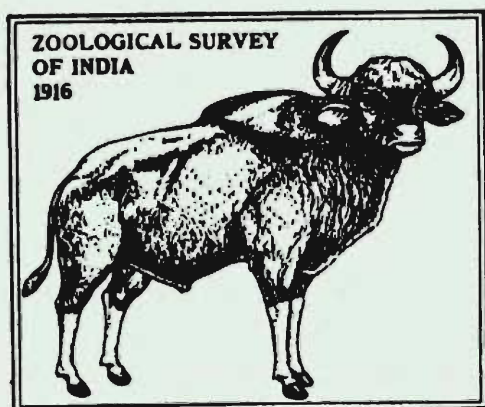


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Organisms of Watermasses**

by,

M. SRINIVASAN



**ZOOLOGICAL SURVEY
OF INDIA**

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TAXONOMY AND ECOLOGY OF CHAETOGNATHA OF THE WEST COAST OF INDIA IN RELATION TO THEIR ROLE AS INDICATOR ORGANISMS OF WATERMASSES

BY

M. SRINIVASAN

*Zoological Survey of India
Southern Regional Station, Madras*



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Pages 1-47

CONTENTS

	<i>Page</i>
INTRODUCTION	1
ACKNOWLEDGEMENTS	1
TAXONOMY OF CHAETOGNATHA	1
LIST OF SPECIES REPORTED FROM WEST COAST OF INDIA	2
KEY TO THE SPECIES	3
DESCRIPTION OF SPECIES	6
<i>Sagitta bedoti</i>	6
<i>Sagitta bipunctata</i>	8
<i>Sagitta bombayensis</i>	9
<i>Sagitta decipiens</i>	11
<i>Sagitta fevox</i>	13
<i>Sagitta hexaptera</i>	14
<i>Sagitta hispida</i>	16
<i>Sagitta inflata</i>	18
<i>Sagitta lyra</i>	20
<i>Sagitta macrocephala</i>	21
<i>Sagitta maxima</i>	23
<i>Sagitta minima</i>	24
<i>Sagitta neglecta</i>	26
<i>Sagitta pacifica</i>	27
<i>Sagitta pulchra</i>	29
<i>Sagitta regularis</i>	31
<i>Sagitta robusta</i>	32
<i>Pterosagitta draco</i>	34
<i>Krohmitta pacifica</i>	36
<i>Krohmitta subtilis</i>	37
<i>Eukrohnia fowleri</i>	39
<i>Eukrohnia minuta</i>	41
POSSIBLE USE OF CHAETOGNATHS AS INDICATOR ORGANISMS	43
REFERENCES	46

INTRODUCTION

The phylum Chaetognatha including in it the popularly known "Arrow-worms", forms an important group of carnivorous planktonic organisms, except the species of the genus *Spadella* which are benthic inhabitants. Studies on chaetognaths attracted the attention of biologists and oceanographers, in view of their close relationship with particular types of watermasses. In spite of the importance of this group as one of the major constituents of the marine plankton, playing a vital role in the food chain, a comprehensive account on the description of individual species, their ecology and the possibility of using them as indicators of watermasses and their movements is lacking and hence an attempt is made here to involve all these aspects.

The Phylum Chaetognatha includes about 70 species so far known from the Oceans of the world and of these, the 24 species known from the Indian seas are reported from the West Coast of India. Of these 24 species, 2 species belong to the genus *Spadella* are benthic, the rest 22 are pelagic and in this account all these pelagic species are described. Brief notes are provided on the ecology of individual species, and the possibility of using certain species as indicator of watermasses and their movements are also discussed.

In the description of individual species, all the important morphometric characters such as, total length, tail length, anterior fin length, posterior fin length, position of the ventral ganglion, position, shape and structure of the seminal vesicles, ovary length, arrangement of ova, position and shape of collarete, if present, shape and structure of the eyes and meristic characters such as prehensile hook, anterior teeth, and posterior teeth that are useful in the identification of the species are described in detail.

ACKNOWLEDGEMENTS

My sincere thanks are due to Dr. T. N. Ananthakrishnan, Director, Zoological Survey of India for suggesting the problem and encouragement and to Dr. A. G. K. Menon, Deputy Director, Southern Regional Station, Zoological Survey of India for the facilities offered and keen interest shown in this work.

TAXONOMY OF CHAETOGNATHA

It is very difficult to establish the correct phylogenetic position for chaetognaths. There are differences of opinion regarding the inclusion of chaetognaths in the major invertebrate phyla such as Mollusca, Annelida, Nematoda and Brachiopoda. The chaetognaths resemble the annelids in certain aspects such as the nervous system, and coelom, but differ in the absence of segmentation, excretory and circulatory systems. As the form and structure of the nervous system of chaetognaths resembles those of molluscan type, it was considered to be related to Mollusca. In one or two characters, the chaetognaths resemble other animals of the groups such as Annelida, Nematoda, Mollusca, Brachiopoda, Echinodermata, Hemichordata and Chordata. As stated by Ghirardelli (1968), the fact that chaetognaths may show affinities or resemblances to such widely separated groups may actually prove that, there is no real affinity to any one of these groups. So, chaetognaths enjoy a separate phyletic rank in the animal kingdom.

Tokioka (1965) has proposed a new classification for the Phylum Chaetognatha as given below:

Phylum CHAETOGNATHA (Leuckart, 1894)

Class 1. ARCHISAGITTOIDEA

Family 1. AMISKWIIDAE (Genus *Amiskwia*)

Class 2. SAGITTOIDEA

Order PHRAGMOPHORA

Family 1. SPADELLIDAE (Genus *Spadella*)Family 2. EUKROHNIIDAE (Genera, *Eukrohnia*, *Heterokrohnia* & *Bathyspadella*)

Order 2. APHRAGMOPHORA

Suborder 1. CTENODONTINA

Family 1. SAGITTIDAE (Genus *Sagitta*)Family 2. PTEROSAGITTIDAE (Genus *Pterosagitta*)

Suborder 2. FLABELLODONTINA

Family 1. KROHNITTIDAE (Genus *Krohnitta*)

This new classification of dividing the Phylum into classes, orders, suborders and families in the conventional way has not been well received and accepted by other Taxonomists and the general opinion is that as this is a small group with only 70 known species, this need not be necessarily divided into classes, orders, families, as it is usually done for other Phyla.

As stated by Alvarino (1967), the highest rank, which might be used in grouping the integrants of this Phylum is that of *genus*. Furthermore, the species included in each of the genera are separated by means of slight differences in the position of various morphological structures, which are very closely related to each other. Therefore any other systematic division of this Phylum would be quite arbitrary (Alvarino, 1967). Dr. Colman has also opined the same (Personal communication). So here, the classification proposed by Tokioka (1965) is not followed and the Phylum Chaetognatha is divided into Genera.

LIST OF SPECIES REPORTED FROM WEST COAST OF INDIA

- Genus I. *Sagitta* Quoy and Gaimard, 1827
1. *Sagitta bedoti* Beraneck, 1895
 2. *Sagitta bipunctata* Quoy and Gaimard, 1827
 3. *Sagitta bombayensis* Lele and Gae, 1936
 4. *Sagitta decipiens* Fowler, 1905
 5. *Sagitta ferox* Doncaster, 1903
 6. *Sagitta hexaptera* d'Orbigny, 1834
 7. *Sagitta hispida* Conant, 1895
 8. *Sagitta inflata* Grassi, 1881
 9. *Sagitta lyra* Krohn, 1853
 10. *Sagitta macrocephala* Fowler, 1905
 11. *Sagitta maxima* (Conant, 1896)

- 12. *Sagitta minima* Grassi, 1881
- 13. *Sagitta neglecta* Aida, 1897
- 14. *Sagitta pacifica* Tokioka, 1940
- 15. *Sagitta pulchra* Doncaster, 1903
- 16. *Sagitta regularis* Aida, 1897
- 17. *Sagitta robusta* Doncaster, 1903

Genus II. *Pterosagitta* Costa, 1869

- 18. *Pterosagitta draco* (Krohn, 1853)

Genus III. *Krohnitta* Ritter Zahony, 1910

- 19. *Krohnitta pacifica* (Aida, 1897)
- 20. *Krohnitta subtilis* (Grassi, 1881)

Genus IV. *Eukrohnia* Ritter Zahony, 1909

- 21. *Eukrohnia fowleri* Ritter Zahony, 1909
- 22. *Eukrohnia minuta* Silas and Srinivasan, 1969

Genus V. *Spadella* Langerhans, 1880

- 23. *Spadella angulata* Tokioka, 1951
- 24. *Spadella cephaloptera* (Busch, 1861)

KEY TO THE GENERA AND SPECIES OF CHAETOGNATHA OF WEST COAST OF INDIA

1. Two pairs (Anterior and Posterior) of lateral fins present (<i>Sagitta</i> , Quoy and Gaimard)	2
— Only one pair of lateral fin present (<i>Eukrohnia</i> , Ritter Zahony <i>Krohnitta</i> Ritter Zahony <i>Pterosagitta</i> Costa and <i>Spadella</i> Langerhans)	18
2. Collarette absent	3
— Collarette present	8
3. Eyes with pigmented region (Fig. 1-C)	4
— Eyes without pigmented region (Fig. 1-B)	<i>Sagitta macrocephala</i> Fowler
4. Fin-bridge present connecting the two lateral fins	5
— Fin-bridge absent and the two lateral fins are free from one another	6
5. Tail segment occupies 16 to 19% of the animal; anterior lateral fin commences behind the level of ventral ganglion; Caudal fin bifurcated into two equal oval lobes	<i>Sagitta lyra</i> Krohn
— Tail segment occupies 24 to 25% of the animal; anterior lateral fin commences at the level of the middle region of ventral ganglion; Caudal fin not bifurcated	<i>Sagitta maxima</i> Conant
6. Small species; total length never exceeds 10 mm. Intestinal diverticula present; anterior lateral fin originates behind the level of ventral ganglion; ova arranged in one row; ova are few (3 to 4)	<i>Sagitta minima</i> Grassi
— Large species; grows upto 40 mm. Intestinal diverticula absent; anterior lateral fins originates far behind the ventral ganglion; ovary long and ova are arranged in three rows	7

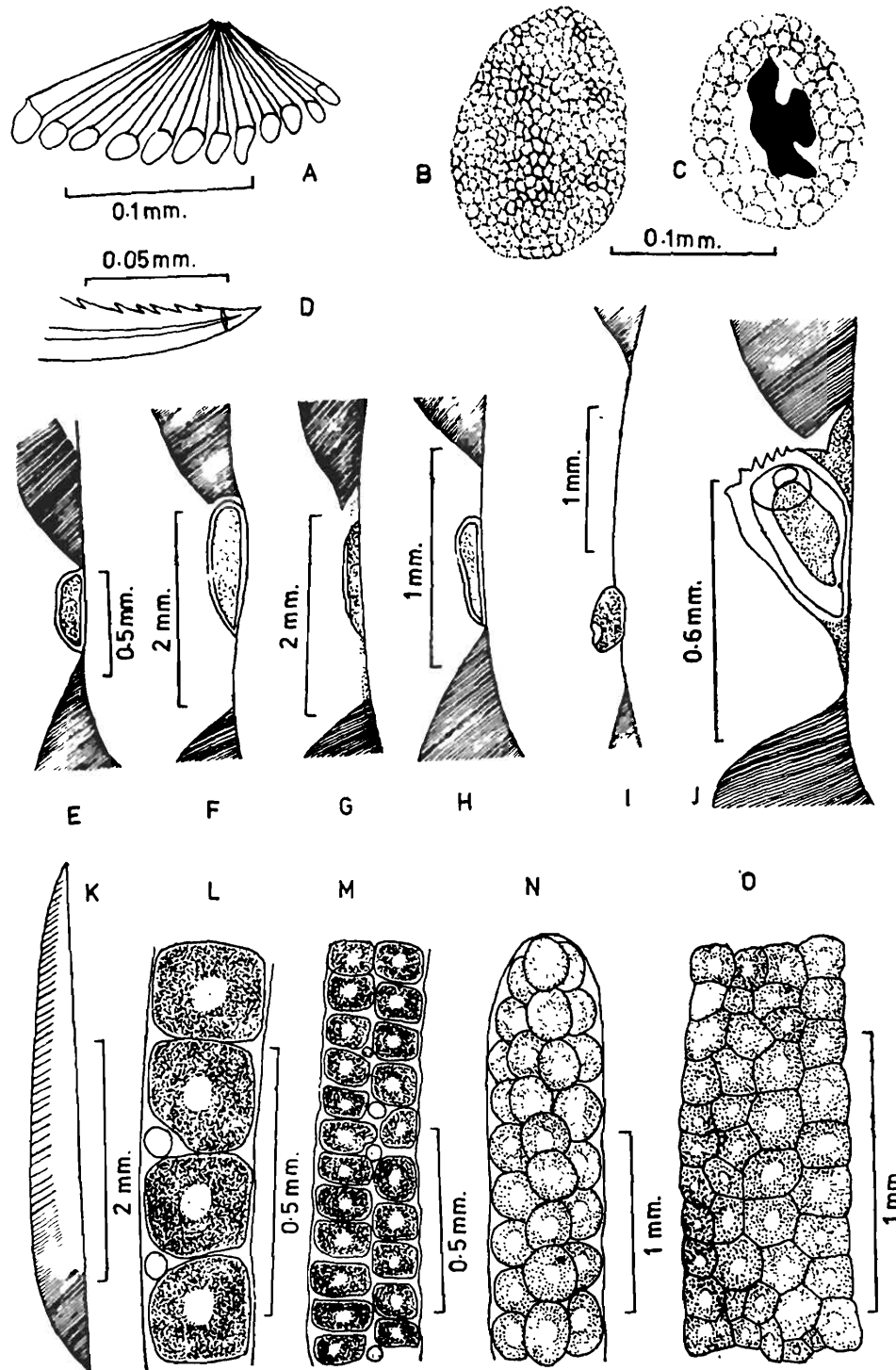


Fig. 1. A. Arrangement of teeth in *Krohnitta subtilis*; B. Unpigmented eye (*S. macrocephala*); C. Pigmented eye (*S. robusta*); D. Portion of a serrated hook (*S. pacifica*); (E-J). Seminal vesicles: E. touching both the lateral fins and tail fin (*S. bedoti*); F. touching posterior lateral fins (*S. hispida*); G. closer (not touching) to posterior lateral fins (*S. zetesios*); H. touching tail fin (*S. pulchra*); I. closer to tail fin (*S. hexaptera*); J. with chitinous teeth (*S. pacifica*); K. Anterior fin without fin rays along inner margin (*S. pulchra*); (L-O). Arrangements of ova: L. in one row (*S. robusta*); M. in two rows (*S. ferox*); N. in three rows (*S. inflata*); O. in four rows (*S. lyra*).

7. Maximum size 25 mm; anterior lateral fin more than 80% of tail segment; seminal vesicles touch caudal fin; anterior teeth 4 to 8; posterior teeth 4-13; ovary not surpass anterior lateral fins *Sagitta inflata* Grassi
- Maximum size 40 mm; anterior lateral fins less than 80% of tail segment; seminal vesicles separated from caudal fin

	by a gap equal to its length; anterior teeth 2 to 6; ovary surpasses the anterior fins	...	...	...	<i>Sagitta hexaptera</i> d'orbigny	9
8.	Concave inner margin of hooks without serrations	...	...	...	...	9
—	Concave inner margin of hooks with fine serrations	...	...	...	<i>Sagitta pacifica</i> Tokioka	
9.	Seminal vesicles touching both the posterior lateral and caudal fins	...	...	...	...	10
—	Seminal vesicles touching either the posterior lateral or caudal fins or apart from both the lateral and caudal fins	...	...	...	...	13
10.	Intestinal diverticula present; Collarette well developed extending from head to tail; ova arranged in one or two rows	...	...	...	...	11
—	Intestinal diverticula absent; collarette short, seen only at neck region; ova arranged in three rows	...	...	...	<i>Sagitta bedoti</i> Beraneck	
11.	Collarette seen as a thick layer from head to ventral ganglion, and spreads as a thin layer throughout the body; posterior teeth 10 to 15; hooks, 5 to 8	...	...	...	...	12
—	Collarette seen as a thick layer from head to the middle of posterior lateral fin, more or less of uniform width throughout; posterior teeth 18-23; Hooks 9 or 10	...	...	...	<i>Sagitta bombayensis</i> Lele and Gae	
12.	Anterior fin shorter than posterior fin and originates behind the level of ventral ganglion; ova arranged in one row	...	...	...	<i>Sagitta robusta</i> Doncaster	
—	Anterior fin longer than posterior fin; originates at the middle region of ventral ganglion; Ova arranged in two rows	...	...	...	<i>Sagitta ferox</i> Doncaster	
13.	Seminal vesicles touch the caudal fin and separated from posterior lateral fin by a wide gap	...	...	...	...	14
—	Seminal vesicles touching the posterior lateral fin or close to the posterior lateral fin and away from the caudal fin by a wide gap	...	...	...	...	16
14.	Epiplanktonic species; Intestinal diverticula absent; posterior teeth 8 to 16	...	...	...	...	15
—	Mesoplanktonic species; Intestinal diverticula present; posterior teeth 10 to 12	...	...	...	<i>Sagitta decipiens</i> Fowler	
15.	Lateral fins fully rayed; anterior lateral fin shorter than posterior lateral fin; ova arranged in one irregular row	...	...	...	<i>Sagitta bipunctata</i> Quoy and Gaimard	
—	Lateral fins rayed only along the outer margin; anterior lateral fin twice longer than posterior lateral fin; ova arranged in three rows	...	...	...	<i>Sagitta pulchra</i> Doncaster	
16.	Matured specimens less than 8 mm in length; collarette extends from head to tip of the tail; hispid condition is not conspicuous	...	...	...	...	17
—	Matured specimen range between 8 and 12 mm; collarette extends from head to ventral ganglion; hispid condition conspicuous	...	...	...	<i>Sagitta hispida</i> Conant	
17.	Collarette seen as a thick covering from the tip of head to tail; seminal vesicle elongate; posterior teeth 2 to 6; anterior teeth 2-4; hooks 7-11	...	...	...	<i>Sagitta regularis</i> Aida	
—	Collarette seen as a thin layer from head to tail; seminal vesicles roundish; posterior teeth 9-18; anterior teeth, 5-7	...	...	...	<i>Sagitta neglecta</i> Aida	
18.	Tail segment more than 50% of the animal (<i>Spadella</i>)	...	...	...	...	19
—	Tail segment less than 45% of the animal	...	...	...	...	...
					... (<i>Pterosagitta</i> , <i>Eukrohnia</i> , <i>Krohnitta</i>)	20
19.	Lateral fins begin at the posterior part of trunk and extends upto the seminal vesicles	...	...	...	<i>Spadella angulata</i> Tokioka and Pathansali	
—	Lateral fins begin at tail septum and extend to Caudal fin covering the seminal vesicles	...	...	...	<i>Spadella cephaloptera</i> (Busch)	
20.	Tail segment less than 38% of the animal; head with only one set of teeth on either side; Collarette absent at the neck region; lateral fins seen on the trunk and tail segments	...	...	...	... (<i>Eukrohnia</i> , <i>Krohnitta</i>)	21

	Tail segment 42 to 45%; head with 2 sets of teeth on either side; collarette massive from head to seminal vesicles; lateral fins confined to tail segment	<i>Pterosagitta draco</i> (Krohn)	
21.	Collarette totally absent; teeth arranged in the shape of a triangle; lateral fins originate at the middle region of the animal; epiplanktonic species (<i>Krohnitta</i>) ... ..	...	22
—.	Collarette present either at the ventral ganglion region or at the tail septum and tail fin region; teeth arrangement is normal; lateral fins originate behind the ventral ganglion region; meso or bathy planktonic species	(<i>Eukrohnia</i>)	23
22.	Tail segment 30–32% of the animal; ovarian tubes are long and extend to ventral ganglion; lateral fins triangular and not very broad	<i>Krohnitta pacifica</i> (Aida)	
—.	Tail segment 35–38% of animal; ovarian tubes are short and not extend beyond the lateral fins; lateral fins are broad and semicircular	<i>Krohnitta subtilis</i> (Grassi)	
23.	Collarette present as a thick band at ventral ganglion region; tail segment is 22 to 27% of the animal; grow up to 23 mm; bathy planktonic species	<i>Eukrohnia fowleri</i> Ritter-Zahony	
—.	Collarette absent at ventral ganglion region; but seen at the origin of caudal fin; tail segment constitutes 27–35% of the animal; grows upto only 12 mm; mesoplanktonic species...	<i>Eukrohnia minuta</i> Silas and Srinivasan	

DESCRIPTION OF SPECIES

Genus *Sagitta* Quoy and Gaimard, 1827

Species of this genus are characterised by the presence of two pairs of lateral fins and 2 sets of teeth on either side of the head.

