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# 4 Studies on Chaetognatha of the Indian EEZ

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***ABSTRACT***

*The Phylum Chaetognatha, the members of which are popularly known as 'arrow worms' is a holoplanktonic group found in all the oceans in the epi, meso and bathypelagic zones. The animals play a vital role in the marine food web forming food for a variety of animals and themselves feeding on a host of zooplankters. Recognising the importance of chaetognaths in the marine ecosystem, the CMFRI had taken up investigations on different aspects of these organisms to understand their role as predator and prey in the food chain. The facilities offered by several ocean going research vessels enabled us to get a comprehensive picture of the chaetognaths of our EEZ. The present paper is a digest of the work done at the CMFRI on the distribution, ecology, biology and taxonomy of the Chaetognatha of the Indian EEZ.*

## Introduction

The members of the phylum Chaetognatha form a major constituent of the tropical zooplankton and play an important role in the food web, feeding on a variety of other zooplankters and forming themselves forage for several of the higher animals. The work on Chaetognatha of the Indian seas and some of the estuaries as one of the constituents of the general zooplankton was started at the Central Marine Fisheries Research Institute from the very inception of the Institute (Prasad *et al.*, 1952; Prasad 1954; Muthu, 1955; George, 1958). The investigations by R.V. *Varuna* in the nineteen sixties were a land mark in the marine biology of the west coast of India and made it possible to carry out exclusive research on chaetognaths of the Indian seas

and consequently good amount of information became available on the distribution in space and time, ecology and biology of these animals (Silas and Srinivasan, 1968, 1969, 1970; Srinivasan, 1971 a, b, 1974). In addition, the chaetognath fauna of the southern and Antarctic Ocean was also investigated with the help of samples collected by the CMFRI during the 3rd Indian Antarctic Expedition (Srinivasan and Mathew, 1990.1992). Recently the extensive zooplankton collections made during the cruises of FORV *Sagar Sampada* have made it possible to make a study of this group in the Indian EEZ and contiguous waters (Srinivasan, 1990,1996). The present paper makes a review of the scientific information generated so far on the chaetognaths as a result of the work in CMFRI.

**Distribution in space and time**

Prasad *et al.* (1952) while making a study of the inshore plankton in the Gulf of Mannar have given the numerical abundance of chaetognaths, at six localities. Specimens at an average rate of 31 per ml of plankton were obtained, the range being 21-48. The zooplankton of the coastal waters of calicut was studied by George (1953). Three genera of chaetognaths namely *Sagitta*, *Pterosagitta* and *Krohnitta* were recorded in the plankton. According to the study *Sagitta inflata*, the most conspicuous species may be found in abundance from November to January. Its young ones were found in smaller number throughout the year with peak from December to May. *S. robusta* usually occur from January to June. *S. regularis*, a less abundant species makes its presence during November-December and during March-April. Another rare species, *Pterosagitta draco* usually occurs during the summer months of March to May. Moderate numbers of *Krohnitta pacifica* may be present from December to May.

The marine plankton of the Mandapam waters was studied by Prasad (1954) who made a short discussion on the chaetognaths. According to his study the abundance of chaetognaths as a group can be observed in the February-March period which is the post-northeast monsoon season in the area. Following this period a highly fluctuating trend may be seen. The most common species in the Mandapam area is *S. inflata*. Others such as *S. tenuis* and *S. robusta* may occur rarely.

George (1958) has studied the zooplankton of the Cochin estuary and he has specially dealt with the chaetognaths. The study resulted in the identification of three species in this estuary namely *S. Inflata*, *S. bedoti* and *S. robusta*. Making their appearance in December the chaetognath population gradually increases in January and February and starts declining from March and totally disappears by July. The variation in the population of chaetognaths in the estuary has been attributed by him to the variations in salinity.

The spatial and seasonal distribution of 14 species of chaetognaths of the southwest coast of India and Lakshadweep was studied in detail by Srinivasan (1974). The species belonged to the genera *Sagitta* (11 sp.), *Pterosagitta* (2 sp.) and *Krohnitta* (2 sp.).

As found by Srinivasan (1974) the chaetognaths in genereal are abundant in the shelf region. They are especially more during February but relatively less during June and August. *Sagitta inflata* is the most dominant species very often forming about 50% of the total chaetognath population. Maximum abundance is in the shelf waters in April and minimum in October. In the oceanic waters *S. inflata* has an almost uniform distribution throughout the year. In the shelf area where a strong seasonal variation is observed the maximum will be during the pre-monsoon (February-May) followed by monsoon (June-Septmber) and post-monsoon (October to January).

