

# BREEDING AND GROWTH OF CHAETOGNATHS IN THE COCHIN BACKWATERS

VIJAYALAKSHMI R. NAIR

Indian Ocean Biological Centre, National Institute of Oceanography, Cochin-18

## ABSTRACT

Studies on the breeding and growth of the common chaetognath species inhabiting the Cochin backwaters were made. Regular fortnightly collections were taken from two fixed stations during the year 1968. *Sagitta bedoti* Béranec and *S. enflata* Grassi were the common species found in the estuary. Breeding is continuous in this tropical estuary and periods of heavy spawning are superimposed on continual spawning. The coincidence of the peak periods of chaetognaths and high density population of copepods are evidence of the acceleration of breeding with abundant food supply. The scarcity of adults in the samples is attributed to their preference for deeper layers. The annual length variations of different maturity stages of *S. bedoti* and *S. enflata* indicate great overlapping. However, in the same sample there is definite relationship between size of the individual and maturity upto stage II.

## INTRODUCTION

Published information relating to the breeding cycles of *Sagitta* indicates that these cycles appear to vary with geographical location. The number of generations produced each year generally increases with distance from poles (Dunbar, 1941; Owre, 1960 and Ghirardelli 1968). In the Arctic, *S. elegans arctica* (Dunbar, 1941) and in the subantarctic *S. gazellae* (David, 1955) produce one brood per year. There are two spawning periods during spring and summer with a possible third in October in the North Sea (Wimpenny, 1937). In the Irish Sea *S. elegans* breeds in one long period (Pierce, 1941). Russell (1932 a, b) records 4 - 5 broods in the Plymouth area. Clark *et al.* (1943) found a major spawning in spring and another in late summer in Georges Bank. Off the west coast of Florida (Pierce, 1951) and off Miami, (Owre, 1960) many of the tropical oceanic species breed throughout the year.

However, little is known about the breeding of chaetognaths from the Indian Waters. Rao and Kelly (1962) have given an account of the breeding of *S. enflata* in Lawson's Bay. They found the species to breed almost throughout the year with several periods of intense breeding. Recent studies of Srinivasan (1971) on the chaetognaths of the Cochin Harbour area also indicate continuous breeding of *S. enflata*.

In the present investigation attempt was made to study the breeding and growth of the common

chaetognath species occurring in the Cochin backwaters, an estuary connected to the Arabian Sea. An assessment of the chaetognath fauna inhabiting this estuary and their seasonal fluctuations have already been studied (Vijayalakshmi, 1971). The incidence of juveniles or mature individuals of a particular species in regular plankton collections is taken as a measure to evaluate the reproductive conditions of the population.

## ENVIRONMENT

The Cochin backwaters is part of a long chain of lakes and canals extending into the north and south of Cochin parallel to the coast in central Kerala. This is a tidal estuary and the conditions in the area are influenced both by the sea and by the freshwater influx which is considerable during the monsoon period. The hydrographical pattern characteristic of this area has been investigated by previous workers (Ramamirtham and Jayaraman, 1960, 1963; Qasim and Gopinathan, 1969 and others).

## MATERIAL AND METHODS

The material is from the fortnightly collections from two fixed stations, one at Fairway Buoy (lat. 09°57' N and long. 76°10'E) and the other at Aroor (lat. 09°54' N and long. 76°17'E) during the year 1968. The stations are shown in fig. 1. The samples were taken from surface hauls of five minutes duration with a HT net (Tranter *et al.*,

1972). The details of the collections are given by Menon *et al.*: (1971).

Chaetognaths from these collections were examined for stages of maturity and each species was separated into five stages based mainly on the works of Colman (1959) and Alvarifio (1967).

- |           |     |  |
|-----------|-----|--|
| Juveniles | ... | Testes and ovaries have not started developing.  |
| Stage I   | ... | Testes visible, but no sperm ball or spermatozoa free in the tail coelom. Ovaries small. |
| Stage II  | ... | Tail filled with spermatozoa. Ovaries developing. Ova small.                             |
| Stage III | ... | Tail empty. Ovaries reaching a further step in their develop-                            |

ment, and filled with large and small ova, some of which are full size.

Stage IV ... Tail empty. All ova fully developed.

