

THE ECOLOGY OF CHAETOGNATHS IN THE ESTUARINE SYSTEM OF GOA

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ABSTRACT

Incidence, seasonal fluctuations and breeding of chaetognaths in the Mandovi-Zuari estuarine system were studied at twelve stations during the year 1971 to 1972. Chaetognaths constitute an immigrant fauna from the sea to the estuary and salinity appears to be the major factor controlling their distribution in the estuarine system. At the stations close to the mouth, where annual variations in salinity were relatively less, they were found throughout the year, with maximum abundance from January to May. Towards the upper reaches, chaetognaths were absent during the monsoon period. Even though species diversity was greater at Mandovi estuary quantitatively, Zuari estuary, on the other hand, sustained a greater abundance of chaetognaths. Possibly the more marine conditions prevailing in the Zuari estuary could sustain a higher density of chaetognaths.

Of the six species encountered in the estuaries, *Sagitta bedoti* alone could be considered as a true inhabitant of this estuarine system. *S. enflata* was found during the period of relatively high salinity. *Pterosagitta draco*, *S. ferox* and *S. robusta* were accidental immigrants associated with the incursion of high salinity water into the system. *S. pulchra* was caught only in the first week of June. *S. bedoti* breeds throughout the year with three peak periods of heavy spawning.

INTRODUCTION

Although chaetognaths form an important constituent of neritic and oceanic plankton, estuaries can sustain them in appreciable quantity only during certain months (Nair, 1975). Mainly neritic species are found to thrive well in the estuaries during the relatively high saline period. Thus, their presence in the estuary is indicative of the salinity regime. In addition to that, when present they form a significant part of the carnivore population, thereby playing an important role in the estuarine ecosystem.

Chaetognaths from a few estuaries of India have been studied earlier. Rao (1962) reported on chaetognaths off Kakinada and Chandramohan (1963) from the Godavari estuary of the east coast of India. Chaetognaths from the Cochin backwaters have been investigated by George (1958), Nair (1971 and 1973), Srinivasan (1971) and Madhupratap and Haridas (1975). There is no detailed report on chaetognaths from the estuaries of Goa and hence this study on the incidence of chaetognaths, their seasonal fluctuations and breeding in the Mandovi-Zuari estuarine system was taken up.

Table I. Average values of salinity (‰) at different stations during the period June 1971 to May 1972.

Month	Station											
	*1 (5)	2 (7.7)	3 (10.9)	4 (15.5)	5 (27.3)	6 (32.1)	7 (20.2)	8 (17.7)	9 (14.3)	10 (11.5)	11 (7.8)	12 (4)
June	4.07	1.19	1.01	0.30	0.12	0.68	0.12	0.39	1.30	1.96	3.53	5.30
July	6.01	6.83	2.28	1.14	0.36	0.31	0.49	1.32	1.79	5.76	10.97	12.59
August	3.96	3.30	4.74	0.84	0.14	0.24	1.93	2.23	2.70	4.64	10.39	15.80
September	25.39	20.82	13.60	5.01	2.45	5.20	8.59	12.25	16.50	19.07	21.78	24.06
October	31.44	25.99	14.76	7.76	4.91	10.99	16.74	19.50	21.27	23.55	28.88	28.52
November	31.61	26.95	18.62	12.62	10.18	18.49	25.42	29.15	31.35	31.92	33.71	34.41
December	33.14	32.00	29.77	21.79	19.19	25.31	27.90	30.85	30.40	31.29	31.10	32.85
January	32.31	31.83	30.94	25.51	21.58	26.93	28.99	30.05	30.32	30.41	31.30	32.62
February	34.17	32.12	29.16	24.18	21.39	27.90	31.16	32.20	32.17	32.46	32.67	33.39
March	34.01	30.44	29.14	27.49	26.04	30.98	34.17	34.41	34.48	34.46	34.85	35.17
April	35.00	35.16	34.23	31.86	30.09	35.48	35.94	35.31	35.70	35.81	35.77	35.58
May	35.67	35.83	35.61	33.51	32.32	36.37	36.29	36.52	36.38	36.34	36.61	36.14

* Approximate distance (km) of each station from the corresponding mouth.
Stations 1 to 6 from Mandovi and 12 to 7 from Zuari.