Next to *S. inflata* in abundance is *S. bedoti* which usually constitutes more than 15% of the total chaetognaths. The peak period of occurrence of this species in the shelf is during October and the least in April to August in the oceanic area.

*S. decipilus* is mostly an oceanic species with more than 80% occurring there. Along the southwest coast this species makes a movement towards the shelf by August-December period and appears in the shallow waters upto 40 m depth in October when the upwelling is at its maximum. The species prefers to dwell in waters having temperature less than $20^0$ C. Among the oceanic chaetognaths, *S. decipiens* occupies the second place in order of abundance. Contrary to the earlier views that this is rarely occurring species in the Arabian Sea, Srinivasan (1974) reported its abundant occurrence in the oceanic waters of the southwest coast and the Lakshadweep sea.

*Sagita pacifica* is the fourth abundant species along the southwest coast commonly found in the oceanic waters. It appears in the shelf region during February to April and October to December period but never comes closer to the coast within 20 m water depth. The species is usually absent north of Mangalore coast during the southwest monsoon.

*Pterosagitta draco* is also an oceanic species contributing almost 65% and the rest in the shelf waters. It seldom occurs in waters having depth less than 20 m. The species avoid the shelf area during June to October period. Its population reaches the maximum in the pre-monsoon and postmonsoon months.

Among the chaetognaths of the west coast of India *Sagitta hispida* ranks sixth in the order of abundance and is more an oceanic species. It widely occurs during the pre and postmonnsoon seasons. *Sagitta regularis* is another oceanic species with more than 75% present in the oceanic waters. They make a complete withdrawal from the shelf waters from August to October. Even if they come into the shelf waters they prefer to be away from the coastal waters.

*Sagitta ferox* is a neritic species rarely found in the oceanic waters. More than 80% of the population is present in the shelf area and the maximum abundance is in June. Another oceanic species is *Sagitta robusta* having around 90% representation there. *Sagitta pulchra* is a cosmopolitan species almost equally distributed in the shelf and the oceanic areas in all the months of the year. More than 85% of *Sagitta hexaptera* is represented in the oceanic area. While they may be present in all the months in the oceanic waters their presence in the shelf may be restricted to the period from December to April. Another species rarely found in the southwest coast is *Sagitta lyra* which is mesopelagic and exclusively oceanic.

The spatial distribution of chaetognaths as a group of the Indian EEZ has been studied by Srinivasan (1990) based on samples collected by the FORV *Sagar Sampada* from 1159 stations. The study revealed that the chaetognaths as a whole are distributed more off the west coast and attributed this to the intense upwelling along the west coast. The study indicated a general decrease from the shelf to the oceanic waters in the Arabian Sea but a reverse trend in the Bay of Bengal. This trend in the Bay of Bengal, he says,

is due to the free mixing of the Pacific waters which flows into the Bay of Bengal through the Malacca Strait during the northeast monsoon.

Based on the epipelagic zooplankton collected by the CMFRI during the Third Indian Expedition to the Antarctica, some studies were made on the distribution of Chaetognatha between Antarctica and Mauritius in a linear route covering Sub-tropical, Sub-Antractic and Antractic zones (Srinivasan and Mathew,1990). According to the study 12 species may be encountered in the southern ocean of which *Eukrohnia hamata* may be the most abundant with more than 50,000 specimens per 1000 $m^3$ of water making about 70% of the total chaetognaths. The Sub-Antarctic seems to be the most productive contributing 54% of the total chaetognaths followed by the Antractic (25%) and the sub-Tropical (21%).'

The distribution of chaetognaths in a geographical area between 67° 30' & 68° 30'N and 14° 00' & 20° 00' E in the Antarctic waters was studied by Srinivasan and Mathew (1992). The study revealed that among the zooplankters, numerically, the chaetognaths occupy the 3rd position next to copepods and fish eggs, however, with a meagre share of 1.34%.

The spatial and temporal distribution of chaetognaths of the eastern Arabian Sea was investigated by Srinivasan (1996). The region is inhabited by 13 species belonging to the genera *Krohnitta*, *Pterosagitta* and *Sagitta*. *Sagitta enflata* with a share of about 75% among the chaetognaths is the most dominant species of the area. All the other species may contribute between 0.1 and 8.5% only. The monsoon season may account for the maximum quantity of the group with more than 50% of the total, the concentration being south of 14° N where there is intense upwelling during the monsoon season. *Sagitta decipiens* though a bathypelagic species may occur in the shelf waters during the monsoon season and this may be attributed to upwelling and incursion of the cold deep oceanic waters into the shelf along with *S.decipiens*. Therefore, this species may be considered as an indicator species of coastal upwelling (Srinivasan and Mathew, 1996).