For indicating the frequency of different stages during the course of the year, the five stages were reduced to four categories i. e. juveniles, stage I, Stage II and Stage III + IV. The stages III and IV were combined into one category since they include individuals whose ovaries contained at least some mature eggs plus individuals which are fully mature and will be referred as Stage III + in the text. These two stages formed a very small percentage of the total chaetognath population and when combined, they had a better representation, more clarity and little accuracy lost.

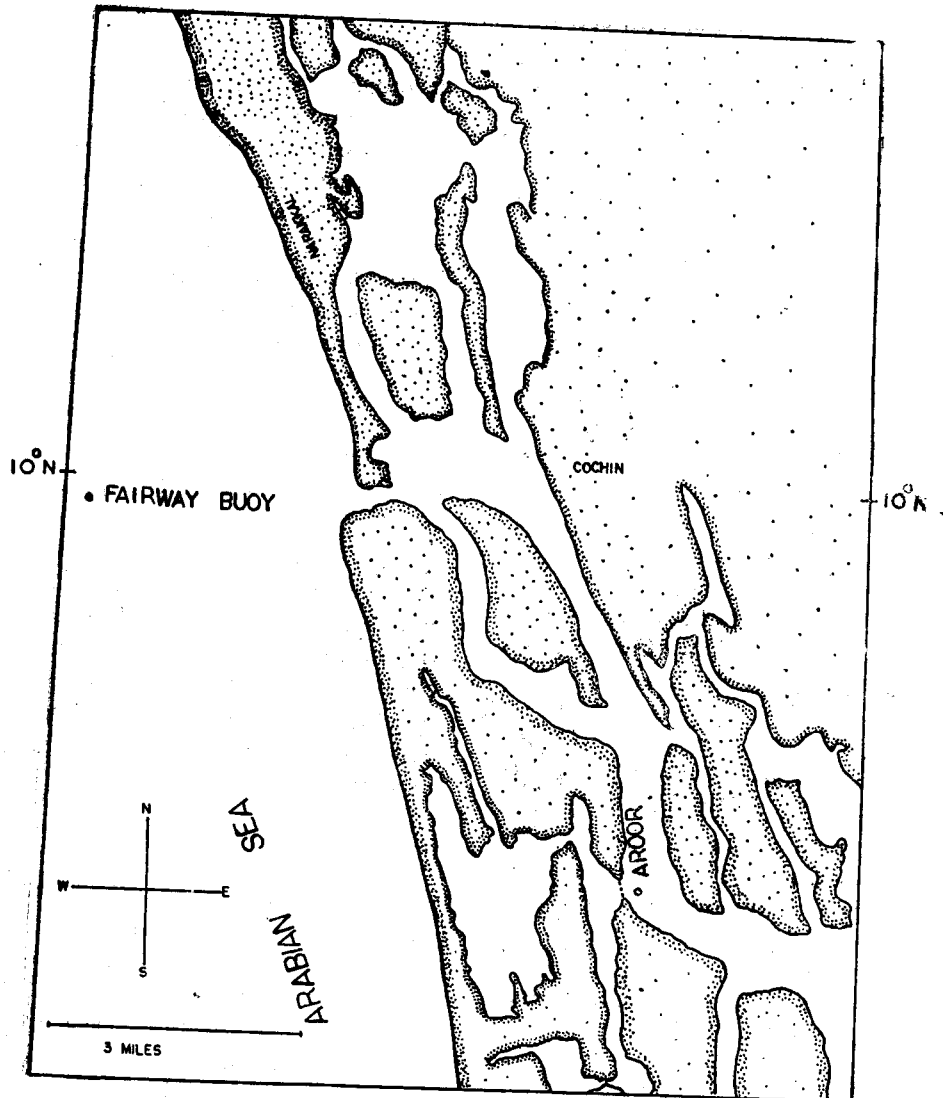


Fig. 1. Map of the Cochin backwaters showing the location of stations.

For the study of length distribution of different maturity stages, the total length, i. e. the distance from the anterior extremity of the head to the tip of the caudal segment excluding the caudal fin was measured. The values recorded are average measurements of 5-10 largest individuals of a particular stage in each sample.