Sagitta bedoti Beraneck, 1895

(Fig. 2)

Lele and Gac, 1936; Pillai, 1944; George, 1952; Silas and Srinivasan, 1968, 1969, 1970; Nair, 1972, 1973; Srinivasan, 1972, 1976; Nair and Rao, 1973; Rao and Nair, 1973.

Size.—Total length (including the tail fin) of the specimens varies between 7 and 13.0 mm and the estuarine forms are smaller in size (Srinivasan, 1972).

Body.—The body is long, slender and opaque. The longitudinal muscles are strong and hence the shape of the body is maintained. Intestinal diverticula are absent.

Head.—The head is small and differentiated from the body by a well defined neck. A thin collarette is seen from the head region extending to the origin of the anterior lateral fins.

The number of prehensile hooks varies from 6 to 8, anterior teeth range between 7 and 13 and the posterior teeth vary from 18 to 26.

Eyes.—The eyes are spherical, and have a star shaped pigmented region at the center.

Tail segment.—The tail segment is narrow, conical, measures from 23 to 25% of the total length and the constriction at the tail septum is not marked.

Ventral ganglion.—This is situated at the origin of the anterior lateral fins.

Anterior lateral fins.—The origin of the fins is at the level of the ventral ganglion. They are longer and narrower than posterior lateral fins. The inner most region are rayless and the posterior part is wider than the anterior region.

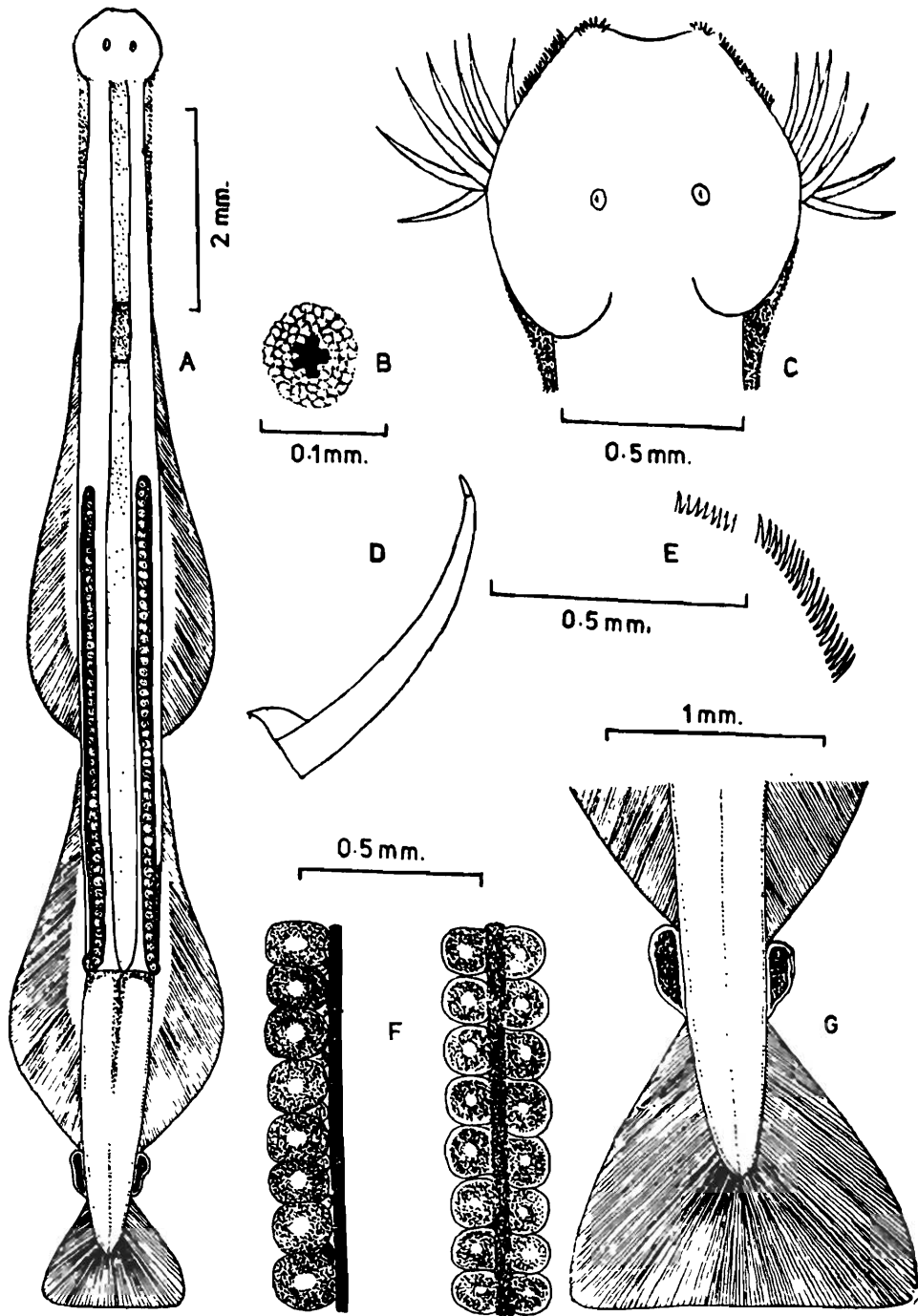


Fig. 2. *Sagitta bedoti*—A. Dorsal View; B. Eye; C. Head; D. Hook; E. Anterior and posterior teeth; F. Dorsal and lateral views of the ovary; G. Posterior region of tail segment.

Posterior lateral fins.—The origin of the posterior lateral fins is closer to the end of anterior lateral fins and extend to the seminal vesicles. More than half of the fin is on the trunk segment and the interior region is without fin rays.

Male gonads.—Seminal vesicles are in touch with both the posterior lateral and tail fins. They are oval, the anterior half is slightly broader than the posterior portion and they break open along the anterolateral margin, through which the sperms are liberated.

Female gonads.—In matured specimens the ovarian tubes grow up to the ventral ganglion and they never surpass the ganglion. The ova are round and arranged in three rows.

Distribution.—This is a neritic species seen in the coastal waters of the Indian and Pacific oceans.

Ecology.—This is an epiplanktonic species seen in the upper 200 m of the ocean and it is abundant in the neritic waters than the oceanic waters. This species has also been reported from the estuaries (Nair, 1969; Srinivasan, 1972, 1977). This is an euryhaline species, that can tolerate a salinity range of 11.6 to 33‰. (Nair, 1972). The estuarine specimens are smaller in size (Srinivasan, 1972) because they are living in an environment where the fluctuation of the salinity is very great.

***Sagitta bipunctata* Quoy and Gaimard, 1827**
(Fig. 3)

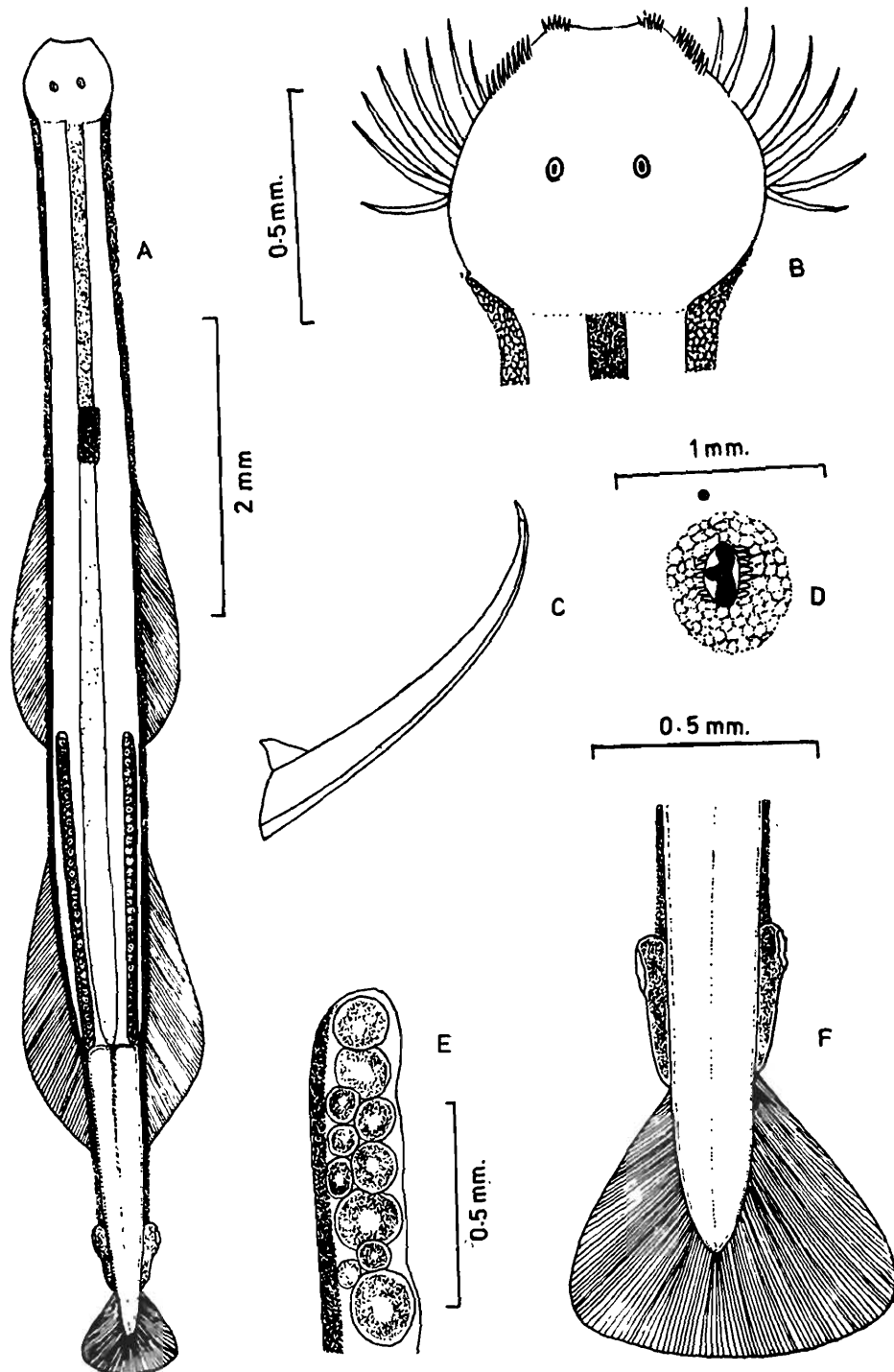


Fig. 3. *Sagitta bipunctata*—A. Dorsal View; B. Head; C. Hook; D. Eye; E, Arrangement of ova in ovary; F. Posterior region of tail segment,

Nair, 1972; Nair and Rao, 1973; Rao and Nair, 1973.
Sagitta hispida George, 1952.

Size.—The specimens of the west coast of India are less than 12 mm in total length whereas, in the Atlantic and Pacific oceans specimens are larger in total length (15 to 18.5 mm).

Body.—The width of the body is uniform from head to tail septum. It is strong and opaque due to strong longitudinal muscles. Intestinal diverticula are absent.

Head.—This is slightly bigger than the body and has a well differentiated neck which is covered by a thick layer of collarette that extends upto the tip of the tail.

The number of prehensile hooks varies from 7 to 9 on either side of the head. The anterior teeth number between 4 and 7 and the posterior teeth between 6 and 8 on either side of the head.

Eyes.—The eyes are small, roundish and have a three lobed pigmented region at the centre.

Tail segment.—This occupies 25% of the animal length and the constriction at the tail septum is very prominent.

Ventral ganglion.—This is situated just at the level of the origin of the anterior lateral fins.

Anterior lateral fins.—This originates at the posterior end of the ventral ganglion and is smaller than the posterior lateral fins. These are fully rayed.

Posterior lateral fins.—These are broader and longer than the anterior lateral fins. More than 60% of the fins are seen on the trunk segment and the fins are fully rayed.

Male gonad.—The seminal vesicles are elongated with anterior bulged portion. The posterior end of the seminal vesicles are in touch with the tail fin. A wide gap is seen between the seminal vesicles and posterior lateral fins.

Female gonad.—The ovarian tubes are long and reach upto the anterior lateral fins in matured specimens. The ova are, roundish, small and irregularly placed in one or two rows.

Distribution.—This is a cosmopolitan epiplanktonic species seen in abundance along the west coast of India particularly during North East monsoon period (Nair and Rao, 1973).

Ecology.—This is an Oceanic species present in the upper 200 m of the temperate and warm oceanic waters.

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

(Fig. 4)

Silas and Srinivasan, 1969; Nair and Rao, 1973.
Sagitta robusta, George, 1949, 1952.

Size.—Total length of the specimens varies from 7.8 to 15.2 mm.

Body.—Body is elongated, slender, translucent and rigid due to strong longitudinal muscles. Intestinal diverticula are absent.

Head.—Head is of moderate size, wider than long and the width is about 88% of the length. The collarette is well developed extending from the head to slightly behind the middle of the posterior lateral fins, more or less the width is uniform except in front of the anterior lateral fins and close to the tail septum.

Prehensile hooks range between 9 and 10. Hooks are long and slender.

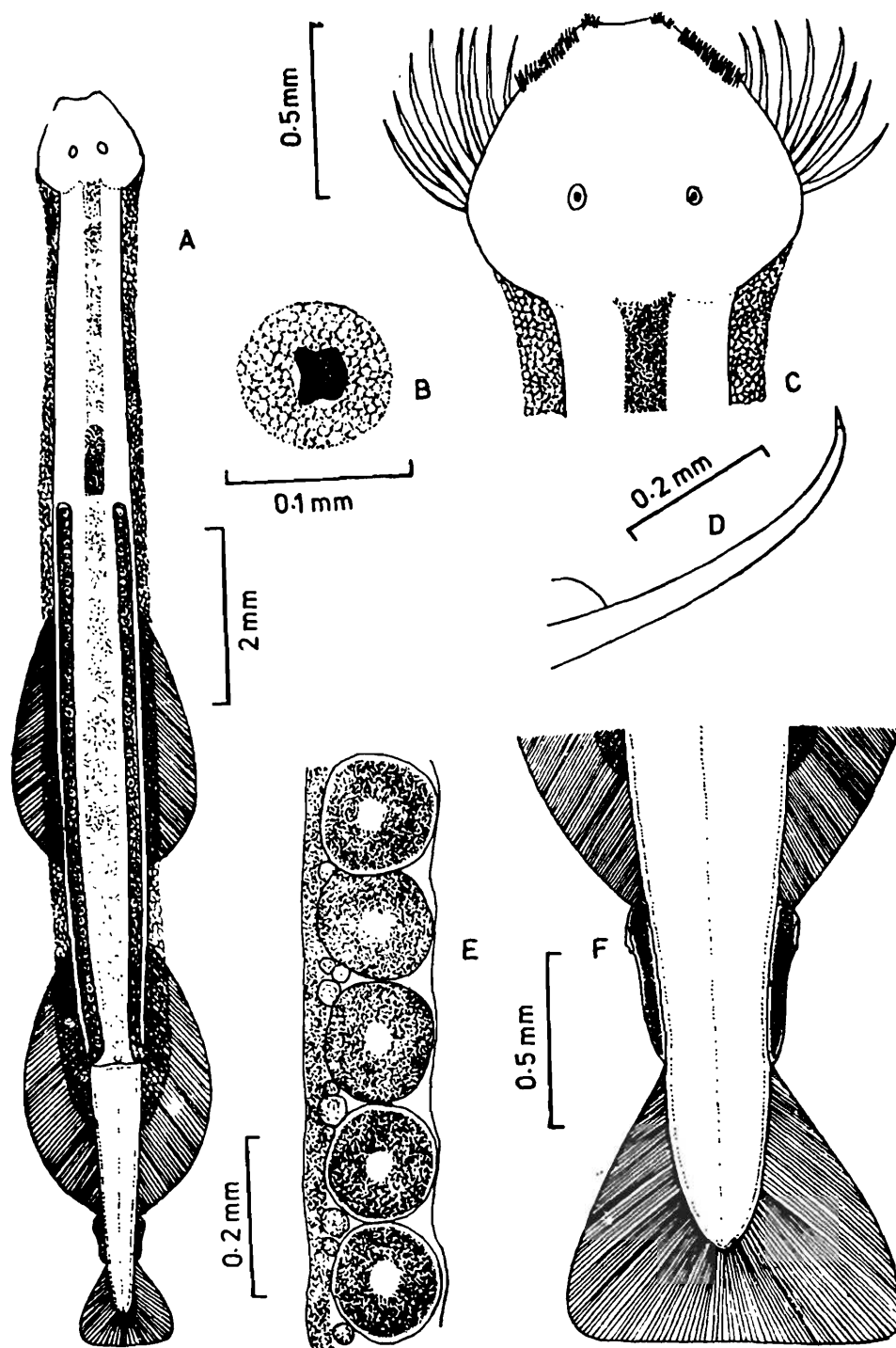


Fig. 4. *Sagitta bombayensis*—A. Dorsal view; B. Eye; C. Head; D. Hook; E. Arrangement of ova in ovary; F. Posterior region of tail segment.