MATERIAL AND METHODS

Zooplankton samples were collected from June 1971 to May 1972 from twelve stations in the Mandovi–Zuari estuarine system. Station locations are shown in Fig. 1-

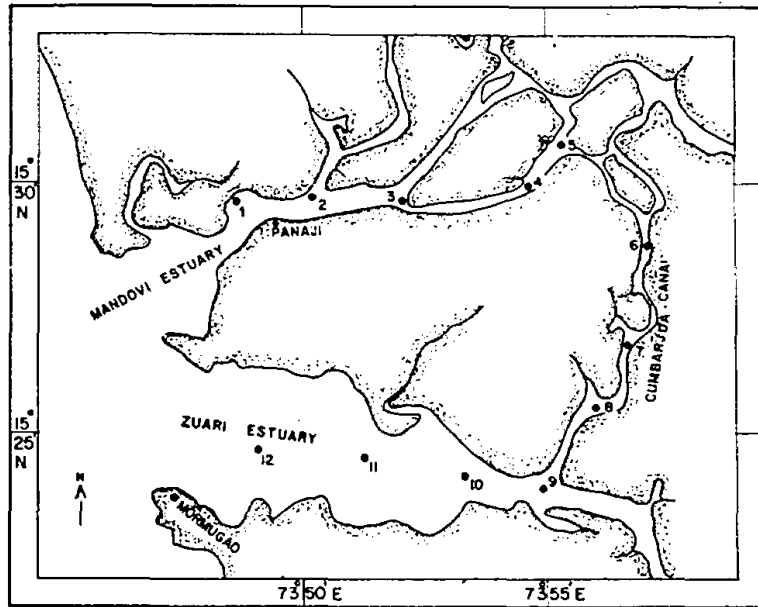


Fig. 1. Location of stations.

Fortnightly samples were taken from the surface using a HT net having a mouth area of 0.25 m^2 and a mesh width of 0.3 mm . The volume of water filtered was measured by using a flowmeter. The chaetognaths from these collections were analysed for numerical abundance of different species and their stages of maturity were noted. The estimated mean density of chaetognaths for the different months is expressed as $\text{no./}100 \text{ m}^3$. The samples taken in the first week of June were just before the onset of the monsoon when salinity was fairly high, and hence chaetognaths were represented throughout the system. By about the middle of June monsoon was fully established and chaetognaths started disappearing from stations located towards upstream (stations 4–9). June is considered as a monsoon month for seasonal studies and so the values from the later collections alone were represented in the graph.

For studying the stages of maturity of chaetognath species they were grouped into three stages: (i) *Juveniles* – The primitive germ cells have not started developing. (ii) *Developing* – Testes in different stages of development and may or may not fill the tail. Ovaries developing, ova small. (iii) *Mature* – Tail empty. Ovaries further developed. A few or all ova fully developed.

The incidence of juveniles or mature specimens of a particular species in the collections is considered as a measure of the reproductive phase of the population.

RESULTS

Hydrography

The mean surface salinity for the different months is given in Table I. According to the hydrographical conditions, three seasons are recognised in the area under study – the monsoon period of very low salinity (June to September), post monsoon period of rising and fluctuating salinity (October to January) and premonsoon period of high