## OBSERVATIONS

The two stations, namely Aroor and Fairway Buoy were found to be under different hydrographical conditions. The salinity of the Aroor region varies from that of fresh water to practically that of sea water during the course of the year. In general the later part of June to November is the period of low salinity (0.4 to 22.2‰) and December to May of high salinity (27.2 to 32.8‰). Fairway Buoy area is also influenced by monsoon cycle having low salinity water during the southwest monsoon period (11.6 to 21.5‰). These salinity variations had consequently affected the abundance and seasonal fluctuations of chaetognath population at the two locations (Vijayalakshmi, 1971).

Temperature of the water was almost constant at both the stations throughout the year except for a slight decline during the southwest monsoon period.

Four species were encountered in the collections, the species being *Krohnitta pacifica* Aida, *Sagitta bedoti* Béranek, *Sagitta enflata* Grassi and *Sagitta robusta* Doncaster. Of these *S. bedoti* was found to occur more or less constantly in the Cochin backwaters, while *S. enflata* was a frequently occurring species (Vijayalakshmi, 1971). The other two species were rare in the collections and hence no attempt was made to study their breeding periods.

In these collections, mature individuals of *S. bedoti* and *S. enflata* were found to be rare and hence juveniles had been considered as an index to the breeding.

### Breeding of chaetognaths at Aroor

Aroor is typically estuarine with a complete turnover of saltwater into fresh water and chaetognaths were found only during the period (December to early June) of relatively high salinity.

#### *S. bedoti*

Variation in the abundance of different maturity stages for *S. bedoti* is represented in Fig. 2A.

The peak occurrence of the different maturity stages coincided with the later part of February, the number of specimens for each category being 347/100m<sup>3</sup> for juveniles, 2798/100m<sup>3</sup> for Stage I, 121/100m<sup>3</sup> for Stage II and 5/100m<sup>3</sup> for Stage III+. This was followed by a small peak of juveniles during April to early May and this seems to be the young ones of mature individuals encountered in the later part of March. The second peak period for stage I was in the latter part of May.

Although breeding is continuous fluctuations in the relative abundance of juveniles should indicate periods of high and low spawning. The percentage variation of juveniles of *S. bedoti* is shown in Fig. 2B. The mean percentage of juveniles considered as the level at, and above which abundance indicates a period of heavy spawning. This assumption indicates the occurrence of three such periods of heavy spawning in the middle of January, middle of February and April to early May.

#### *S. enflata*

Fig. 2 C. shows two peak periods of juveniles, one in the latter part of December and the other in February. The other categories were only very sparsely represented. No attempt was made to find the periods of heavy spawning as they were poorly represented in the samples.

### Breeding of chaetognaths at Fairway Buoy

A perusal of the hydrographical data at the time of collection reveals the existence of three different water masses at Fairway Buoy. From late October to May, diluted Arabian Sea Surface water prevailed, having a salinity range of 29.5-33.0‰ and temperature 28.8-32.6°C. In July surface water was of low salinity (18.0‰) and of relatively low temperature (25.4°C). During early September, upwelled cold (25.7°C) water was present, but the salinity was still lower (13.4‰) due to run off from land. These upwelled waters in July and September may or may not be the result of the same upwelling movement. So, unlike the single population existing at Aroor, different populations are bound to occur at different times at Fairway Buoy. The life cycle of the species was found to be correlated with the presence of different water masses.