Anterior teeth number between 9 and 10.

Posterior teeth count from 18 to 23.

Eyes.—Eyes are oval, have a square shaped pigmented region, with the convex inner side.

Tail segment.—This constitutes 25 to 26.3% of the animal and clearly differentiated from the trunk by a tail septum.

Ventral ganglion.—This is small, elliptical and situated distinctly ahead of the anterior lateral fins.

Anterior lateral fins.—These are slightly smaller than the posterior lateral fins and measure between 16 and 20% of the animal length. The fins are fully rayed.

Posterior lateral fins.—These are longer and broader than the anterior fins and measure from 17 to 21% of the total length. The fins are fully rayed and the posterior ends are in touch with the seminal vesicles. More than 60% of the fins are seen on the tail segment.

Male gonad.—In matured specimens, the tail segment is completely filled with sperms. The seminal vesicles are in touch with both the posterior lateral and caudal fins. They are greatly enlarged and anteriorly spout shaped when discharging.

Female gonad.—Ovarian tubes are long, slender and do not extend beyond ventral ganglion in matured specimens. Ova are round, compactly and uniserially arranged with minute undeveloped ova placed in between large ova.

Distribution.—This is a neritic species reported from the upper 200 m of the Indian Ocean and from the Harbour areas of Bombay (Lele and Gae, 1936; Silas and Srinivasan, 1969).

Ecology.—This is an endemic species seen in areas where the salinity is less than the ocean. This has been recently reported from Malaysian coastal waters by Pāthansali (1976) and he has stated that this was recorded in the near shore waters of low salinity generally less than 30‰. Nair and Rao (1973) who have reported this species from the Gulf of Combay from 30 m depth, have also stated that, this is a rather rare species in the Arabian sea and it seems to prefer shallow waters with relatively low salinity.

As this species is always associated with shallow waters with less salinity, this could be used as an indicator of the inlet waters along the Indian coasts (Tokioka, 1962).

***Sagitta decipiens* Fowler, 1905**

(Fig. 5)

Silas and Srinivasan, 1969, 1970; Nair and Rao, 1973; Srinivasan, 1972, 1976, 1977.

Size.—The total length varies from 6 to 11 mm. The specimens available along the west coast are smaller than those of Atlantic and Pacific Oceans.

Body.—Body is long, slender, translucent and flexible due to weak longitudinal muscles. Intestinal diverticula are present.

Head.—The head is not prominent, but well differentiated from the trunk by a neck. The collarette is absent at the neck and other regions of the body.

The prehensile hooks are long, slender and range from 6 to 8 on either side of the head. Anterior teeth are between 6 and 8 and posterior teeth are between 11 and 16 on either side of the head.

Eyes.—Eyes are oval, with branched pigmented region at the centre.

Tail segment.—This constitutes from 23 to 26% of the animal and the constriction at the tail septum is not prominent.

Ventral ganglion.—The posterior end of ventral ganglion is more or less at the level of the origin of anterior lateral fins. This is seen roughly at one fourth ($\frac{1}{4}$) distance from the anterior end.

Anterior lateral fins.—These are slightly longer and narrower than the posterior lateral fins and their origin is at the level of ventral ganglion. They measure from 26 to 28% of the animal length and are fully rayed.

Posterior lateral fins.—These are broader and shorter than the anterior lateral fins and more than 60% of the fin is seen on the trunk region. The fins are fully rayed and measure between 21 and 23% of the total length.

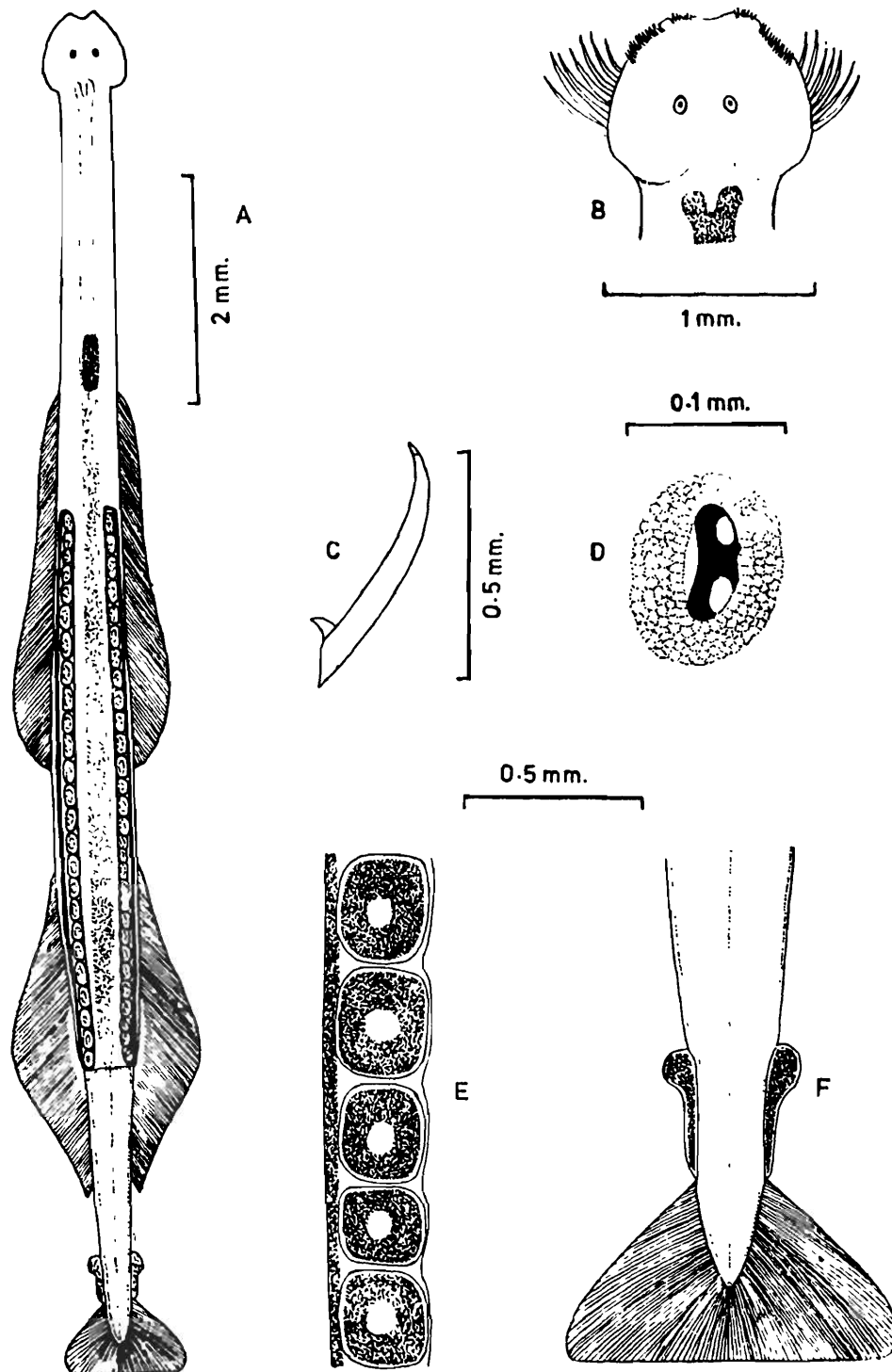


Fig. 5. *Sagitta decipiens*—A. Dorsal view; B. Head, C. Hook; D. Eye; E. Arrangement of ova in ovary; F. Posterior region of tail segment.

Male gonad.—Seminal vesicles are closer to the caudal fin, than to the posterior lateral fins. Anterior part is wider and breaks open along the antero-lateral margin, through which the sperms are liberated.

Female gonad.—Ovarian tubes are long, slender and never extend beyond the start of the anterior lateral fins. Ova are oval and uniserially arranged.

Distribution.—This is an Oceanic, mesopelagic cosmopolitan species reported from the subsurface waters of Atlantic, Indian and Pacific oceans.

Ecology.—*S. decipiens* is an inhabitant of waters of low temperature, low oxygen and high salinity. This species has always been associated with colder waters and seen usually below 200 m depth. Along the west coast of India, this has been reported from shallow waters (40 m depth) during certain seasons (Srinivasan, 1976) when the temperature at these depth was very low. Further Nair and Rao (1973) have reported the occurrence of this species from the subsurface waters of the Arabian Sea, where the temperature was 13.48°C.

The possibility of using *Sagitta decipiens* as an indicator of upwelling along the south west coast of India, has been pointed out by Srinivasan (1976). The importance of *S. decipiens* as an indicator species of movements of water masses is discussed in this account elsewhere under the head "Chaetognatha as indicator organisms".

***Sagitta ferox* Doncaster, 1903**

(Fig. 6)

Silas and Srinivasan, 1970; Srinivasan, 1972, 1976, 1977; Nair and Rao, 1973; Rao and Nair, 1973.

Size.—Total length of the specimens from the west coast of India varies from 5 to 16.5 mm.

Body.—Body is opaque, firm and rigid due to strong and thick longitudinal muscles. The body is of uniform size and the shape is maintained due to thick muscles. Intestinal diverticula are present.

Head.—Head is bigger than the body and clearly differentiated from the trunk by a well marked neck. Thick collarette is seen from neck to ventral ganglion and then it spreads as a thin layer upto the tip of the tail.

Prehensile hooks are long, thick and 6 numbers are seen on either side of the head. Anterior teeth vary between 6 and 8 on either side of the head and the posterior vary between 11 and 14.

Eyes.—Eyes are spherical with a pigmented region at the centre.

Tail segment.—This constitutes 26 to 28% of the total length of the animal and clear constriction is seen at the tail septum that separates the trunk and tail.

Ventral ganglion.—This is situated at the level of the origin of anterior lateral fins.

Anterior lateral fins.—These fins are larger than the posterior lateral fins. This is one of the main character in which this species differs from *S. robusta*, where the anterior fins is smaller than the posterior fins. These fins measure from 26 to 29% of the animal length and originate at the level of the ventral ganglion. The fins are fully rayed.

Posterior lateral fins.—These are shorter and broader than anterior lateral fins and measure from 23 to 26% of the animal. More or less the fins are equally placed on the trunk and tail segment and the posterior end of the fins are in touch with seminal vesicles. The fins are fully rayed except a small region near the tail septum.

Male gonad.—Seminal vesicles are in touch with both the posterior lateral fins and caudal fins. They are oval in shape with anterior bulged portion and break open along the anterolateral margin, through which the sperms are liberated.

Female gonad.—Ovarian tubes are long, wide, fill up the body cavity and reach upto the neck region in matured specimens. Ova are large and arranged in two rows. This is another important character in which this species differs from *S. robusta* where the ova are arranged in one row.

Distribution.—This is an epiplanktonic species seen in the upper 200 m of the Indian and Pacific Oceans.

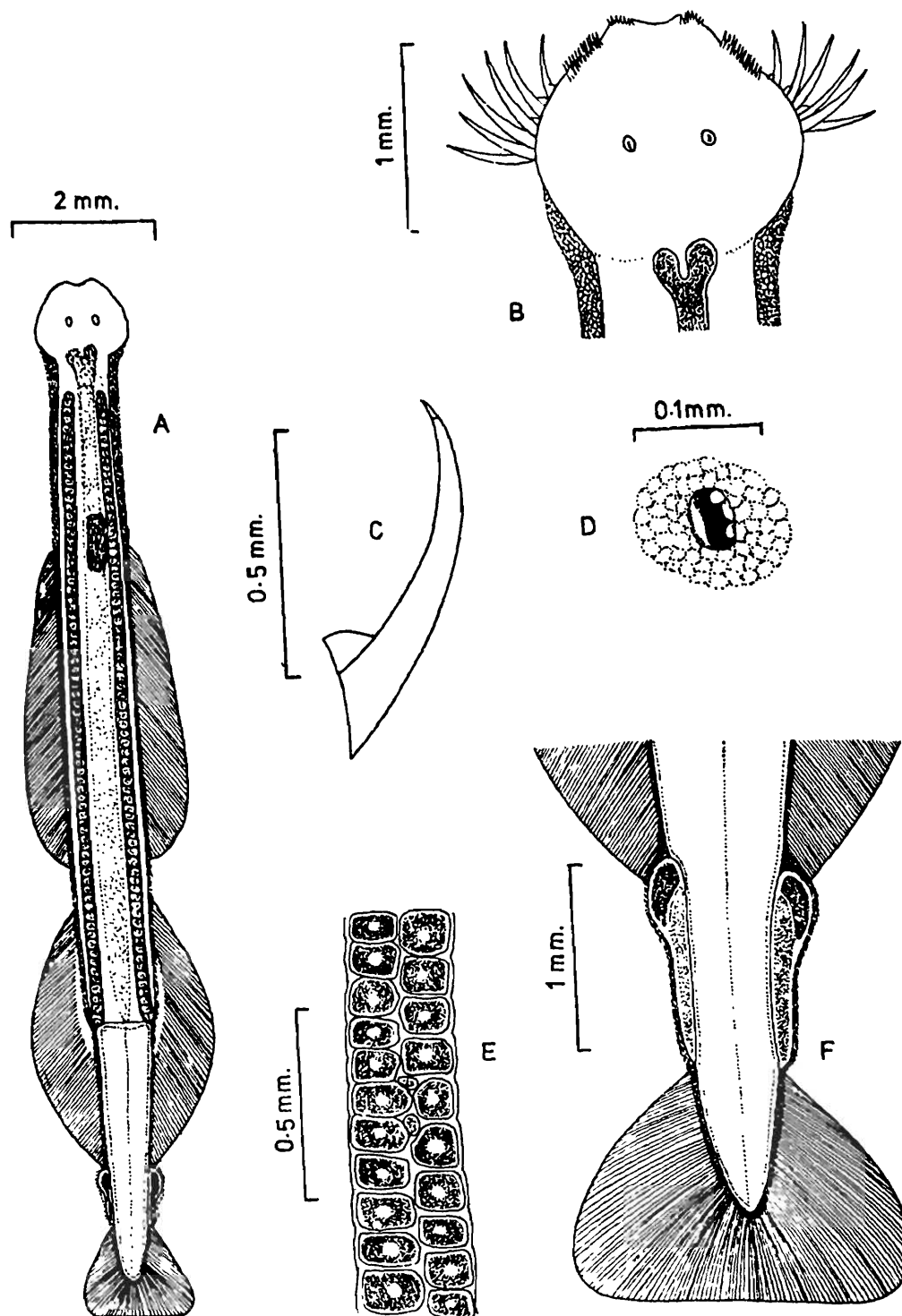


Fig. 6. *Sagitta ferox*—A. Dorsal view; B. Head; C. Hook; D. Eye; E. Arrangement of ova in ovary; F. Posterior end of tail segment.

Ecology.—This is a stenohaline oceanic species seen in the marine habitat, where the standard salinity conditions occur.

Sagitta hexaptera d' Orbigny, 1834
(Fig. 7)

Silas and Srinivasan, 1970; Srinivasan, 1972, 1976, 1977; Nair and Rao, 1973, Rao and Nair, 1973.

Size.—This is one of the largest species of Chaetognatha available along the west coast of India from the epipelagic region. The maximum size from these areas is 35 mm.

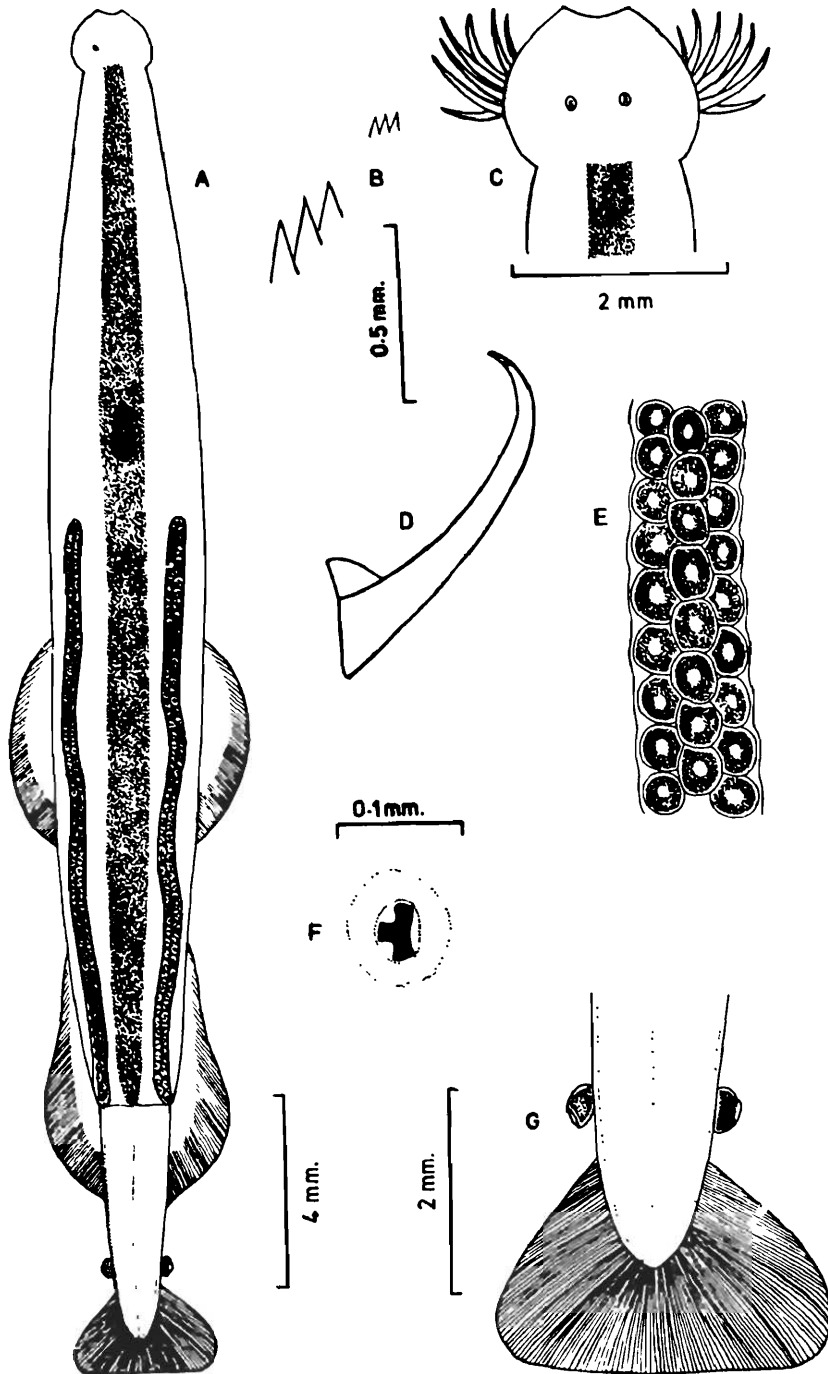


Fig. 7. *Sagitta hexaptera*—A. Dorsal view; B. Anterior and Posterior teeth; C. Head; D. Hook; E. Arrangement of ova in ovary; F. Eye; G. Posterior portion of tail segment.