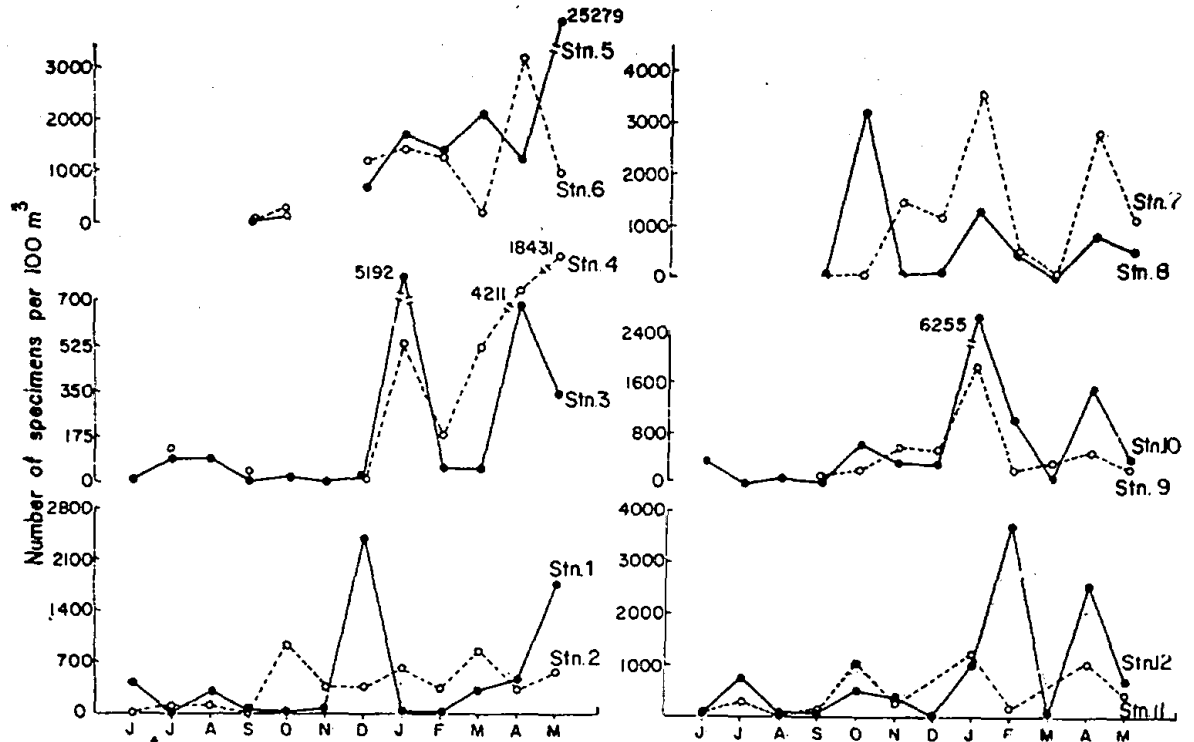


Fig. 2. Seasonal fluctuations in abundance of *S. bedoti* at different stations in the Mandovi-Zuari estuarine system.

salinity (February to May). There was well defined gradient in salinity from stations located near the mouth towards the corresponding stations occupied upstream, particularly during the monsoon and post monsoon periods. Salinity values decreased from station 1 towards 5 with a maximum difference of 26.53‰ in October and from station 12 towards 6 with a maximum difference of 18.86‰ in September (Table I). The width of the mouth of Mandovi is approximately 3.2 km and that of Zuari is about 4.9 km. The average depth at the midstream of Mandovi is reported as 7 m and that of Zuari 8.5 m (Cherian, Rao and Varma, 1975; Varma, Rao and Cherian, 1975). In general, salinity values at the stations in the Zuari estuary were relatively higher than those at the corresponding stations at Mandovi. Much riverine discharge and lesser width at the mouth area of the Mandovi contribute to the relatively low salinity recorded from this estuary. Tidal influence is also more at Zuari estuary than at Mandovi estuary. In Cumbarjua Canal, salinity values were higher than that at stations 4 & 5, possibly by the influence of Zuari estuary (Das, Murty and Varadachari, 1972). The estuarine system changed from a stratified type during monsoon to a well mixed uniform type in premonsoon (Cherian, Rao and Varma, 1975; Varma, Rao and Cherian, 1975). Variations in the temperature of surface water were normal for a tropical estuary with maximum in May (31.9°C) and minimum during January (25°C). Oxygen values did not differ appreciably (3.02 to 5.93 ml/l) during the period of study, but the values were relatively higher during monsoon period than during post monsoon and premonsoon seasons.

Seasonal fluctuations of chaetognaths

Six species were found in the collections. They were *Pterosagitta draco*, *Sagitta bedoti*, *S. enflata*, *S. ferox*, *S. pulchra* and *S. robusta*. The dominant species in the