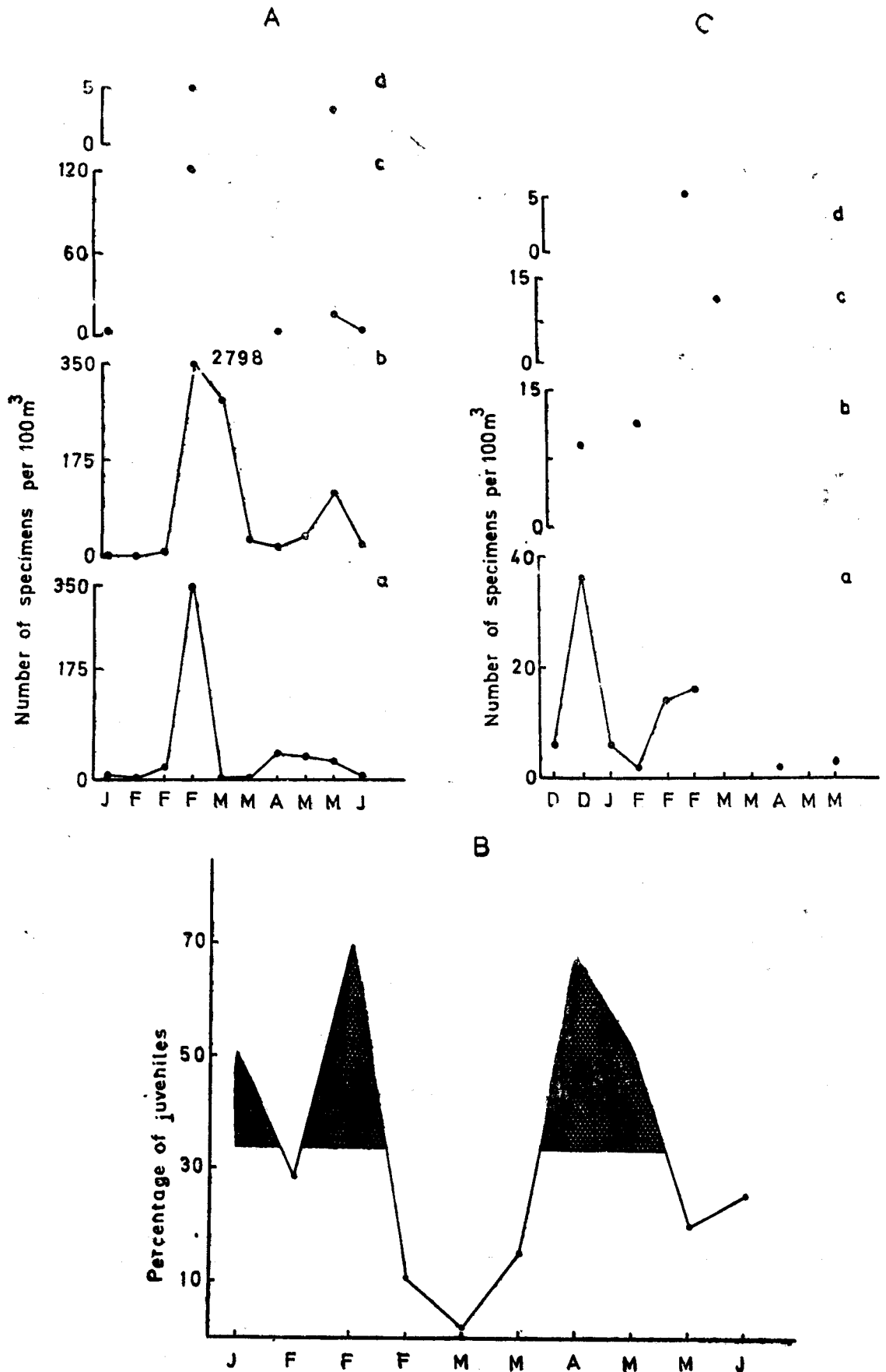


Fig. 2. A Variation in the abundance of *S. bedoti* at Aroor.

a - juveniles  
b - stage I

c - stage II  
d - stage III +

C. Variation in the abundance of *S. enflata* at Aroor.

a - juveniles  
b - stage I

c - stage II  
d - stage III +

B. Variation in the percentage distribution of juveniles of *S. bedoti* at Aroor. Darkened areas indicate values above the mean percentage.