Body.—Body is highly transparent, flaccid, but the shape is maintained due to strong longitudinal muscles. The body shape closely resembles that of *S. inflata*. Intestinal diverticula are absent.

Head.—Head is smaller than the body and clearly demarcated from the trunk by a neck. Collarsette is absent at the neck and other regions of the body.

Prehensile hooks vary from 7 to 9 on either side of the head. Anterior teeth number from 2 to 4 and posterior teeth from 3 to 6 on either side of the head. This species differs from *S. inflata* in the possession of lesser number of anterior and posterior teeth.

Eyes.—Eyes are oval in shape with a small pigmented region at the centre.

Tail segment.—This species has a longer tail segment than *S. inflata* and it varies from 19 to 21% of the animal length. Constriction at the tail septum is not very prominent.

Ventral ganglion.—This is situated roughly at the central region between the tip of head and posterior end of anterior lateral fins.

Anterior lateral fins.—Origin of these fins is at about the midway between the anterior end of the head and tip of the tail segment. These fins are shorter and narrower than the posterior lateral fins. The fin rays are sparsely arranged and the inner region of the fins are rayless.

Posterior lateral fins.—These are broader and longer than the anterior lateral fins. More than 60% of the fins are seen on the trunk region. Innermost region of the fins are rayless and the fin rays at other region are sparsely arranged.

Male gonad.—The seminal vesicles are closer to the caudal fin and separated from the caudal fin by the gap equal to its length. They are spherical in shape and break open along the mid dorsolateral region through which the sperms are liberated.

Female gonad.—Ovarian tubes are long, slender and they grow upto the ventral ganglion. Ova are spherical and arranged in three rows.

Distribution.—This is a cosmopolitan species reported from the epipelagic region of the Atlantic, Indian and Pacific Oceans.

Ecology.—This is a stenohaline, oceanic species abundant in the upper 200 m of the oceanic waters than shelf waters. Along the west coast of India, this is seen throughout the year in the oceanic collection, whereas, in the shelf collections, it is present only during the post-monsoon and premonsoon period (Nair and Rao, 1973; Srinivasan, 1976).

***Sagitta hispida* Conant, 1895**

(Fig. 8)

Silas and Srinivasan, 1969, 1970; Srinivasan, 1976, 1977.

Size.—Total length of the specimens from this coast varies from 5.5 to 9.5 mm.

Body.—Body is stout, rigid and opaque due to well developed strong longitudinal muscles. The intestinal diverticula are well developed.

Head.—Head is of medium size and differentiated from the trunk by a neck. A thick layer of collarette is seen extending from the head to the ventral ganglion. Sensory hairs are seen in the collarette at regular intervals.

Prehensile hooks number from 6 to 8. They are short, stout and gently curved. Anterior teeth vary from 5 to 9 on either side of the head and the posterior teeth vary between 9 and 15.

Eyes.—The eyes are spherical with a central pigmented region.

Tail segment.—The tail segment constitutes 29 to 33% of the total length of the animal and separated from the trunk by a tail septum.

Ventral ganglion.—This is seen just at the level of the origin of anterior lateral fins.

Anterior lateral fins.—These are shorter and narrower than the posterior lateral fins and they start just behind the level of ventral ganglion. The fins are fully rayed. They measure from 20 to 22% of the animal.

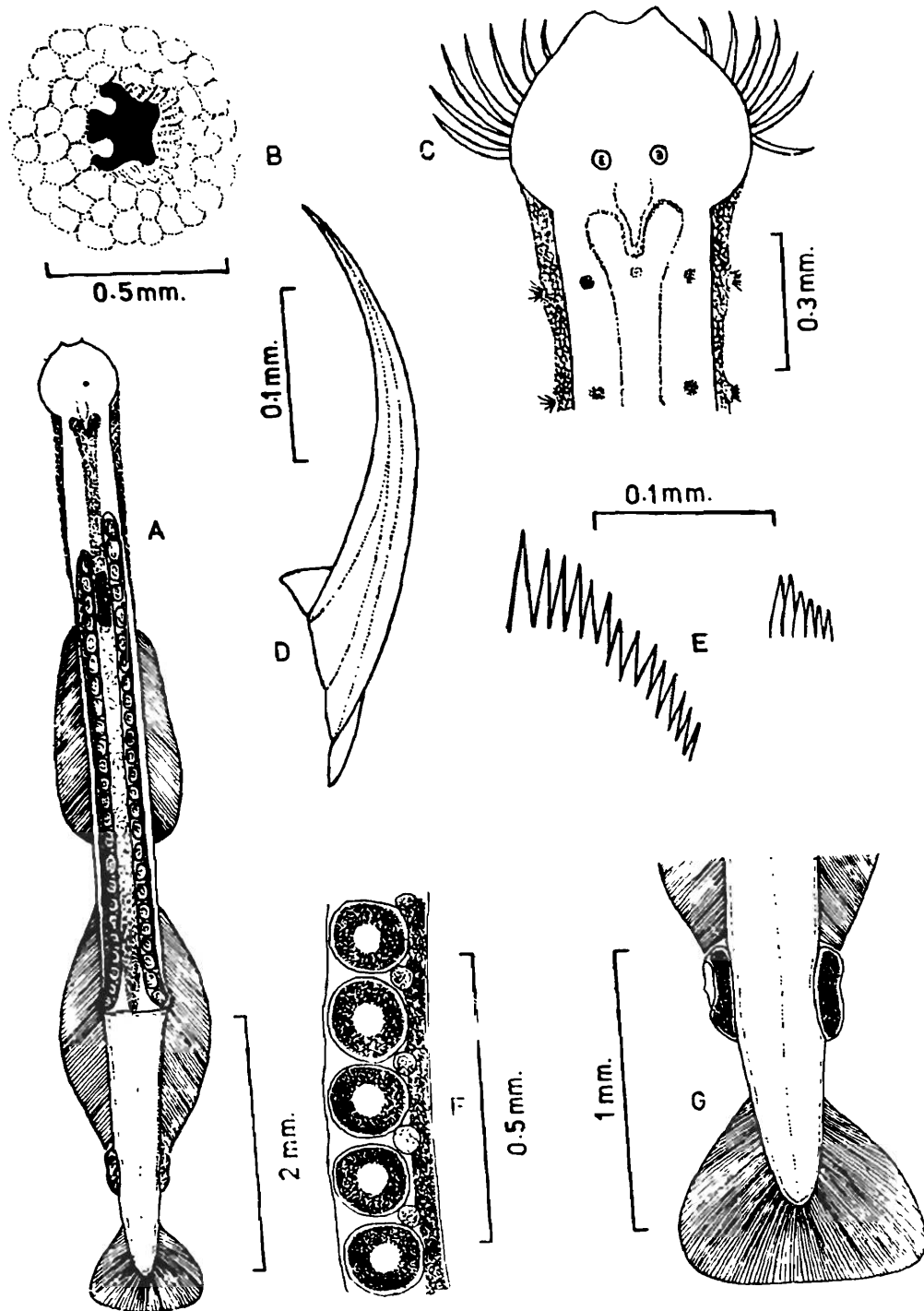


Fig. 8. *Sagitta hispida*—A. Dorsal view; B. Eye; C. Head; D. Hook; E. Anterior and Posterior teeth; F. Arrangement of ova in ovary; G. Posterior portion of tail segment.

Posterior lateral fins.—Posterior lateral fins measure from 23 to 27% of the animal length. About 60% of the fins are seen on the tail segment. The fins are fully rayed and the posterior ends are closer to seminal vesicles.

Male gonads.—Seminal vesicles are seen just behind the posterior lateral fins. They are prominent. More swollen anteriorly and burst along the antero-lateral margin, through which the sperms are liberated.

Female gonad.—Ovarian tubes are long and extend well beyond the ventral ganglion in matured specimens. Ova large, spherical and arranged in a single row.

Distribution.—This is an epiplanktonic species seen in the Tropical and Equatorial waters of the Atlantic and Indian Oceans.

Ecology.—This species is available in the upper 200 m of the west coast of India and is abundant in the oceanic waters than the neritic waters. This occurs widely along the west coast during the premonsoon (February–April) and postmonsoon (October–December) periods (Srinivasan, 1976).

***Sagitta inflata* Grassi, 1881**

(Fig. 9)

Silas and Srinivasan, 1969, 1970; Srinivasan, 1972, 1976, 1977.

Sagitta inflata Pillai, 1944; Menon, 1945; George, 1949, 1952; Nair, 1967, 1969, 1972; Silas and Srinivasan, 1969; Nair and Rao, 1973; Rao and Nair, 1973.

Sagitta gardineri, Lele and Gae, 1936.

Size.—Total length varies between 6.0 and 24.0 mm. Estuarine specimens are smaller in size and measure from 3.5 to 11.2 mm. (Srinivasan, 1969).

Body.—Body is highly transparent, flaccid and flexible due to thin and weak longitudinal muscles. Intestinal diverticula are absent.

Head.—Head is smaller than the body and differentiated from the body by a narrow neck. The head is wider than long. Collar is totally absent at the neck and other regions of the animal.

The number of prehensile hooks varies from 7 to 10. Anterior teeth range between 4 and 8, and posterior teeth count from 8 to 16.

Eyes.—Eyes are oval and have a star shaped pigmented region at the centre.

Tail segment.—Tail segment measures from 17.0 to 19.0% of the animal length. The constriction at the septum clearly demarcates the tail segment from the body.

Ventral ganglion.—This is situated at the middle region between the neck and the start of the anterior fin.

Anterior lateral fins.—Fin rays are absent in the anterior region of these fins. They are narrow, elongated and measures between 14 and 15% of the total length. The ganglion is equidistantly placed between the neck and start of anterior lateral fin.

Posterior lateral fins.—Fin rays are absent in the inner margin of the posterior lateral fins. They are larger and broader than the anterior lateral fins and measures between 16 and 18% of the animal length. More than 50% of the fin is seen on the trunk segment of the animal.

Male gonad.—The testis occupies the posterior half of the tail segment, and the sperms are liberated through the laterally placed seminal vesicles. The seminal vesicles are spherical and situated close to the caudal fins and break open along the anterior lateral margin through which the sperms are liberated.

Female gonad.—In matured specimens, the ovarion tubes grow up to the anterior lateral fins. The ova are large, round and arranged in three rows. This is a continuous breeder (Rao and Kelly, 1962; Srinivasan, 1972; Nair, 1973) and it breeds throughout the year with several periods of intensive breeding.

Distribution.—This is an epiplanktonic cosmopolitan species, seen in the upper layers of the Atlantic, Indian and Pacific Oceans. It occurs in the oceanic, neritic and estuarine waters.

Ecology.—*S. inflata* is one among the few species of the Phylum Chaetognatha, that can tolerate a wide range of salinity. It has been reported from several estuaries, where the salinity ranges from 3.0 to 33‰. (Srinivasan, 1977). Generally the estuarine specimens are smaller in size than the marine forms. The reduction in

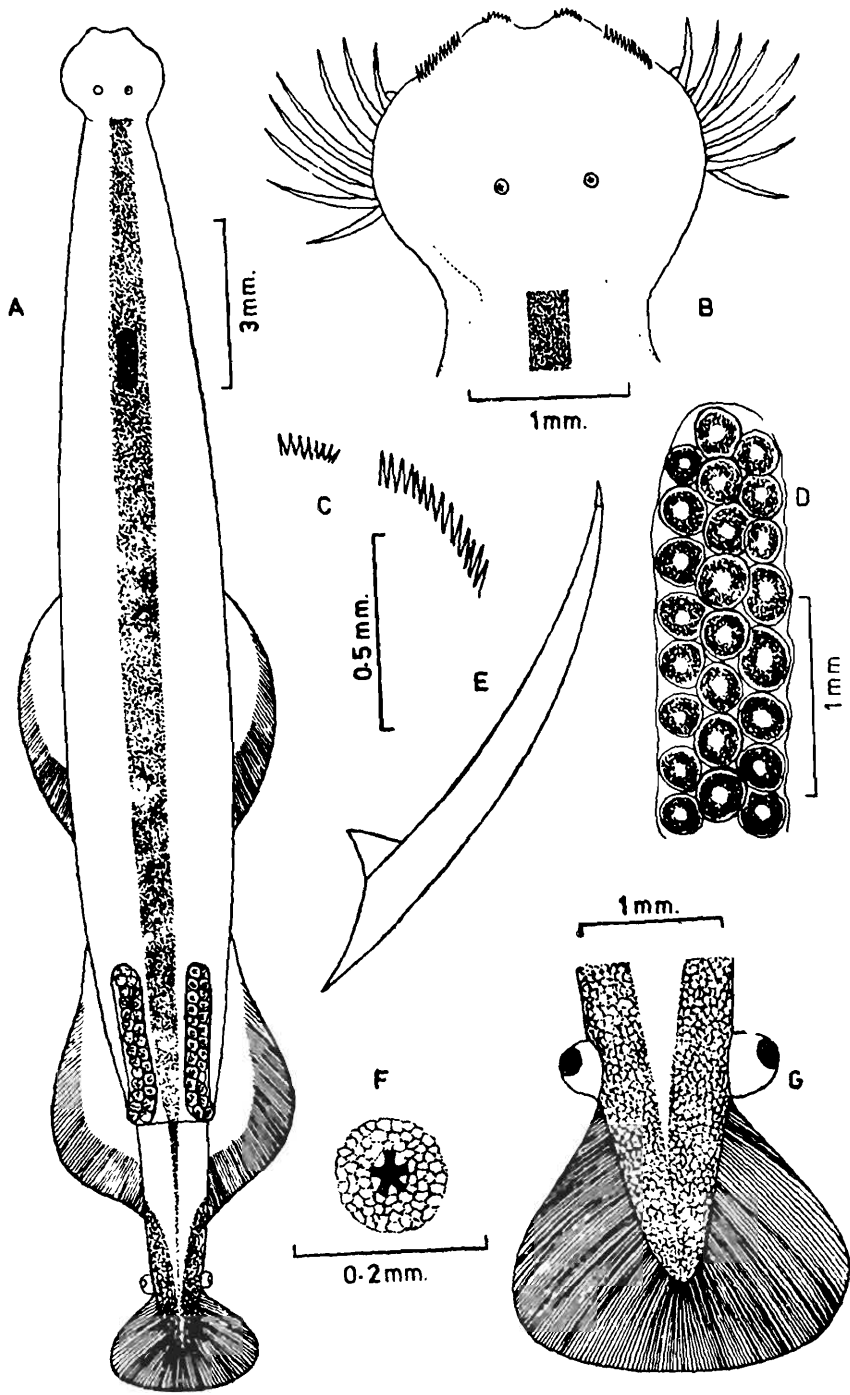


Fig. 9. *Sagitta inflata*—A. Dorsal view; B. Head; C. Anterior and posterior teeth; D. Arrangement of ova in ovary; E. Hook; F. Eye; G. Posterior portion of tail segment.

total length of the same species living in two different environment has been earlier noticed in crustaceans by Kinne (1964) and he has stated that the marine organisms are known to exhibit a reduction in final size in areas of their distribution where the salinity is significantly reduced. Though the estuarine specimens have a retarded growth in size, other aspects such as breeding and spawning are not at all affected.

Sagitta lyra Krohn, 1853

(Fig. 10)

Silas and Srinivasan, 1969, 1970; Srinivasan, 1972, 1976; Nair and Rao, 1973.

Size.—This is one of the larger species of the genus *Sagitta* from the mesoplanktonic realms and the specimens measure from 10 to 38 mm in total length.

Body.—Body is transparent, flabby and flexible due to weak longitudinal muscles. Intestinal diverticula are absent.

Head.—The head is broad and well differentiated from the trunk by a neck and the collarette is totally absent at the neck and other regions of the body.