**Ecology**

The lowering of salinity conciding with a bloom of dinoflagellates can cause a sudden decline in the population of chaetognaths of a given area.

This was the finding of Muthu (1955) who studied the effect of unusual lowering of salinity on plankton of the Madras coastal waters in October 1995.

Srinivasan (1974) made a study of the day/night variation among chaetognaths of the shelf and oceanic waters separately. Among *S. inflata* and *S. bedotti* there may not be any marked difference in the occurrence during day or night in the shelf or oceanic areas. Among *S. pacifica* a more than 50% increase may be expected during the night both in shelf and oceanic waters. On the other hand among *S. deciptens* and *S. pulchra* the number of specimens obtained during the day may be greater. In species such as *S. pacifica, P. draco* and *S. hispida* more specimens can be obtained in the night collections.

In *S. regularis, S. ferox. K. pacifica* and *S. robusta* the number of specimens can be more in the night collections from the shelf area but a reverse can happen in the oceanic area. The occurrence of *S. decipiens* in relation to the environmental parameters has also been studied by Srinivasan (1974). This is a cosmopolitan mesopelagic species found in warm and temperate oceanic regions which seldom migrates to the shelf waters. The study made by Srinivasan (1974) showed that the species can come upto areas where depth to bottom is 10 m in the shelf area in October where the water temperature go down to 22°C and dissolved oxygen content to 0.3 ml/l. This made him to infer that the species follows the low oxygenated upwelled water which influxed into the shelf along the southwest coast. The southwest coast is known for strong upwelling durihg the period from June to October. The above finding by Srinivasan (1974) has helped to identify *S. decipiens* as an indicator species of water mass and its movement.

Srinivasan (1971b) made an attempt to study the ecology of cheatognaths of the Cochin backwaters. The species usually found in the estuary are *S. inflata, S. befotl* and *S. pulchra.* They may occur at a proportion of 72, 16 and 13 % respectively. *S. pulchra* may occur even during the southwest monsoon when the salinity is not too low. *S. inflata* and *S. bedotl* are more sensitive to salinity and may not occur during April to August period. Greater influx of fresh water resulting in a lowering of salinity to around 1 ppt may exclude them from the estuarine environment.

In the Cochin estuary *S. inflata* may be absent during the latter half of

the premonsoon and during the active southwest monsoon period. Their maximum abundance in the estuary may be in November. The seasonal occurrence of *S. bedoti* may resemble that of *S. inflata* but their period of abundance may be from January to March. The pattern of occurrence of *S. pulchra* may be different from the other two species being more abundant in May and June.

**Biology**

In the Cochin backwaters, according to Srinivasan (1971), while *S. inflata* may be totally absent during the April to August period their maturity stage I and II may be ecountered during September and October. All maturity stages (I-IV) may occur during November to January. However, in February and March stage-0 may be absent indicating no breeding in the estuarine environment. In *S. bedoti* the April to August period may account for nil population while immature specimens (0-II) may be encountered during September to January. March may be the month when all the maturity stages of this species may occur in the plankton. Stage-0 may be seldom found in the estuary which would indicate that the breeding of *S. bedoti* takes place in more offshore areas and that the specimens when they enter the estuary may have passed the stage-0. With regard to *S. pulchra*, Srinivasan (1971) found that their adult specimens occurred in stray number in May only.

One interesting thing observed by Srinivasan (1971) was that the mean lengths of all the maturity stages in the estuarine environment for *S. inflata* was considerebly less when compared to those collected from the marine environment. This led him to conclude that the *S. inflata* population is distinctly separate from that in the marine environment and there is a resident population in the estuary. However, in such a case it would be pertinent to ask one question as to where do they go in the April to August period? It would be more appropriate to think that all the stages of the species are brought into estuary by the tidal effect and once they arrive, the stress due to the extreme variations in the environment might slow down the growth rate resulting in a reduction in average length of all maturity stages. According to Kinnie (1964) marine organisms exhibit reduction in final size in areas of their distribution where the salinity is significantly reduced.

In the marine environment all the marutity stages (0-IV) of *S. inflata*

have been reported by srinivasan (1974) to be present throughout the year which indicated the protracted breeding among this species. Among *S. bedoti* all the maturity stages are obtained in all months except April and June. This species is also a protracted breeder especially in the shelf waters. In the oceanic waters the fully mature specimens are rarely found.