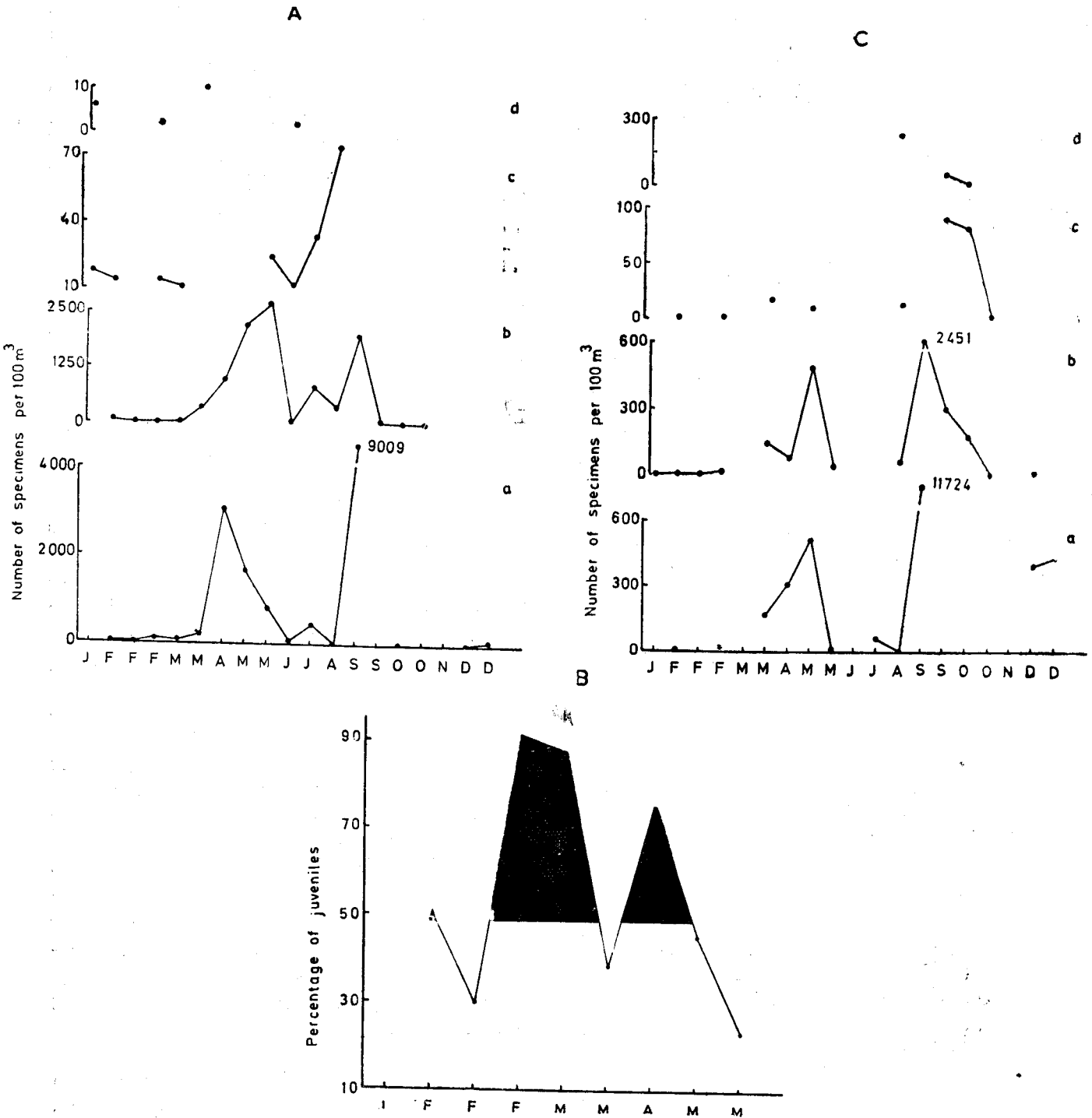


Fig. 3. A. Variation in the abundance of *S. bedoti* at Fairway Buoy.  
 a - juveniles  
 b - stage I  
 c - stage II  
 d - stage III +

B. Variation in the percentage distribution of *S. bedoti* at Fairway Buoy. Darkened areas indicate values above the mean percentage.

C. Variation in the abundance of *S. enflata* at Fairway Buoy  
 a - juveniles  
 b - stage I  
 c - stage II  
 d - stage III +

### *S. bedoti*

Three peak spawning periods were observed for this species (Fig.3A.) From January through May a single population was present. The peak for juveniles in April may be the result of intense spawning in January to March as indicated by the presence of individuals with mature ova all through this period. Low population density of *S. bedoti* during June was correlated with lowering of salinity (21.5 ‰) caused by the influx of water from the estuary. During July along with the presence of upwelled waters small peaks in the abundance of juveniles, Stage I and Stage II were observed. The maximum abundance of the juveniles (9009/100m<sup>3</sup>) and the third peak for Stage I were noticed during early September. The three peaks of juveniles do not represent the same population but the existence of different water masses. The second and third peaks may refer to the same upwelled waters as stated above.