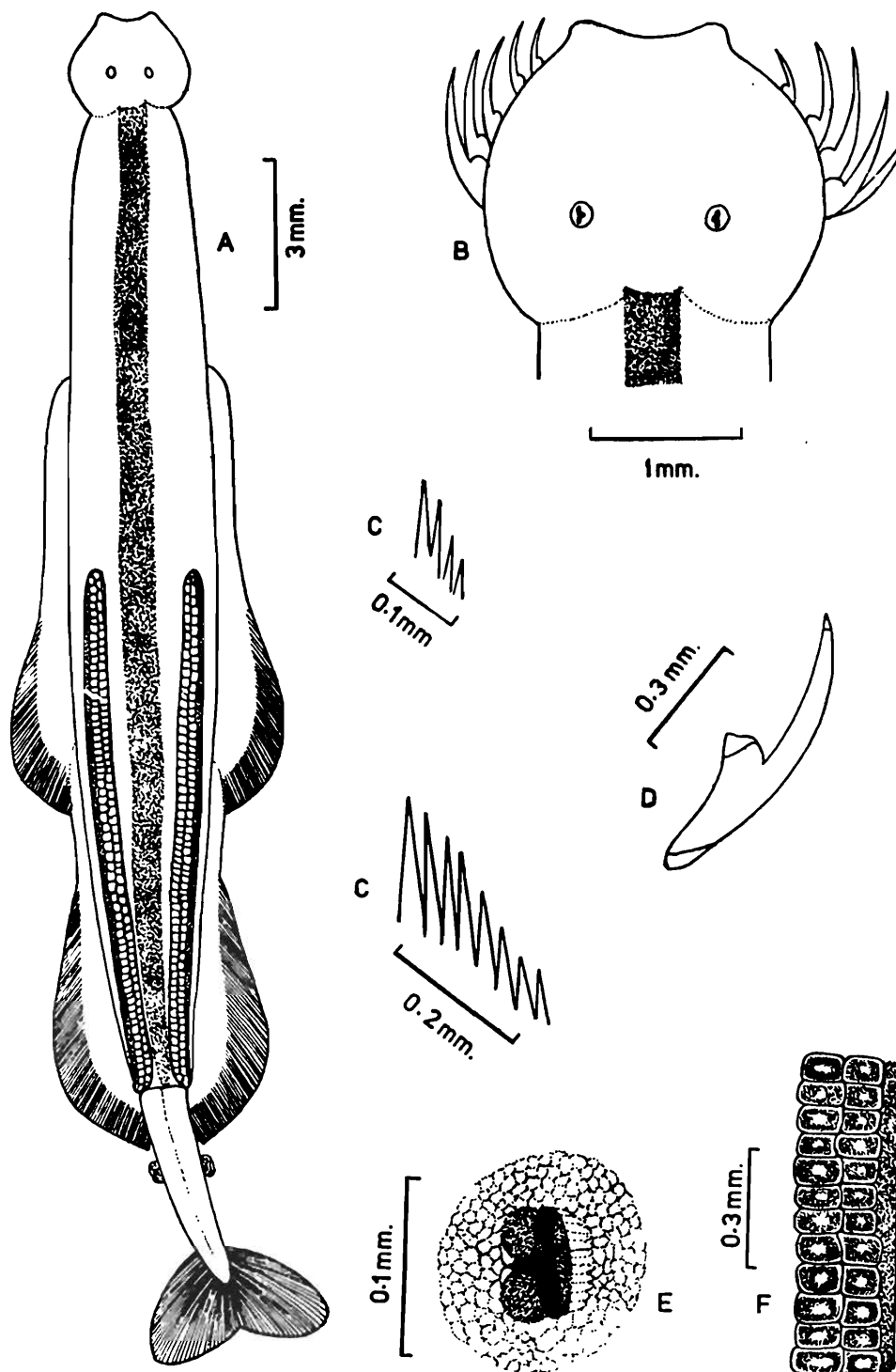


Fig. 10. *Sagitta lyra*—A. Dorsal view; B. Head; C. Anterior and posterior teeth; D. Hook; E. Eye; F. Arrangement of ova in ovary.

Prehensile hooks are short, stout and well curved with a straight tip. The number is highly variable, decrease with maturity from 8 to 2 and posterior teeth from 12–0. Both the anterior and posterior teeth decrease in number with the maturity of the animal (Silas and Srinivasan, 1969).

Eyes.—Eyes are oval in shape with a pigmented region at the centre.

Tail segment.—This varies from 16 to 19% of the animal length. A clear constriction is seen at the tail septum that separates the tail segment from trunk.

Ventral ganglion.—This is small, when compared with the body size and located just above the level of the start of anterior lateral fins.

Anterior lateral fins.—These are longer than the posterior lateral fins and the posterior one third outer margin of the fins are rayed. Their origin is just behind the level of the ventral ganglion.

Posterior lateral fins.—These are connected with the anterior lateral fins by a narrow rayless fin bridge. These are wider than the anterior lateral fins and more than 75% of these fins are seen on the trunk segment. The inner region of these fins are rayless. Caudal fin is bifurcated into two equal oval lobes, by a small fissure at the centre of the fin.

Male gonad.—Seminal vesicles are oval in shape and located closer to the end of posterior lateral fins and break open along the middle region through which the sperms are liberated.

Female gonad.—Ovarian tubes are long, extend to the anterior lateral fins and ova are arranged in four dorso-ventral rows.

Distribution.—This is an oceanic, cosmopolitan species, reported from the deeper waters of the Atlantic, Indian and Pacific Oceans. Along the west coast this has been reported from mesoplanktonic waters (Silas and Srinivasan, 1969, 1970; Srinivasan 1972, 1976; Nair and Rao, 1973).

Ecology.—This is a mesoplanktonic species seen in the subsurface cold waters with low temperature, low oxygen content and high salinity. This species is seen in abundance below 700 m depth (Silas and Srinivasan, 1969).

***Sagitta macrocephala* Fowler, 1905**

(Fig. 11)

Srinivasan, 1972.

Size.—Total length of the specimens from the west coast varies between 6.0 and 14.0 mm. The specimens are smaller in size when compared with those of Atlantic and Pacific Oceans.

Body.—Body is robust and firm due to strong longitudinal muscles. Intestinal diverticula are absent and the intestine is bright red in colour.

Head.—The head is very prominent, bigger than the body and clearly differentiated from the trunk by a neck. The collarette is absent.

Prehensile hooks range between 10 and 12 on either side of the head. Anterior teeth number from 6 to 8 and posterior teeth from 21–27 on either side of the head.

Eyes.—The eyes are large and oval in shape and characterised by the absence of a pigmented region. This is the only species of the genus *Sagitta* that has a non-pigmented eye.

Tail segment.—This constitutes 31 to 34% of the animal length and a clear constriction is seen at the tail septum that separates the trunk and tail segments.

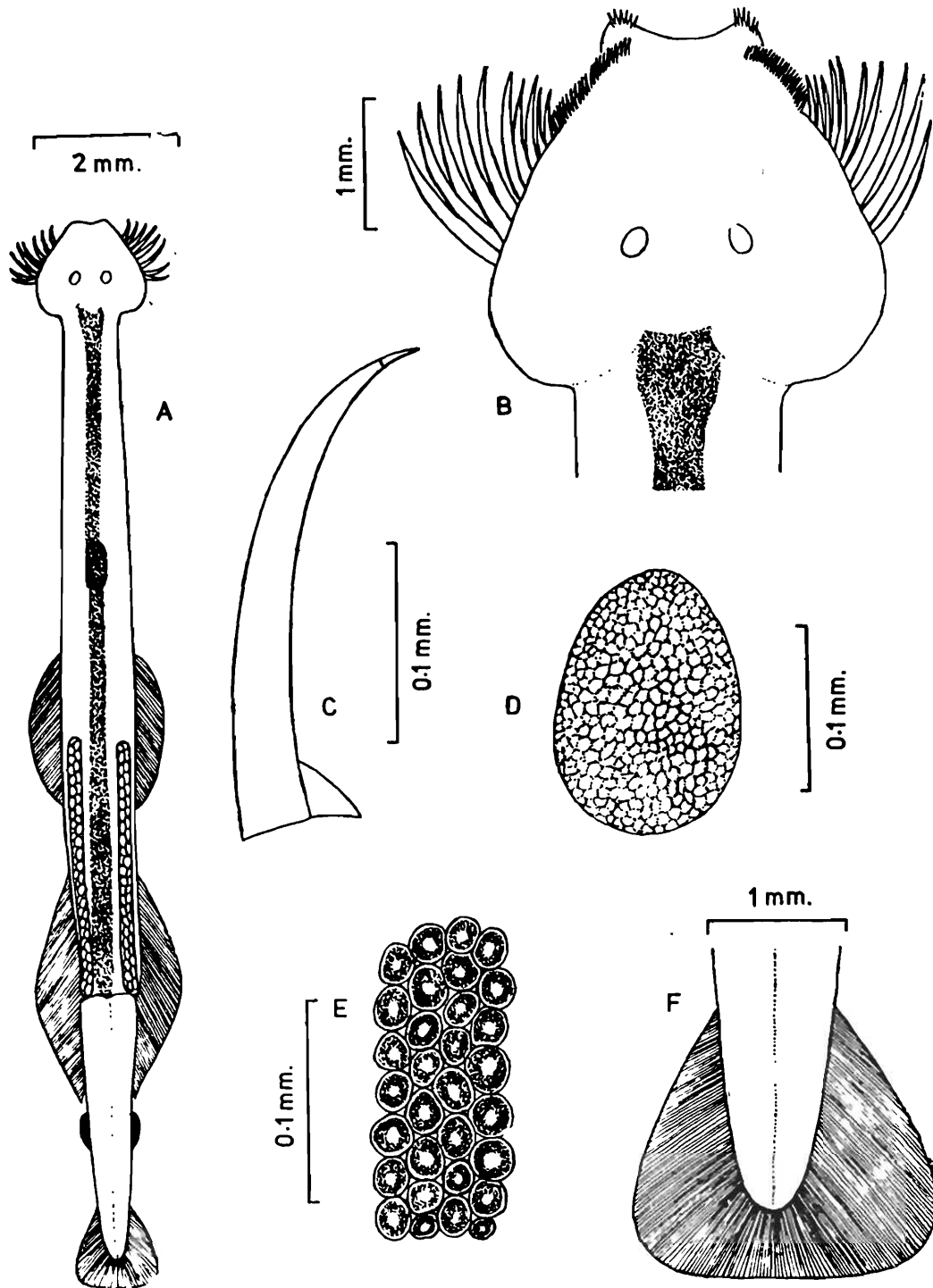


Fig. 11. *Sagitta macrocephala*—A. Dorsal view; B. Head; C. Hook; D. Eye; E. Arrangement of ova in ovary; F. Posterior portion of tail segment.

Ventral ganglion.—This is situated roughly at $1/3$ distance from the anterior end of the animal.

Anterior lateral fins.—These are smaller and narrower than the posterior lateral fins and situated far behind the ventral ganglion. The fins are fully rayed.

Posterior lateral fins.—These are wider and larger than the anterior lateral fins and are equally placed on the trunk and tail segments. Anterior outer margin of these fins are rayless and the rest of the fins are fully rayed.

Male gonad.—Seminal vesicles are oval and located closer to the posterior lateral fins, than to the caudal fins, and they open along the lateral margins, through which the sperms are liberated.

Female gonad.—Ovarian tubes are long and extend in matured specimens upto the level of the ventral ganglion and the ova are arranged in four rows.

Distribution.—This is an oceanic mesoplanktonic species seen in the Atlantic, Indian and Pacific Oceans. This has been reported along the west coast of India from 1730 m depth (Srinivasan, 1972).

Ecology.—This is an oceanic species seen at the sub-surface cold waters with low temperature, low oxygen content and high salinity. As this species is always seen at greater depths, where light cannot penetrate, the eyes of these species do not have any pigmented region.

Sagitta maxima (Conant, 1896)
(Fig. 12)

Srinivasan, 1972.

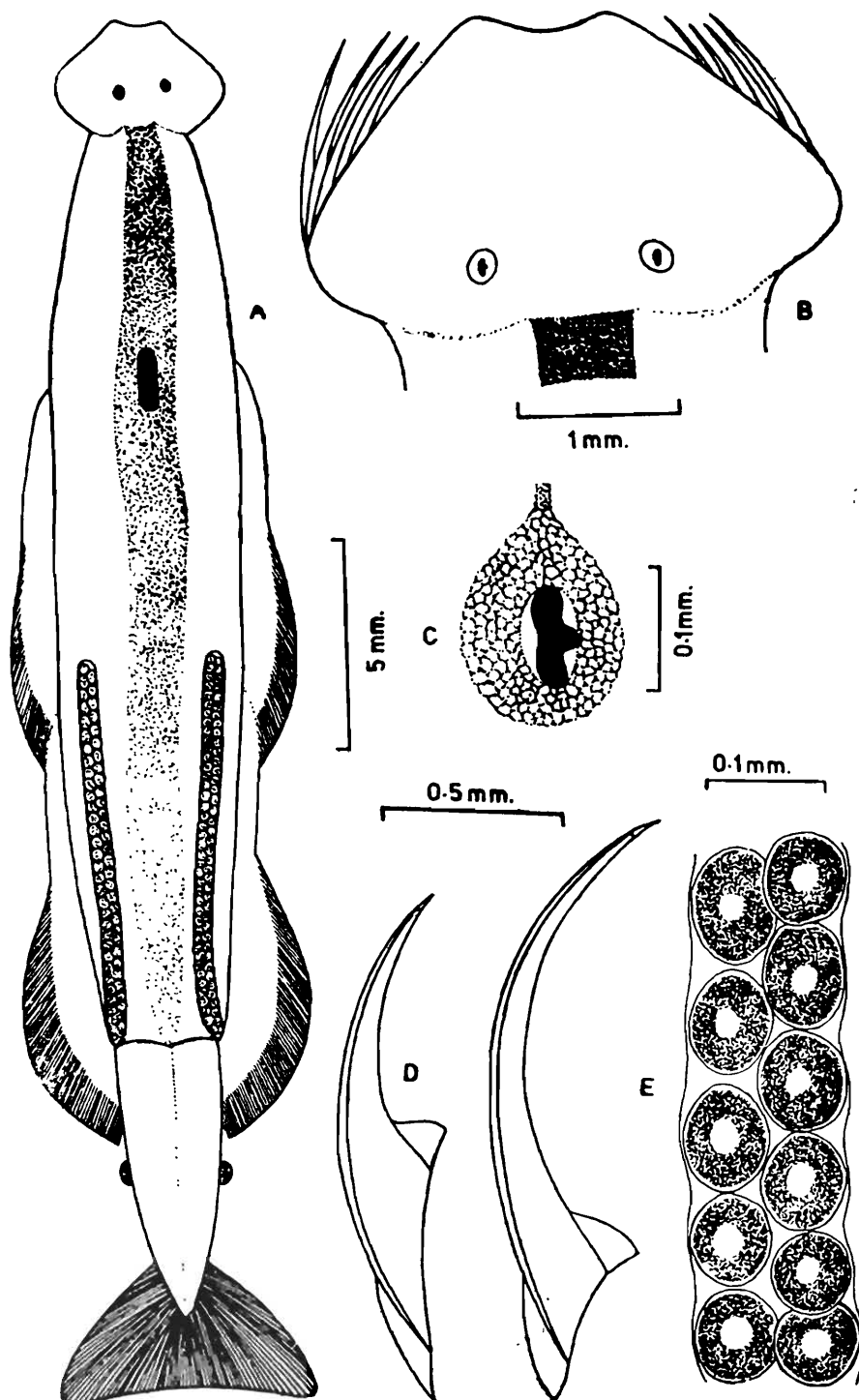


Fig. 12. *Sagitta maxima*—A. Dorsal view; B. Head; C. Eye; D. Hooks; E. Arrangement of ova in ovary.

Size.—This is the largest known species of the phylum Chaetognatha and it grows upto 90 mm. The specimens obtained from the west coast of India measured between 33 and 36 mm.

Body.—Body is highly transparent, flaccid and flexible due to weak longitudinal muscles. Intestinal diverticula are absent.

Head.—Head is of medium size, wider than long and differentiated from the trunk by a well defined neck. The collarette is absent at the neck and other parts of the animal.

Eyes.—The eyes are large, oval and have a small pigmented region at the centre.

Tail segment.—This occupies roughly 1/4 of the animal and ranges between 24 and 25% of the animal length. A constricted tail septum is seen between the trunk and tail segments.

Ventral ganglion.—This is situated at 1/4th distance from the anterior end of the animal.

Anterior lateral fins.—These fins commence at the level of the middle region of ventral ganglion. They are longer and narrower than the posterior lateral fins. The anterior half of these fins are rayless.

Posterior lateral fins.—These are shorter and wider than the anterior lateral fins and only outer margin of these fins are rayed. More than 70% of these fins are seen on the trunk region. Both the anterior and posterior lateral fins are connected by a narrow rayless fin bridge as in *S. lyra*.

Male gonad.—The seminal vesicles are oval and situated closer to posterior lateral fins, than to caudal fin and break open along the lateral margins, through which the sperms are liberated.

Female gonad.—Ovarian tubes are long, slender, and extend up to the anterior lateral fins. The ova are arranged in 2 rows (Srinivasan, 1972).

Distribution.—This is a cosmopolitan bathy-planktonic oceanic species, seen in the Atlantic, Indian and Pacific Oceans. Along the west coast of India, this has been reported from 1730–0 m collection (Srinivasan, 1972).

Ecology.—This is an oceanic species, seen in subsurface cold waters with low temperature, low oxygen content and high salinity.

***Sagitta minima* Grassi, 1881**

(Fig. 13)

Nair, 1972; Nair and Rao, 1973; Rao and Nair, 1973.

Size.—This is one of the smallest species and generally they are less than 7 mm in total length.

Body.—Body is translucent, flaccid and the posterior region is wider than the anterior region. Intestinal diverticula are present.

Head.—Head is clearly demarcated from the body by a neck and slightly bigger than the body. No collarette is seen at the neck and other regions of the body.

The number of prehensile hooks varies from 7 to 8 on either side of the head. Anterior teeth vary from 4 to 5 and posterior teeth from 6 to 10.

Eyes.—The eyes are large, roundish and have three lobed pigmented region at the centre.

Tail segment.—This varies from 18 to 22% of the animal and the constriction at the tail septum is prominent.

