, *Flaccisagitta hexaptera*, *Serratosagitta pacifica*, *Flaccisagitta enflata*, *Mesosagitta minima* are indicators of warm-water masses and *Zonosagitta bedoti* indicates mixing water. The knowledge of physical phenomena supported by these biological data is imperative in understanding the oceanic processes and its functioning and add-on to the data obtained through sophisticated technologies. Hence, further data will enhance the knowledge on ecology of chaetognaths associated with many physical conditions of Indian waters.

## Conclusion

The present checklist provides a detailed report on the description and distribution of phylum Chaetognatha along the Eastern Arabian Sea, putting forward a baseline data for future studies regarding the chaetognatha and its importance as an indicator species of various oceanic conditions along the Arabian Sea.

**Acknowledgements** The second author is thankful to the Council of Scientific and Industrial Research (CSIR), New Delhi, for the award of Senior Research Fellowship.

**Author's contribution** AVKX and AP wrote the manuscript with input from LCT and KBP. AVKX and AP performed the literature search and data analysis. KBP supervised this review and provided research materials. All authors read and approved the manuscript.

**Funding** Council for Scientific and Industrial Research.

**Data Availability** The manuscript has no associated data.

**Code availability** Not applicable.

## Declarations

**Conflicts of Interest** The authors have no conflict of interest.

**Ethics approval** No animal testing was performed during this study.

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