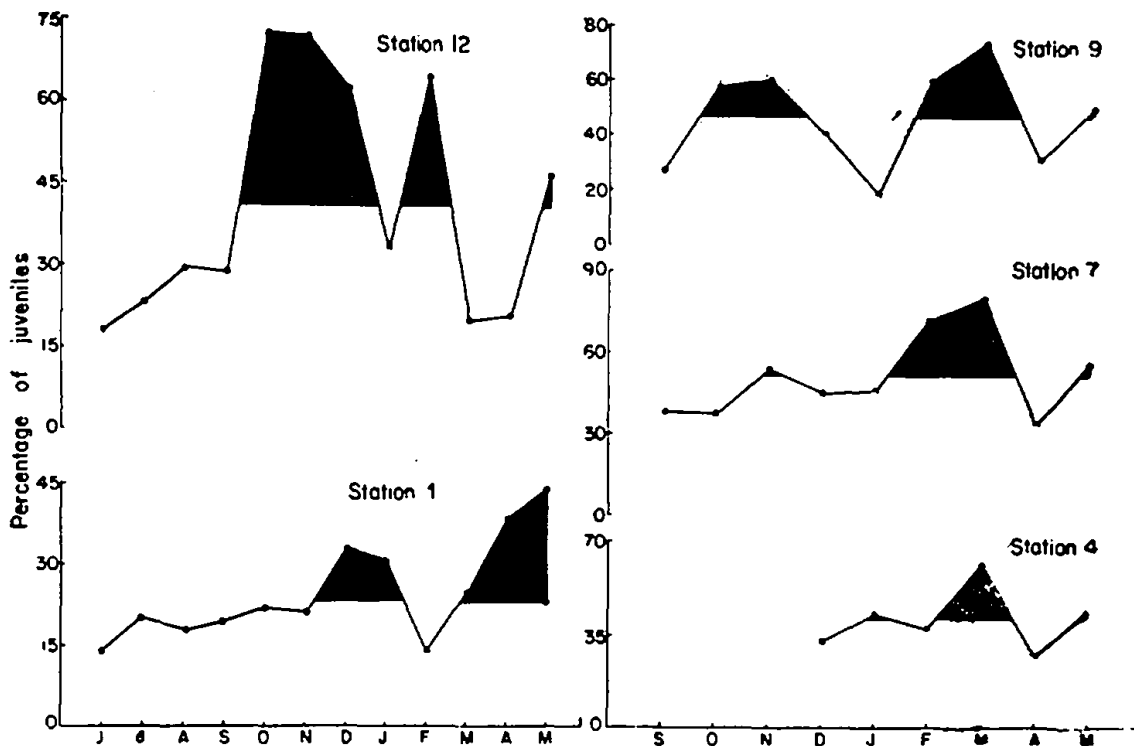


Fig. 3. Variations in the percentage distribution of juveniles of *S. bedoti* at selected stations in the Mandovi-Zuari estuarine system. Darkened areas indicate values above the mean percentage.

estuarine system was *S. bedoti*. *S. enflata* was encountered in the samples occasionally and all the other species were found restricted to the premonsoon period of high salinity.

Sagitta bedoti Beraneck : At all the stations this was the dominant chaetognath (Fig. 2). The species is euryhaline and was found at stations 1 to 3 and 12 to 10 throughout the year with peaks during the post monsoon and premonsoon periods. Stations 4 to 9 sustained this species only from September to May except for their incidence in July at station 4. During the first week of June just before the heavy showers they were encountered in all the samples and later at the end of June they were present only at stations 1 to 3 and 12 to 10. At stations 4, 5 and 6, maximum abundance was noticed during April/May. The post monsoon months (October and January) showed the highest peaks for *S. bedoti* at stations 7, 8 and 9. Maximum density observed was 25279/100 m³ from station 5 in May.

Considering the number of juveniles in the population as the index of breeding, the percentage variations of juveniles was calculated for *S. bedoti*. Variations in the abundance of juveniles of the species at selected stations representing the mouth of the estuary, head of the estuary and the Cumbarjua Canal (Fig. 3) indicate periods of heavy and light spawning. Periods of abundance of juveniles above the estimated mean percentage is taken as periods of heavy spawning. This would indicate occurrence of 2 to 3 periods of intense breeding in estuarine system. At station 1 major peak was observed during the premonsoon period while at station 12, maximum breeding was noticed in the post monsoon months. Two intense spawning periods were observed during the premonsoon period and a single peak during the post monsoon period at

Table II. Incidence of *S. enflata* and rare species in the Mandovi-Zuari estuarine system. Density indicated as no./100 m³.