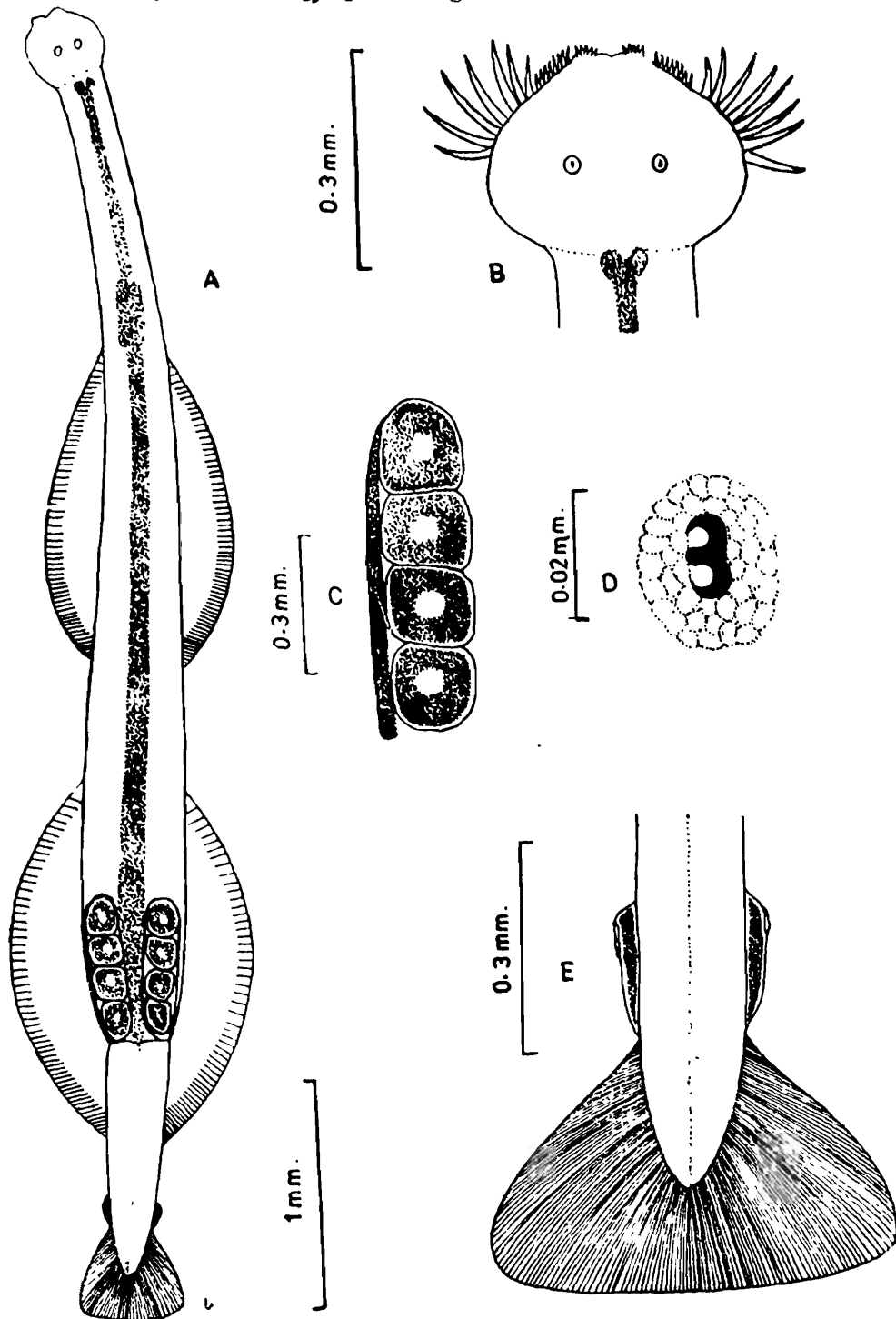


Fig. 13. *Sagitta minima*—A. Dorsal view; B. Head; C. Arrangement of ova in ovary; D. Eye; E. Posterior portion of tail segment.

Ventral ganglion.—This is seen roughly at 1/4th distance from the anterior end of the animal and it is bigger when compared to the body size.

Anterior lateral fins.—These fins originate behind the ventral ganglion and they are smaller than the posterior fins. Fin rays are sparsely arranged only along the margin of the fins.

Posterior lateral fins.—These are slightly longer and broader than the anterior lateral fins. More than 70% of the fins are seen on the trunk segment. Fin rays are sparsely arranged along the margin of the fins.

Male gonad.—Seminal vesicles are elongated and situated near the caudal fin. Wide gap is seen from the seminal vesicles and posterior lateral fins. The vesicles break open along the anterodorsal margin through which the sperms are liberated.

Female gonad.—The ovarian tubes are short, bulky and never surpass the origin of the posterior lateral fins. Ova are large, few in number and arranged in one row.

Distribution.—This is a cosmopolitan species seen in the epipelagic oceanic waters of Atlantic, Indian and Pacific Oceans.

Ecology.—This is a cosmopolitan species seen in the epipelagic oceanic waters and not seen in the coastal waters of the Arabian sea. Maximum density was noticed along the Southern part of the Arabian sea during the South west monsoon (Nair and Rao, 1973).

***Sagitta neglecta* Aida, 1897**

(Fig. 14)

George, 1949, 1952; Nair, 1972; Nair and Rao, 1973; Rao and Nair, 1973.

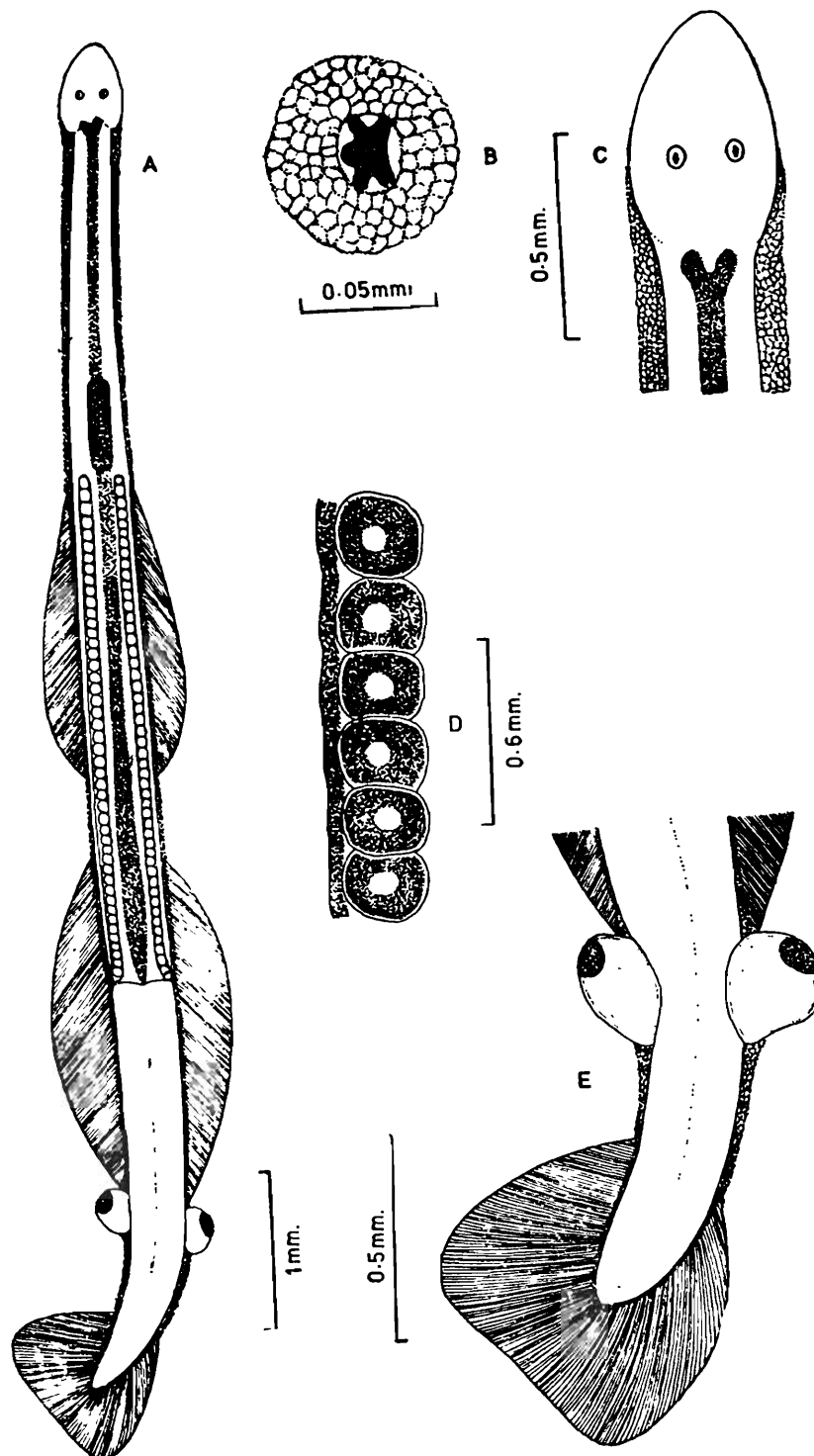


Fig. 14. *Sagitta neglecta*—A. Dorsal view; B. Eye; C. Head; D. Arrangement of ova in ovary; E. Posterior portion of tail segment.

Size.—Total length of the animal is less than 9 mm. This is one of the smaller species. This closely resembles *S. regularis* but longer.

Body.—Body is opaque and rigid due to strong longitudinal muscles. Width is uniform from head to tail septum.

Head.—Head is elongated, longer than wide and slightly bigger than the body. The neck is not prominent. Intestinal diverticula present. A thick layer of collarette is seen from head to the start of anterior fin and then it spreads as a thin layer upto the tip of the tail segment.

Prehensile hooks are 6 to 7 on either side of the head. Anterior teeth range from 5 to 7 and posterior teeth 12 to 16 on each side of the head.

Eyes.—Eyes are large, roundish as in *S. regularis* with a five lobed pigmented region at the centre.

Tail segment.—This occupies 30% of the animal length. The constriction at the tail septum is very clear.

Ventral ganglion.—This is very big when compared to the animal size and located at 1/4th distance from the tip of the head.

Anterior lateral fins.—These are shorter than posterior lateral fins and are fully rayed.

Posterior lateral fins.—More than 60% of these fins, are seen on the tail segment.

Male gonad.—Seminal vesicles are big, roundish and situated in touch with the posterior lateral fins. A gap is seen between the seminal vesicles and tail fin which is covered by a layer of collarette.

Female gonad.—Ovarian tubes are long, wide and extend beyond ventral ganglion in matured specimens. Ova are round and arranged in one row.

Distribution.—This is an Indo-Pacific species seen in the tropico equatorial waters.

Ecology.—This species is found in the epiplanktonic waters and is abundant in the coastal waters than in the Oceanic waters.

***Sagitta pacifica* Tokioka, 1940**

(Fig. 15)

Silas and Srinivasan, 1969, 1970; Nair, 1972; Srinivasan, 1972, 1976, 1977; Nair and Rao, 1973; Rao and Nair, 1973.

Size.—Total length of the specimens varies between 5.0 and 11.6 mm.

Body.—Body is translucent, firm and not flexible due to strong longitudinal muscles. Intestinal diverticula are absent. This species is characterised by the possession of well developed sensory hairs throughout the body as in *S. hispida*.

Head.—Head is of medium size and well differentiated from the trunk by a neck. A collarette is seen at the neck region that extends from the neck to the start of anterior lateral fins.

Prehensile hooks vary between 6 and 7 on either side of the head. The hooks are characterised by the presence of small serrations on the inner margin. This is the only species of the genus *Sagitta* that has serrated hooks. Hooks are short and robust. Anterior teeth vary between 8 and 11 on either side of the head. Teeth are long and pointed.

Posterior teeth number from 11 to 22 on either side of the head and are very compactly arranged.

Eyes.—Eyes are oval, with a small pigmented region at the centre.

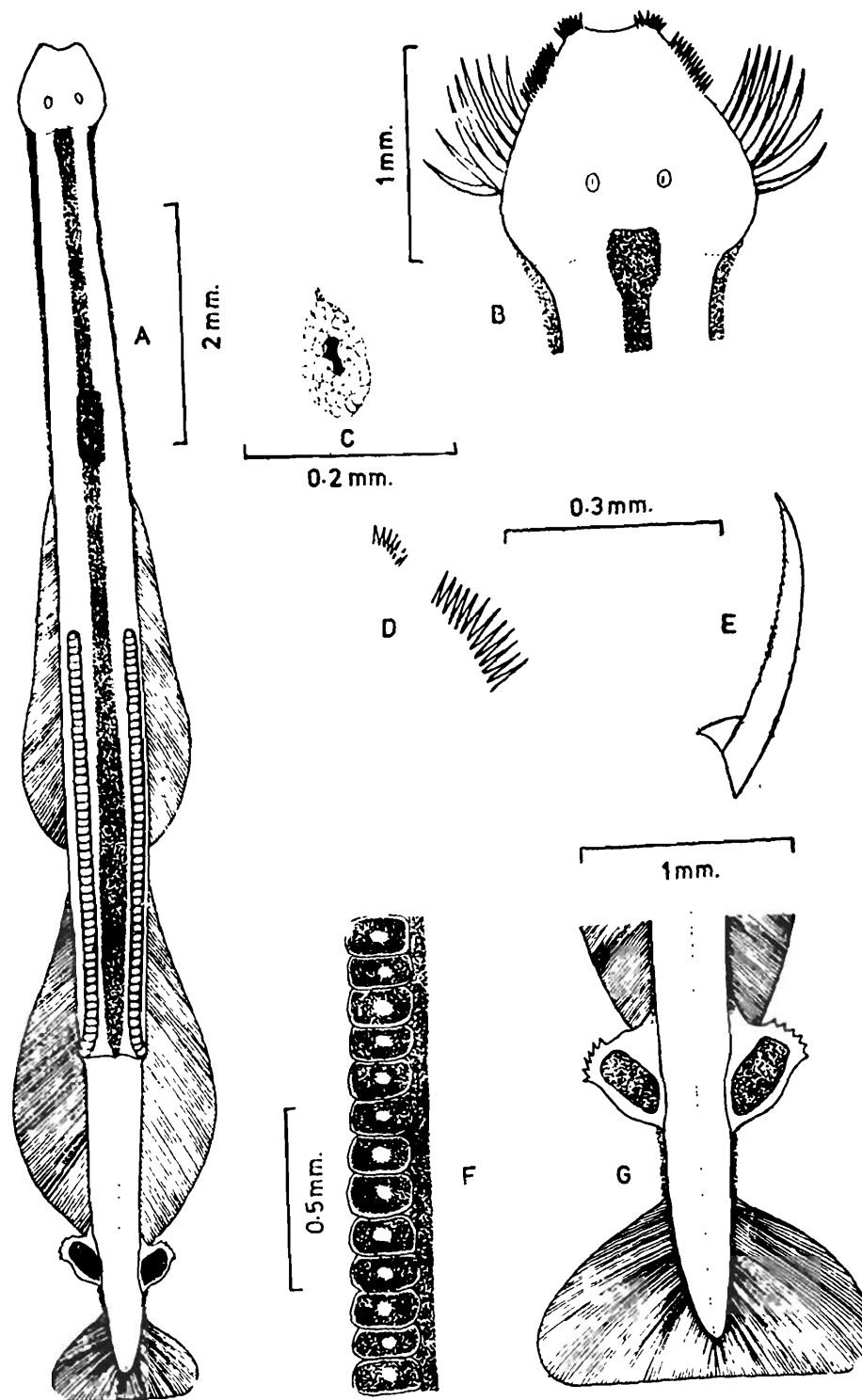


Fig. 15. *Sagitta pacifica*—A. Dorsal view; B. Head; C. Eye; D. Anterior and Posterior teeth; E. Hook; F. Arrangement of ova in ovary; G. Posterior portion of tail segment.

Tail segment.—This constitutes 24 to 26% of the animal length, and clearly differentiated from the trunk by a tail septum. The tail segment is narrow and conical in shape.

Ventral ganglion.—This is situated at $\frac{1}{4}$ th distance from the anterior end of the animal.

Anterior lateral fins.—These fins originate behind the level of the ventral ganglion, and they measure between 23 and 24% of the animal length. The shape is more or less similar to the posterior lateral fins.

Posterior lateral fins.—The origin of these fins is closer to the anterior lateral fins. They measure from 25 to 27% of the animal length. More than 50% of the fin is seen on the tail segment. The posterior end of these fins are in touch with the seminal vesicles, and the fins are fully rayed.

Caudal fin is triangular in shape. All these fins have small black spots.

Male gonads.—Seminal vesicles are very prominent and separated from the caudal fin by a thin layer of collarette. More than 5 Chitinous teeth (serrations) are seen on the inner margin of the seminal vesicles.

Female gonads.—Ovarian tubes are long slender and extend to the start of anterior lateral fins. Ova are spherical in shape and compactly arranged in a single row.

Distribution.—This is an oceanic species reported from the upper 200 m of the Indian and Pacific Oceans.

Ecology.—This is a stenohaline oceanic species, abundantly seen in the off shore waters, than in the neritic waters. As this is associated with high saline Oceanic waters, Rao (1958) has suggested that this species could be used as an indicator of incursion of Oceanic waters into the coastal waters of Visakhapatnam.

***Sagitta pulchra* Doncaster, 1903**

(Fig. 16)

George, 1949, 1952; Silas and Srinivasan, 1968, 1969, 1970; Nair, 1972; Srinivasan, 1972, 1976, 1977; Nair and Rao, 1973; Rao and Nair, 1973.

Size.—Total length of the specimens varies from 8 to 20 mm. Specimens from the estuarine waters are smaller in size (Srinivasan, 1972, 1977).

Body.—Body is highly transparent, elongated, slender, firm and not flexible like *S. inflata* due to strong longitudinal muscles. Intestinal diverticula are absent.

Head.—The head is of medium size and differentiated from the trunk by a neck. A well developed collarette is seen at the neck region, that extends upto the ventral ganglion.

The prehensile hooks vary from 6 to 7 on either side of the head. Hooks are strong and curved well at the tip region. Anterior teeth number between 5 and 9 on each side and the posterior teeth between 10 and 13.

Eyes.—The eyes are small, roundish, with a pigmented region at the centre.

Tail segment.—Length of the tail segment varies from 19 to 24% of the animal length and this is clearly demarcated from the trunk. The tail segment is conical in shape.

Ventral ganglion.—This is situated at the origin of the anterior lateral fins. This can be seen at $\frac{1}{4}$ th distance from the anterior end of the animal.

Anterior lateral fins.—These are longer and narrower than the posterior lateral fins and their origin is at the middle of the ventral ganglion. Fin rays are sparsely arranged at anterior regions of the fins and the inner regions are without fin rays. The hind end of the fins are broader.

Posterior lateral fins.—The origin of the posterior lateral fins is close to the anterior lateral fins. These are shorter and broader in shape. Fin rays are absent at the anterior and inner region of the fins. The posterior end is close to the seminal vesicles. More than 50% of the fins are seen on the trunk segment.

Male gonad.—Seminal vesicles are in touch with the caudal fin. The anterior part of the seminal vesicles are broader and they break open along the anterolateral margins through which the sperms are liberated.