Mature individuals belonging to category III+ were not found from July to December.

Variation in the percentage distribution of juveniles for the period January to May when a single population existed is shown in Fig.3B. The juveniles showed two or probably three periods of heavy spawning in early February, late February to the middle of March and April. No attempt was made to study the periods of heavy spawning from July onwards since different water masses seem to exist during this period.

### *S. enflata*

Fig. 3 C reveals a more or less similar pattern of abundance for *S. enflata* as has already been discussed for *S. bedoti*. There was a single population from January to May which had intense breeding from January to March resulting in the peak during April to early May. A second small peak was seen in July followed by the third and the maximum abundance during early September (number of juveniles being 11724/100m<sup>3</sup>). Unlike *S. bedoti* a conspicuous peak abundance of juveniles was observed in December. Stage III + specimens were occasionally collected from August onwards. Even though the peak occurrence of juveniles is clearly evident from April to early May, the discontinuity of juveniles in the collection prevents an attempt to find the periods of heavy spawning.

An analysis of the stomach content of chaetognath in this backwater shows that copepods (mainly *Acartia* and *Oithona*) form the major food item. A comparison of the chaetognaths with the total number of copepods (Menon *et al.* 1971) during the different months (Table I) is made. It is interesting to note the coincident occurrence of high chaetognath population with that of the peak abundance of copepods. At Aroor maximum abundance of chaetognaths was found in February to March coinciding with the high population density of copepods during this period. Fairway Buoy showed the maximum values for chaetognaths during April, May and September when copepods were also abundant.

### Length variation

The length variation of different maturity stages of *S. bedoti* and *S. enflata* at Aroor is represented in Fig. 4 A and that at Fairway Buoy is shown in Fig. 4 B. In each collection the average value for the maximum size attained by different stages of a particular species is represented in the graph. The salinity and temperature variations for the two localities are also shown in the figures.

At Aroor both *S. bedoti* and *S. enflata* (juveniles and Stage I) showed variation in the length attained at the different stages during the period of collection. The Maximum size attained for *S. bedoti* was in later part of February when temperature and salinity values were 32.6 °C and 29 ‰ and in second half of May when the temperature and salinity at the time of collection were 32.2 °C and 30 ‰ respectively. *S. enflata* had the highest observed size for juveniles in late December (temperature 30.4 °C and salinity 28.2 ‰) and for Stage I in early February (temperature 31.0 °C and salinity 28.9 ‰).

At Fairway Buoy when a single population existed from January to May, the maximum size attained for *S. bedoti* was in early February (temperature 29.8 °C and salinity 31.5 ‰) and for *S. enflata* in early May (temperature 29.8 °C and salinity 33.0 ‰). However, the maximum size attained for the two species was in August when temperature was 29 °C and salinity value was relatively low (16.8 ‰).