According to Srinivasan (1974) *S. decipiens* is also a continuous breeder and all maturity stages could be found in all the months. Among *S. pacifica* immature stages are usually found except during June to October period. From December to April all stages of maturity of *S. hispida* are encountered in the shlef waters whereas in the oceanic waters they occur from June to August. In *S. regularis* all the maturity stages may occur in the shelf waters in all the above months and in June. All the stages of maturity of *S. ferox* may be found in June only that too in the shelf area and in the other months immature specimens may be encountered. In *S. robusta* and *S. hexaptera* all the maturity stages could be expected in the ocanic area only.

**Systematics**

Although Chaetognatha is a well defined group with all the known species well described, occasionally disputes have arisen regarding the validity and correct identity of certain species. This has been true in the Indian waters also. One such dispute existed among scientists as to the validity of *Sagitta bombayensis* (Lele and Gary) which was thought to be a synonym of *S. robusta* (George, 1949) or *S. regularis*. *S. bombayensis* was first described from Bombay harbour and subsequently from Lawsons Bay, Waltair. However, George (1949) who examined specimens of the species from the Bombay harbour area established that *S. bombayensis* was a synonym of *Sagitta robusta*. He compared and contrasted the various morphological characters in the two species.

Later Silas and Srinivasan (1968) collected zooplankton from the Bombay harbour in 1966 for obtaining topotypes of *S. bombaynsis* to enable a redescription of the species as well as for a taxonomic appraisal of it. The collections made possible to re-establish the species and to obtain a graded series (5 maturity stages) of the species.

The study by Silas and Srinivasan (1968) includes illustrated descrip-

tion of morphological features of five stages of the species in comparison with those of *S. robusta* and *S. regularis*. Comparison was also made with the reproductive organs such as testes and ovary, the hooks and teeth on the head and other morphometric and meristic characters. The authors felt that geographical variations occur in the species, giving rise to localised differences in morphometric and meristic characteres from area to area. The study revealed that the abundance as noticed by Silas and Srinivasan (1969) of chaetognaths namely *S. inflata, S. bedotti* and *S. bombayensis* in the Bomaby harbour was of the same order as it was noticed by Lile and Gay some 30 years before which indicated that little change might have occurred to the ecosystem of the harbour area.

Silas and Srinivasan (1968) described a new species namely *Eukrohnia minuta* from the southwest coast and the Lakshadweep Sea. A total of 798 specimens of the species were obtained from 31 deep water plankton samples made during the cruises of R.V. *Varuna*. The species is amply described and illustrated. The species could be identified by the slender nature of the body which is opaque and firm due to strong wavy longitudinal muscles, robust tail segment with distinct constriction at the tail septum, closely placed minute pigmentless eyes with less that 20 ommatidia, 7-9 jaw hooks with almost straight tips, 8-14 teeth, conspicuously broad, pigmented intestine whose anterior width is more than 35% of width of body, large ventral ganglion, intestine and body with numerous oil droplets, inconspicuous colerette, short and straight ovary with tips never curled and mature ova arranged in simple row, inconspicuous seminal vesicle covered by thickening of epidermis and separated from origin of tail fin by wide gap.

Silas and Srinivasan (1968) have also described in detail three more deeepwater chaetognaths namely *Eukrohnia fowleri, Sgitta lyra and S. hispida* and studied their occurrence and abundance in space and time.

Another significant achievement in the study of chaetognaths of the Indian seas was the first time record from the southwest coast of two species of bathypelagic chaetognaths namely *Sagitta macrocephala* Fowler and S. (prox.) *maxima* (Conant) which were thought to be absent north of 30° 00' S. These species have been described, ilustrated in detail, compared and contrasted with closely allied species.

An elaborate study of the systematics of chaetognaths of the Indian Ocean was carried by Silas and Srinivasan (1970). They could identify 33 species, belonging to five genera namely *Sagitta*, *Pterosagitta*, *Knohnitta*, *Eukrohnia* and *Spadella*. Also they have prepared a key for the identification of chaetognath species.

The foregoing acount shows that substantial information have been generated on the distribution, ecology and biology of chaetognaths, an important consituent of the marine zooplankton of the Indian EEZ which play a mjor role in the food web. However, majority of the work was concentrated towards the couthwest coast and Lakshadweep seas. More work needs to be done on the spatial and seasonal distribution, and on the ecology and biology in the entire EEZ so that the knowledge on their role in the food web would be further widened.

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