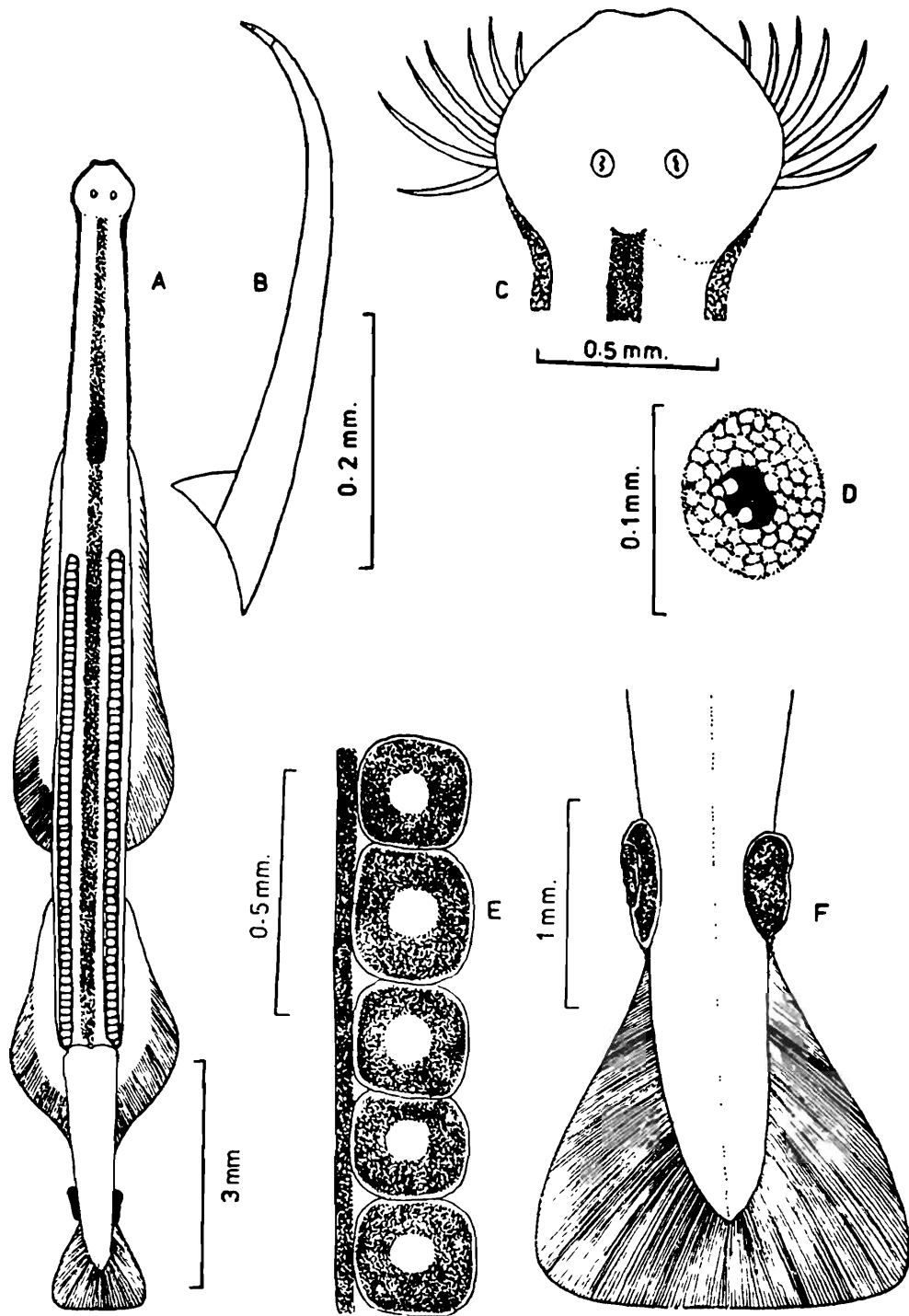


Fig. 16. *Sagitta pulchra*—A. Dorsal view; B. Hook; C. Head; D. Eye; E. Arrangement of ova in ovary; F. Posterior portion of tail segment.

Female gonad.—The ovarian tubes are long, slender and they never grow beyond the ventral ganglion. The ova are round and arranged in 2 rows.

Distribution.—This is an oceanic species, seen in the upper 200 m of the Indian and Pacific Oceans.

Ecology.—Though *S. pulchra* is an oceanic species, this has also been reported from the estuarine waters (Srinivasan, 1972, 1977). Like *S. inflata* and *S. bedoti* this also can tolerate a wide salinity range (3 to 33‰). The estuarine forms are smaller than the marine forms, because they are living in a habitat, where the salinity fluctuation is very great.

***Sagitta regularis* Aida, 1897**

(Fig. 17)

Menon, 1945; George, 1952; Silas and Srinivasan, 1968, 1969, 1970; Srinivasan, 1972, 1976, 1977; Nair and Rao, 1973.

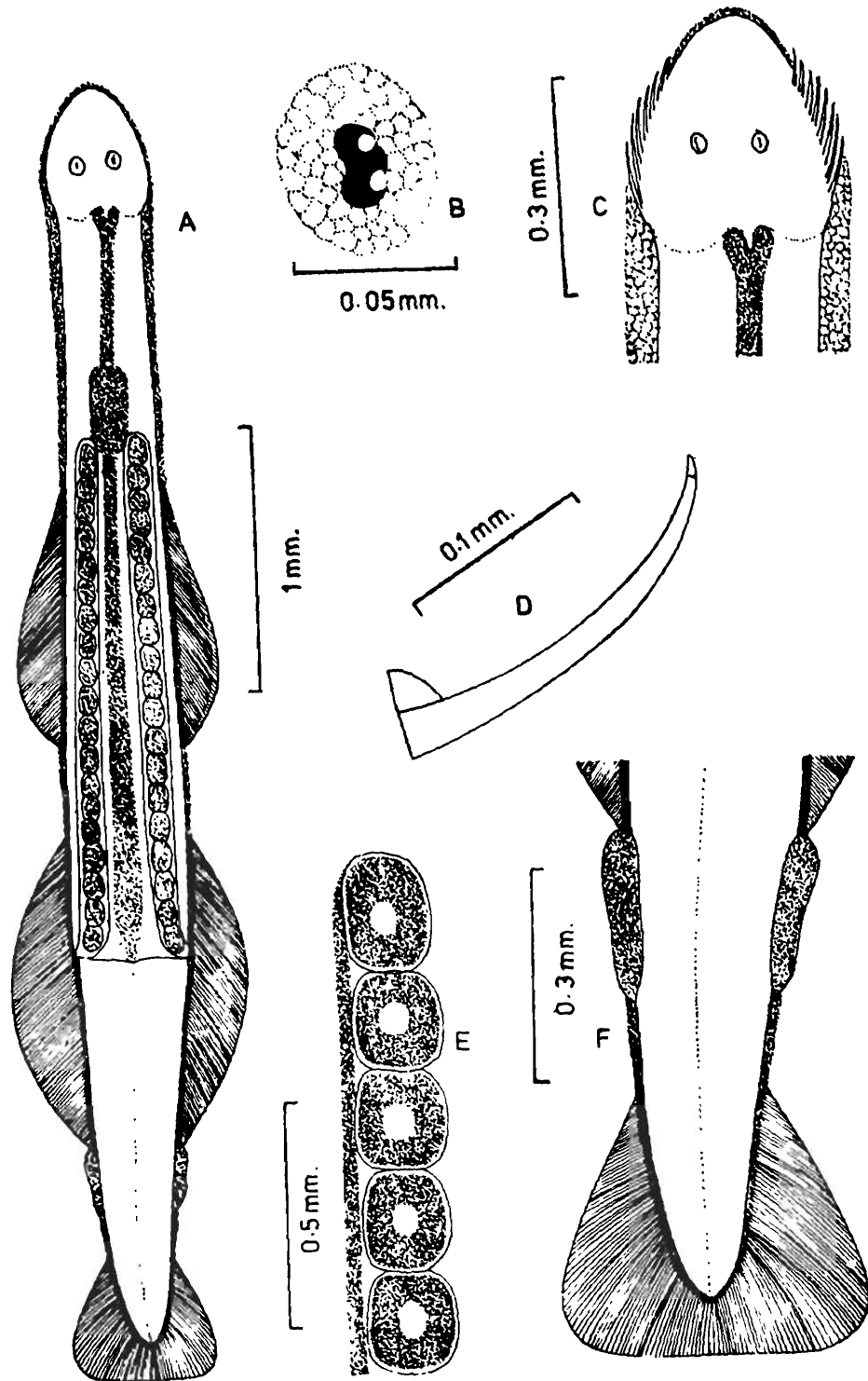


Fig. 17. *Sagitta regularis*—A. Dorsal view; B. Eye; C. Head; D. Hook; E. Arrangement of ova in ovary; F. Posterior portion of tail segment.

Size.—This is the smallest species of the phylum Chaetognatha, from the west coast of India and it measures between 4 and 5.5 m.

Body.—Body is of uniform size from head to the tail septum, opaque and rigid due to strong, thick longitudinal muscles. Intestinal diverticula are present.

Head.—The head is smaller than the body. The differentiation between the head and body is not clear. The head is pointed and fully covered with collarette, that extends from the head to the anterior lateral fins as a thick layer and then extends to the tip of tail segment as a thin layer. This is the only species that is fully covered with collarette from top to bottom.

The prehensile hooks are small and vary from 6 to 8 on either side of the head. Anterior teeth number between 3 and 5 and posterior teeth between 5 and 8 on either side of the head.

Eyes.—The eyes are bigger in size, when compared with the head size and have a central pigmented region.

Tail segment.—This occupies 33 to 34% of the animal length. The constriction at tail septum is not very prominent.

Ventral ganglion.—This is comparatively bigger in size and situated at $\frac{1}{4}$ th distance from the anterior end.

Anterior lateral fins.—These fins originate behind the level of the ventral ganglion. They are smaller and narrower than the posterior lateral fins and measures between 20 and 22% of the animal length. The fins are fully rayed.

Posterior lateral fins.—The origin of these fins are closer to the end of anterior lateral fins and they extend up to the seminal vesicles. They measure from 25 to 27% of the animal length. The fins are fully rayed. More than 75% of the fins are seen on the tail segment.

Male gonad.—The seminal vesicles are in touch with the posterior lateral fins and separated from the caudal fin by a small layer of collarette. The seminal vesicles are oval in shape with a bulged anterior portion.

Female gonad.—Ovarian tubes are long, wide and in matured specimens, they grow up to the ventral ganglion. The ova are large, spherical and compactly arranged in a single row.

Distribution.—This is an epiplanktonic species reported from the upper 200 m of the Indian and Pacific Oceans.

Ecology.—This is a stenohaline, oceanic species, seen in abundance in the off-shore waters of the seas, than in the neritic waters (Srinivasan, 1976). This has not been reported from the West Coast of India, where the depth is less than 20 m.

Sagitta robusta Doncaster, 1903

(Fig. 18)

George, 1949, 1952; Silas and Srinivasan, 1969, 1970; Nair, 1972; Srinivasan, 1976, 1977; Nair and Rao, 1973; Rao and Nair, 1973.

Size.—The specimens obtained from the west coast vary in length from 5.5. to 13.0 mm.

Body.—This species is characterised by the opaque, uniform and robust body. The body is firm due to thick and strong longitudinal muscles. The intestinal diverticula are present.

Head.—The head is very prominent, large, well differentiated from the trunk by a neck. A well developed collarette is seen from neck to the ventral ganglion region, behind that it continues as a thin layer up to the tip of the tail.

The prehensile hooks are strong, well curved and vary between 7 and 8 on either side of the head. Anterior teeth vary between 5 and 10 and posterior teeth between 10 and 15.

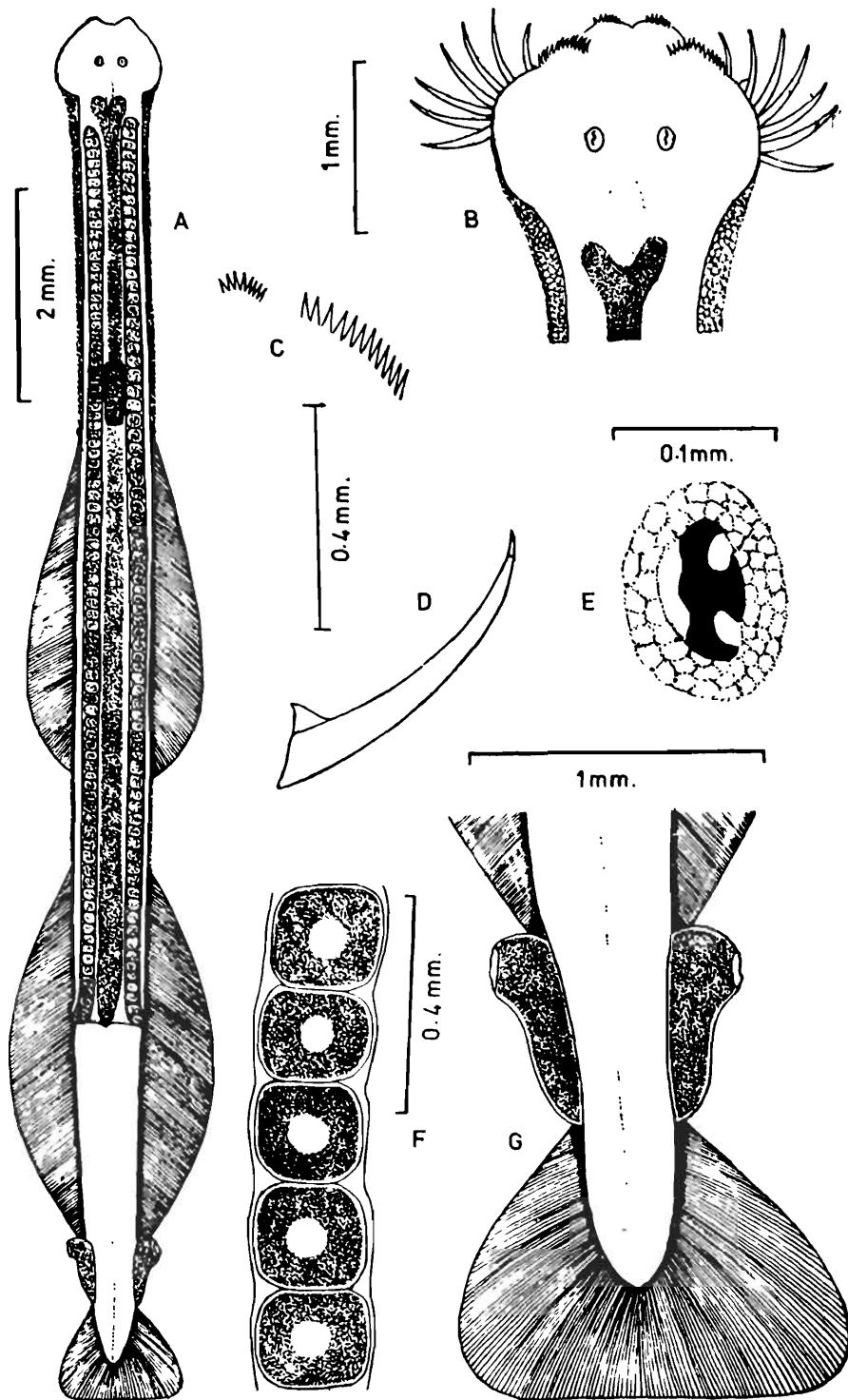


Fig. 18. *Sagitta robusta*—A. Dorsal view; B. Head; C. Anterior and Posterior teeth; D. Hook; E. Eye; F. Arrangement of ova in ovary; G. Posterior portion of tail segment.

Eyes.—Eyes are spherical and have a pigmented region at the centre.

Tail segment.—The tail segment measures between 27 and 29% of the animal length, and well demarcated from the trunk by a tail septum.

Ventral ganglion.—This is situated roughly at $\frac{1}{3}$ distance from the anterior end of the animal.

Anterior lateral fins.—These fins start behind the level of the ventral ganglion and are smaller than the posterior lateral fins. They measure from 19 to 22% of the animal length. The fins are fully rayed.

Posterior lateral fins.—These are longer and broader than anterior lateral fins and they measure between 24 and 26% of the animal length. The posterior end reaches up to the seminal vesicles. More than half of the fin is seen on the trunk segment. These fins are fully rayed but for a small region near the tail septum, where the rays are absent.

Male gonad.—The seminal vesicles are in touch with both the posterior lateral and caudal fins. They are oval in shape, with an anterior broad head region and a narrow posterior body region. The seminal vesicles break open along the anterolateral margin, through which the sperms are liberated.

Female gonad.—Ovarian tubes are long, wide and extend even up to the neck region in matured specimens. Ova are spherical and arranged in a single row.

Distribution.—This is an epiplanktonic species, seen in the upper 200 m of the Indian and Pacific Oceans.

Ecology.—This is an Oceanic species seen in abundance in the offshore waters than in neritic waters. This has been reported once from the Cochin backwaters (Nair, 1972), near the Fairway Buoy, where the salinity was 30.0‰.

Genus **Pterosagitta** Costa, 1869

Species of this genus have only one set of lateral fins on the tail segment and two sets of teeth on either side of the head. This has only one species namely *Pterosagitta draco*.

Pterosagitta draco (Krohn, 1853)

(Fig. 19)

George, 1952; Silas and Srinivasan, 1969; 1970, Srinivasan, 1972, 1976; Nair and Rao, 1973; Rao and Nair, 1973.

Size.—Total length of the specimens obtained from the West Coast of India vary from 4 to 7 mm, whereas the specimens of Pacific Ocean grow upto 10 mm.

Body.—Body is short, stumpy, robust and opaque due to strong and thick longitudinal muscles. The width of the animal is uniform from head to tail septum. Intestinal diverticula are absent.

Head.—Head is larger than body and clearly differentiated from the trunk by a neck. The number of prehensile hooks varies from 8 to 9, anterior teeth 7 to 8 and posterior teeth 12 to 17. The characteristic feature of this species is the possession of a well developed wing like collarette from the head to the seminal vesicles as a thick layer and then continues as a thin layer up to the tip of the tail segment.

Eyes.—The eyes are oval in shape with a central pigmented region.

Tail segment.—This occupies roughly half of the animal length and it ranges from 42 to 45% of the total length. The constriction at the tail septum is clear.

Ventral ganglion.—This is situated more or less at the central region between the head and tail septum.

Lateral fins.—This species has only one pair of lateral fins corresponding to the posterior lateral fins of the genus *Sagitta*. The fins are semi-circular in shape, originate at the level of tail septum and extend up to the seminal vesicles. The fins are fully rayed. The length of the fin varies from 21 to 24% of the animal length.