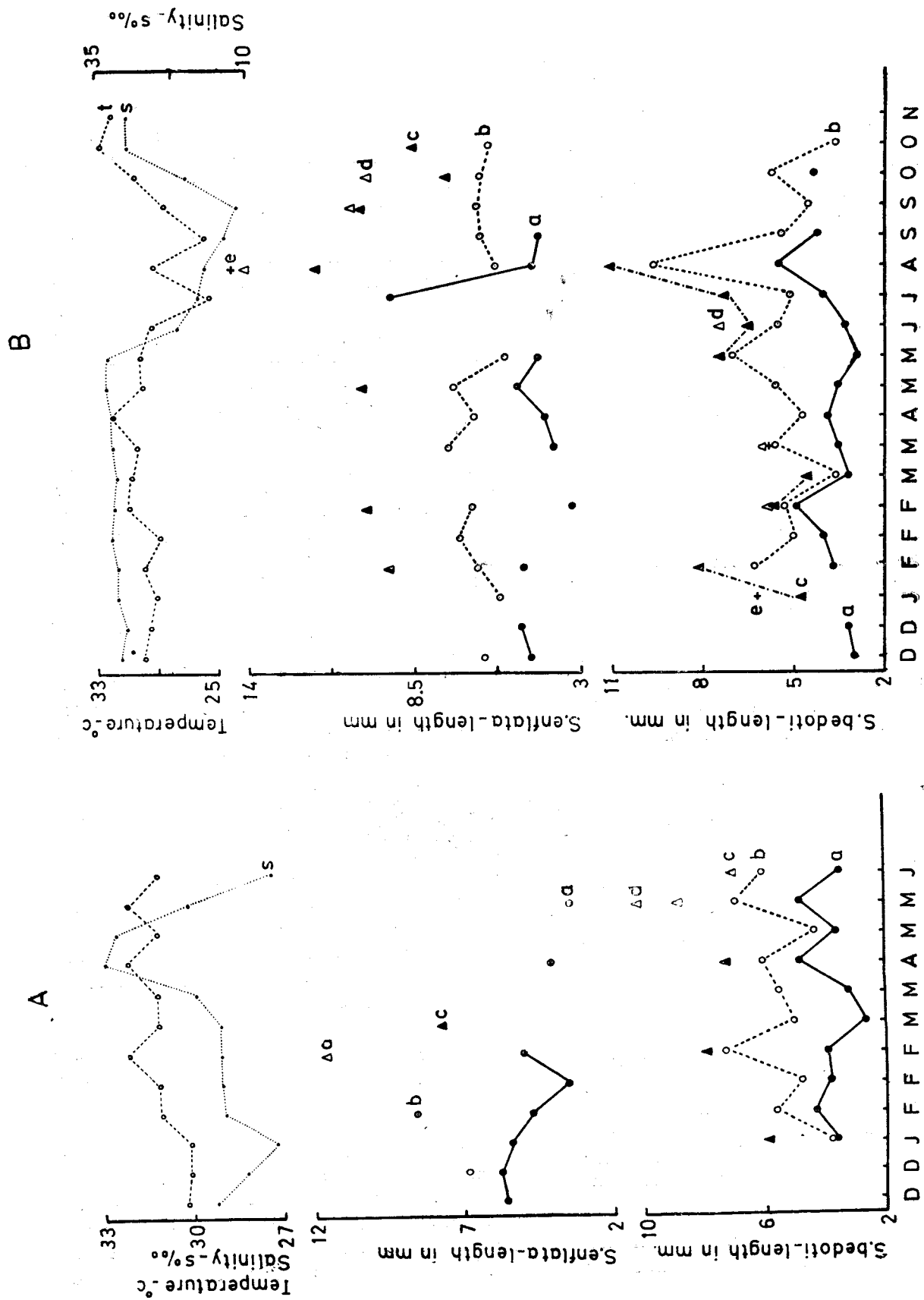


Fig. 4. A. Length variation of chaetognaths at Aroor.  
 a - juveniles  
 b - stage I  
 c - stage II  
 d - stage III  
 s - salinity  
 t - temperature

B. Length variation of chaetognaths at Fairway Buoy.  
 a - juveniles  
 b - stage I  
 c - stage II  
 d - stage III  
 s - salinity  
 t - temperature

Table I

Average number of Chaetognatha and Copepoda at Aroor and Fairway Buoy during the year 1968.

Month	Aroor		Fairway Buoy	
	Chaetognatha (no/100 m <sup>3</sup> )	Copepoda (no/100 m <sup>3</sup> )	Chaetognatha (no/100 m <sup>3</sup> )	Copepoda (no/100 m <sup>3</sup> )
January	17	171100	24	90200
February	1121	97800	122	46200
March	175	303600	501	21700
April	80	41400	4765	469500
May	129	55800	4311	101100
June	20	20100	129	45900
July	..	30100	1378	87600
August	..	16600	777	351400
September	..	28500	12843	399300
October	..	8600	141	25800
November	..	297200	...	31900
December	44	116900	474	101900

## DISCUSSION

In general, the estuarine fauna is constituted of relatively few species but their numerical representation will be large (Emery *et al.*, 1975). The tropical estuary is believed to support a much wider range of species (Emery *et al.*, 1957); however *S. bedoti* and to a certain extent *S. enflata* alone are able to tolerate these estuarine conditions. *S. bedoti* seems to be eurythermal and euryhaline.