Month	Stations											
	1	2	3	4	5	6	7	8	9	10	11	12
	<i>S. enflata</i>											
December	668	193	16		84							
February	4											4
April	140	16	105									
May	346	146	75					264			15	28
June (1st week)	36	4										
	<i>S. pulchra</i>											
June (1st week)	182		6					16	26			
	<i>S. robusta</i>											
May												20
	<i>S. ferox</i>											
April	3											
May	8											
	<i>P. draco</i>											
April	2											
May	4											

stations 4, 7 and 9. The general pattern of breeding indicated the presence of more juveniles in Zuari estuary. The conditions of breeding from station 12 to 9 seemed to occur with some time lag.

Sagitta enflata Grassi : This species was second in abundance. Occurrence of the species at different stations is shown in Table II. They were more common at Mandovi estuary than at Zuari estuary. *S. enflata* occupied the estuarine system during the relatively high saline period from December to the first week of June, particularly at stations towards the mouth of the estuary.

Sagitta robusta Doncaster : Stray individuals of this species were found in the collections taken from the mouth of Zuari estuary in May.

Sagitta pulchra Doncaster : This species was found only during the first week of June from four stations (Table II).

Pterosagitta draco (Krohn) and *Sagitta ferox* Doncaster : These typical oceanic species were recorded from the mouth of Mandovi during April and May when salinity was very high.

DISCUSSION

In an estuarine habitat chaetognaths generally constitute an immigrant population from the sea. Eventhough the tropical estuary is considered to maintain wider range of species (Emery and Stevenson, 1957) the present findings confirm the previous report (Nair, 1971) that *S. bedoti* alone could be considered as a true inhabitant of Indian estuaries. Occurrence of truly marine species *P. draco*, *S. ferox* and *S. robusta* associated with high salinity may also suggest the influx of oceanic water into the system. The overall picture indicates that species diversity was more at Mandovi estuary whil

quantitative abundance of chaetognaths was more at Zuari estuary. Species recruitment to the estuarine system is dependent on the types of species present in the incoming waters. It seems the more marine conditions prevailing in the Zuari estuary could sustain a higher density of chaetognaths.

Being a tropical estuary temperature fluctuations were not significant enough to check the survival of these organisms. Food supply seldom acts as a limiting factor in a tropical estuary and does not seem to govern the seasonal abundance (Qasim, 1970). Hence salinity appears to be the major factor controlling the incidence of these organisms. From the year round observations on the distribution of chaetognaths two distinct regions could be identified in the estuarine system. At stations located towards the mouth of the estuary (1 to 3 and 12 to 10) fluctuations in salinity were relatively less than at stations towards the head of the estuary and Cumbarjua Canal (stations 4 to 9). This difference in salinity was directly reflected in the distribution of *S. bedoti*. Towards the mouth of the estuary, *S. bedoti* was found throughout the year while at other regions the species was absent from June to August. It appears that during the monsoon period they may be removed from the area (stations 4 to 9) and the region seems to be repopulated by fresh individuals from the sea along with the incoming waters of the post-monsoon period. It was reported earlier (Nair, 1975) that chaetognath fauna of the Cochin backwaters are transients that are periodically recruited from the open sea.

Breeding cycles of *Sagitta* vary with geographical location and the number of generations produced each year generally increases with distance from poles towards equator (Owre, 1960 and Alvarino, 1965). In tropical waters most of the species breed throughout the year with marked peak breeding periods (Owre, 1960; Rao and Kelly, 1962; Nair, 1973). Rao and Kelly (1962) found nine separate broods for *S. enflata* in Lawson's Bay. In the present observation juveniles were found throughout the year and two to three distinct peak spawning periods were observed.

The number of adults caught in the present collections was never sufficient to produce such high density of juveniles. Young ones of *S. elegans* were often reported to appear in more superficial layers than do the adults (Russell, 1931). When the gonads mature the increase in weight may result in sinking of adults to deeper layers (Alvarino, 1964). This may account for the lower number of adults caught from the present collection from the surface water.

In the estuarine area around Kakinada, Rao (1962) found discontinuous distribution of *S. enflata* and *S. bedoti* with their absence from March to April. At the Cochin backwaters (Nair, 1971 and Srinivasan, 1971) and Zuari-Mandovi estuarine system depending on the proximity towards the mouth of the estuaries chaetognaths may or may not be present during the monsoon period. The common species found in all these estuaries are identical. However, the oceanic species present during the period of high salinity varied because incidence of these species is dependent on the fauna of the incoming waters.

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