In an estuarine habitat, with an environment of changing hydrographical conditions salinity is the most important physical factor that governs the existence of organisms. This is especially significant in the Cochin backwaters, where on account of the seasonal monsoon, rapid changes in salinity were noticed at Aroor and salinity continued to be at low level from late June to November. So during this period chaetognaths disappeared from Aroor and the area was repopulated when salinity increased during December to a level which is tolerant to the organism. Fairway Buoy is located outside the estuarine system, about 4.8 km. north of barmouth. Unlike the Aroor region, Fairway Buoy is an area dominated by marine conditions. During the periods of low salinity the upwelled water mass seems to maintain the chaetognath population.

Occurrence of juveniles in most of the collections suggest that breeding is continuous in

tropical waters, a fact which has already been emphasised (Owre, 1960; Rao and Kelly, 1962). Rao and Kelly (1962) found nine separate broods for *S. enflata* in Lawsons' Bay. As Owre (1960) stated "it is difficult to recognize separate broods and follow them through maturity because the periods of heavy spawning are superimposed in what appears to be continual spawning throughout the year". Such peak periods of heavy spawning were seen thrice for *S. bedoti* at Aroor. At Fairway Buoy from January to early June, three periods of heavy spawning were noticed. Even though the data are not sufficient to make definite conclusions it can be presumed that the young population of chaetognaths are steady having distinct periodicity in their peak occurrence. The examination of the male and female gonads of the two species shows a tendency to be protandrous.

The frequency of adults was noticeably small in relation to the juveniles and the number of adults found was never sufficient to produce such high density of juveniles. All these collections were from the upper strata, leaving the deeper 5-6 metres without sampling. The adults may be aggregating in deeper layers while the juveniles ascend to surface waters. There is indication in the literature of the mature specimens of chaetognaths going to deeper layers during breeding periods (Mackintosh, 1937; David, 1955). The scarcity of adults in the present samples may also be due to the preference of adults to deeper layers.

Size at maturity is exceedingly variable and length is considered to be a poor indicator of any stage of development. The annual range of each stage for a particular species will greatly overlap. Nevertheless, in the same sample there is definite relationship between the size of the individual and maturity upto Stage II (Fig.4 A and B). After Stage II the maturity stages may or may not have a correlation with size.

Only limited information is available on the growth rates of chaetognath and the factors affecting this. The investigations of Russell (1932a,b) and Clark *et al.* (1943) deal with the effect of temperature on growth and size at which maturity is attained. Being a tropical estuary, temperature variations are relatively insignificant in this habitat. Even though salinity variations are well marked there is no significant correlation between length and salinity. The maximum size attained during



the period of low salinity in July and August at Fairway Buoy is an exception and this may be due to the presence of another population.

The high population density of chaetognaths at particular months indicates the presence of a high standing stock of plankton, since it can sustain an abundant population of highly predaceous carnivorous animals like chaetognaths. Chaetognaths mainly feed on any small animal of suitable size with which they come in contact in the plankton. Copepods being the commonest element of the zooplankton naturally they form the most frequent prey (Vijayalakshmi and Rao, in press). Investigations of Reeve (1966) on the feeding habits and food availability of *S. hispida* from Miami show definite indications of the relationship of *Sagitta* to its food supply. He found that increase in the *Sagitta* population was associated with the incidence of copepods and barnacle nauplii in the water. In the present samples also there is a relationship between the maximum abundance of chaetognaths and dense populations of copepods. This coincidence of the peak periods of chaetognaths and copepods indicates the probability of chaetognaths coming in pursuit of the prey. The availability of abundant food along with other factors favoured intense breeding during February to March at Aror and April to May and September at Fairway Buoy.

### ACKNOWLEDGMENTS

The author is grateful to Dr. N. K. Panikkar, Director, National Institute of Oceanography for providing facilities at the Indian Ocean Biological Centre. Thanks are also due to Dr. T. S. S. Rao and Dr. M. Saraswathy, Indian Ocean Biological Centre for critically going through the manuscript and offering suggestions.

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