Male gonad.—Seminal vesicles are in touch with both the lateral and caudal fins. They are elongated with a bulged anterior portion. Bursting of the vesicles takes place along the anterior lateral margin, through which the sperms are liberated.

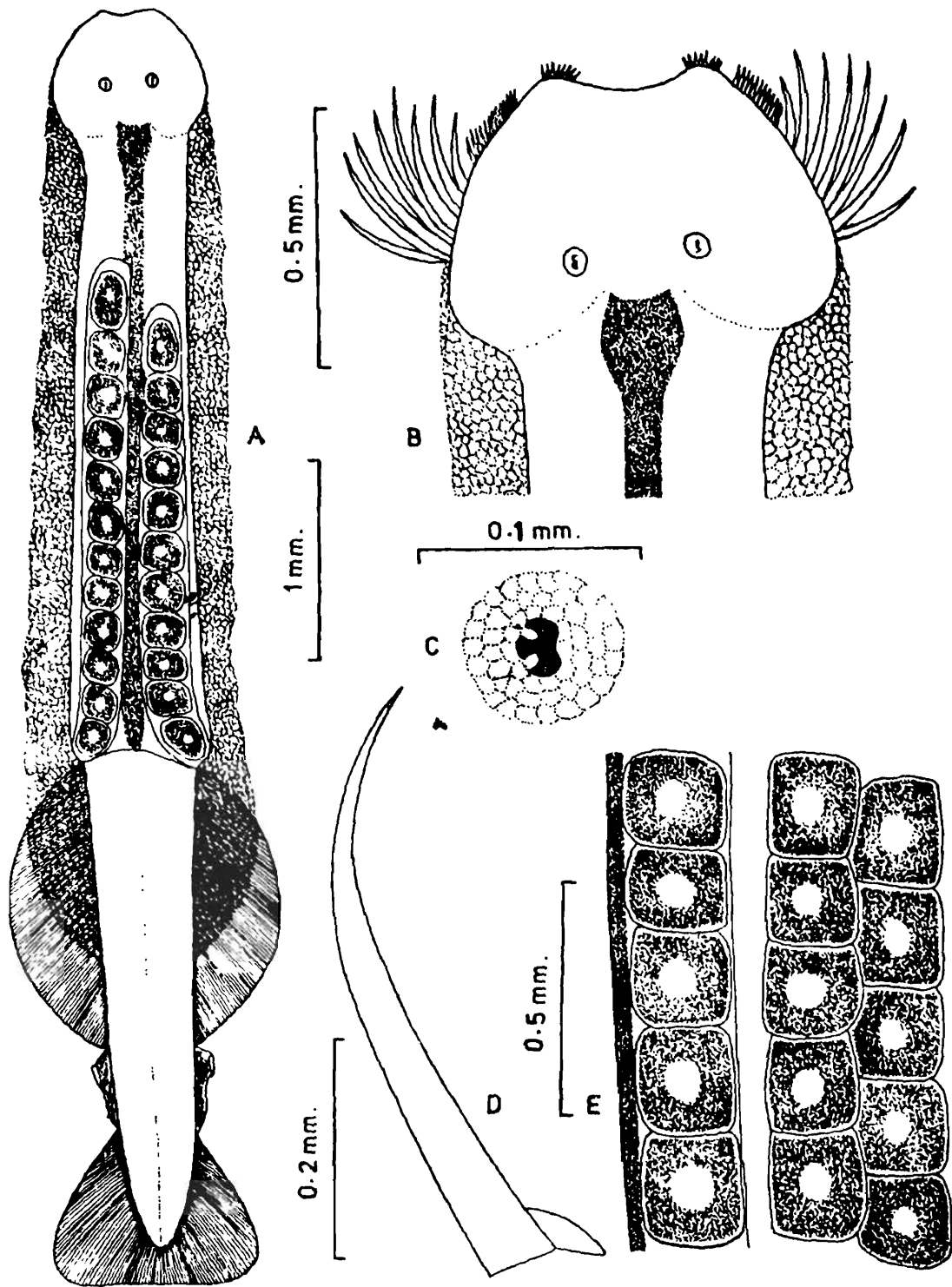


Fig. 19. *Pterosagitta draco*—A. Dorsal view; B. Head; C. Eye; D. Hook; E. Dorsal and lateral views of arrangement of ova in the ovary.

Female gonad.—Ovarian tubes are long, thick and in matured specimens, they extend even up to the neck region. The ova are large, spherical and compactly arranged in two rows.

Distribution.—This is a cosmopolitan species seen in the epiplanktonic waters of the Atlantic, Indian and Pacific Oceans.

Ecology.—This is a stenohaline, oceanic species, found in abundance in the offshore areas of the west coast of India during the premonsoon and post monsoon periods (Srinivasan, 1976). This is not at all seen in areas where the depth is less than 20 m.

Genus **Krohnitta** Ritter-Zahony, 1910

Species of this genus are characterised by the presence of only one pair of lateral fins on the trunk and tail segments corresponding to the posterior lateral fins of the species of the genus *Sagitta*, one set of teeth on either side of the head as in *Eukrohnitta*, and spatula shaped caudal fins. This genus has only two species namely *K. pacifica* and *K. subtilis* and these are epiplanktonic forms.

Krohnitta pacifica (Aida, 1897)
(Fig. 20)

George, 1952; Silas and Srinivasan, 1968, 1969, 1970; Nair, 1972; Srinivasan, 1972, 1976; Nair and Rao, 1973; Rao and Nair, 1973.

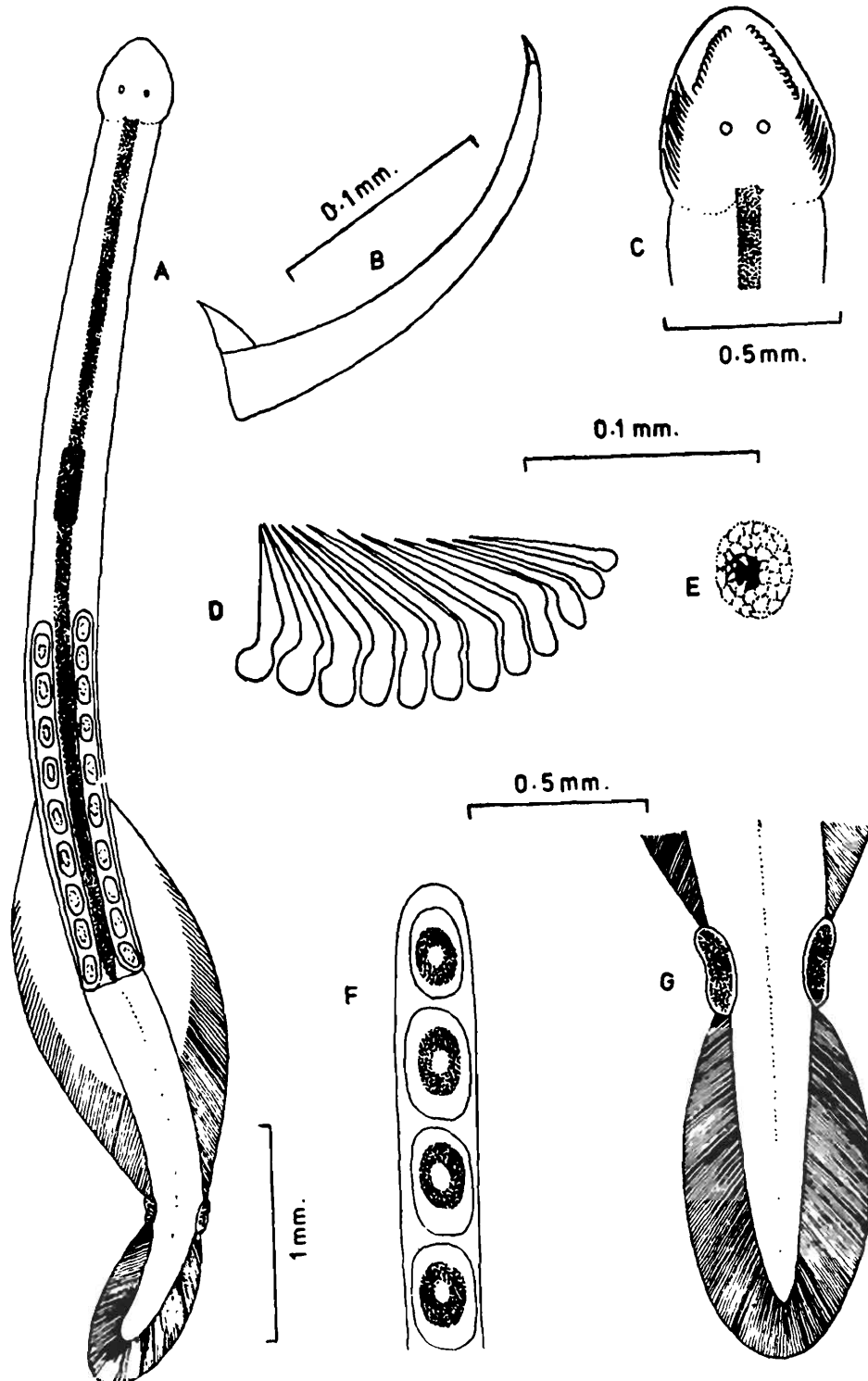


Fig. 20. *Krohnitta pacifica*—A. Dorsal view; B. Hook; C. Head; D. Arrangement of teeth; E. Eye; F. Arrangement of ova in ovary; G. Posterior portion of tail segment.

Size.—The total length of the specimens varies from 5 to 7 mm.

Body.—This species has a slender, flexible, long, transparent body with uniform width from neck to seminal vesicles. The body is not firm due to weak longitudinal muscles. Intestinal diverticula are absent.

Head.—Head is smaller than the body and well differentiated from the trunk by a neck. The collarette is absent at the neck and other regions of the body.

The prehensile hooks vary from 8 to 10 on either side of the head. The hooks are long, thin, curved well and pointed. There is only one set of teeth on either side of the head and the number varies from 9 to 12. The teeth have a flat base and pointed tips and arranged in the shape of the triangle.

Eyes.—The eyes are spherical, small and have a bean shaped central pigmented region.

Tail segment.—The tail segment varies in length from 30 to 32% of the animal. It is conical in shape and separated from the trunk by a tail septum.

Ventral ganglion.—This is situated roughly at $\frac{1}{3}$ distance from the anterior end of the animal.

Lateral fins.—This species has only one pair of lateral fin. The fins originate at the middle region of the body and extend to the seminal vesicles. Fin rays are seen only along the two-third outer margin of the fins. Caudal fin is oval in shape and is in contact with the seminal vesicles. The fin is fully rayed.

Male gonad.—The seminal vesicles are in touch with both the lateral and caudal fins. They are large, oval in shape and open along the anterolateral margin through which the sperms are liberated.

Female gonad.—Ovarian tubes are long and extend to the start of the lateral fins in matured specimens. Ova are spherical, small and arranged in a single row.

Distribution.—This is a cosmopolitan, epiplanktonic species, seen in the tropical and equatorial waters of Atlantic, Indian and Pacific Oceans. Occasionally this species has been reported from estuaries like Cochin backwaters (Nair, 1972) and Ennore estuary (Srinivasan, 1978).

Ecology.—This species is more abundant in the oceanic waters of the west coast of India than shelf waters (Srinivasan, 1976). This is a stenohaline species, seen in areas where the salinity is more than 30‰. This has been noticed in Cochin backwaters when the salinity was at its maximum (30 to 33‰).

***Krohnitta subtilis* (Grassi, 1881)**

(Fig. 21)

George, 1952; Silas and Srinivasan, 1969, 1970; Nair and Rao, 1973; Rao and Nair, 1973; Srinivasan, 1976.

Size.—Total length of the specimens from the west coast of India varies between 7 and 11.5 mm. Specimens from other areas (Atlantic and Pacific Oceans) grow upto 16 mm.

Body.—Body is long slender, flaccid, highly transparent and the width is uniform from head to tail septum. The body is flexible due to weak longitudinal muscles. The intestinal diverticula are absent.

Head.—Head is smaller than the body and differentiated from the trunk by a constricted neck. The collarette is absent at the neck and other regions of the body.

The prehensile hooks vary from 7 to 9 on either side of the head and the teeth number from 10 to 13. Teeth are long, pointed and arranged like a triangle as in *K. pacifica*.

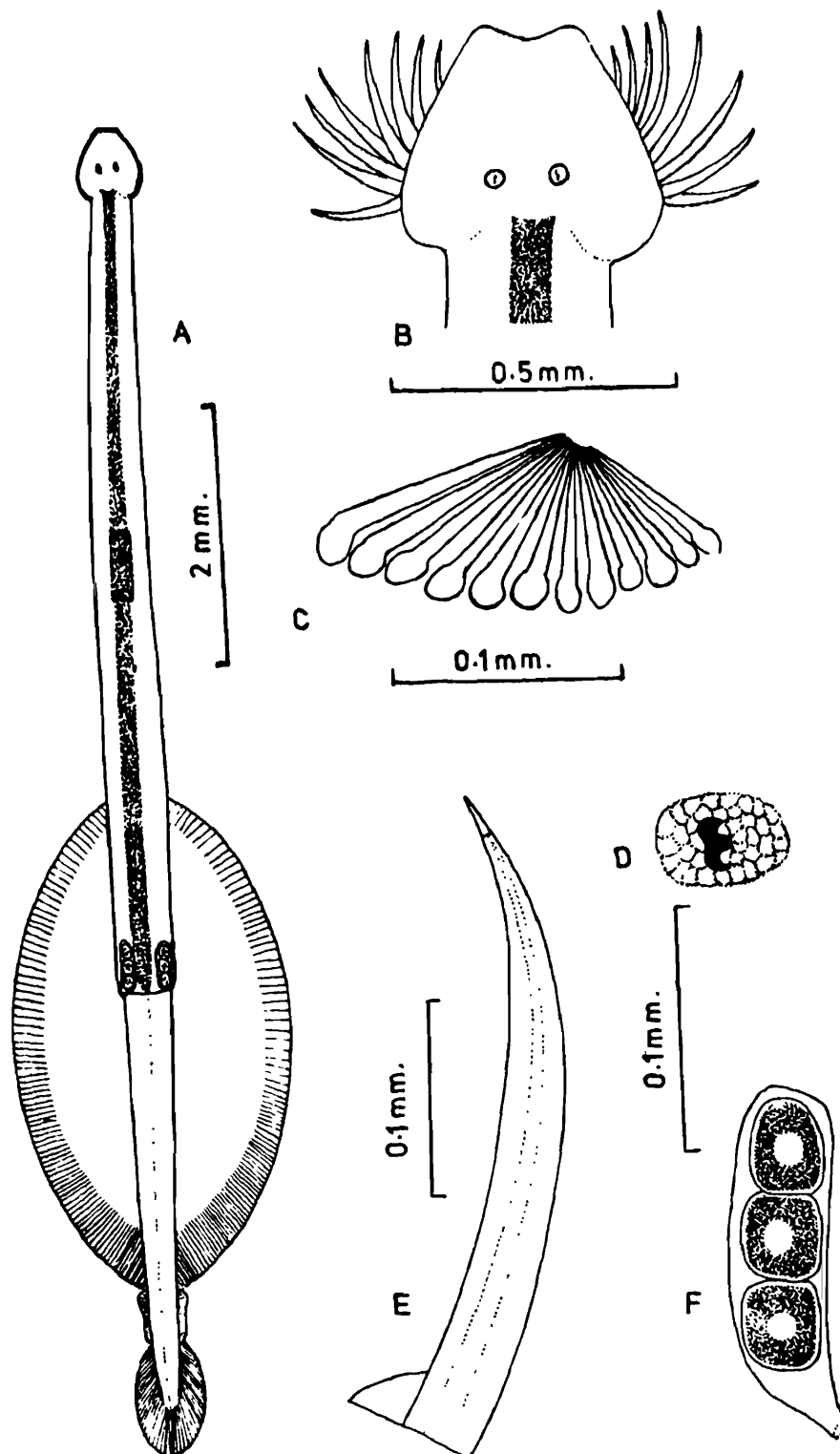


Fig. 21. *Krohnitta subtilis*—A. Dorsal view; B. Head; C. Arrangement of tecth; D. Eye; E. Hook; F. Arrangement of ova in ovary.

Eyes.—The eyes are oval with a central pigmented region.

Tail segment.—This occupies more than $\frac{1}{3}$ of the animal length and the range is between 35 and 38% of the animal. The constriction at the tail septum is very clear.

Ventral ganglion.—This is situated roughly at the middle region between the head and the tail septum.

Lateral fins.—These fins originate at the middle region between the head and tip of the tail segment and extend to the seminal vesicles. More than 60% of the

fins are found on the tail segment and the length of the fin ranges from 32 to 35% of the animal. The fins are very broad, semicircular in shape and the fin rays are sparsely arranged only at the outer margin of the fins.

Caudal fin is spoon shaped. It resembles that of *K. pacifica*.

Male gonad.—Seminal vesicles are elongated, not prominent and located between the lateral and caudal fins. They break open along the anterolateral margin, through which the sperms are liberated.

Female gonad.—Ovarian tubes are short, stout and never extend beyond the start of the lateral fins. Only a few ova are seen arranged in two rows. Ova are large and spherical.

K. subtilis differs from *K. pacifica* mainly in the size and shape of the lateral fins, length of the ovary and arrangement of ova.

Distribution.—This is a cosmopolitan, oceanic species, found in the epiplanktonic region of the tropical and equatorial waters of the Atlantic, Indian and Pacific Oceans.

Ecology.—This is a stenohaline species seen in the upper 200 m of the offshore waters than in the neritic waters. So far this has never been reported from any estuarine areas whereas, *K. pacifica* has been occasionally reported from estuarine waters (Nair, 1972; Srinivasan, 1978).

Genus **Eukrohnia** Ritter-Zahony, 1909

Species of this genus have only one pair of long lateral fins seen on the trunk and tail segments, one set of teeth on either side of the head and usually these are meso or bathy planktonic forms.

Eukrohnia fowleri Ritter-Zahony, 1909

(Fig. 22)

Silas and Srinivasan, 1969; Srinivasan, 1972; Nair and Rao, 1973.

Size.—The specimen obtained from the west coast of India varies in length from 7.5 to 23.0 mm, whereas the specimens of other areas (Atlantic & Pacific) grow upto 40 mm.

Body.—The body is long, stout, opaque and firm due to strong, thick longitudinal muscles. The body is orange in colour and intestinal diverticula are absent.

Head.—The head is prominent, wider than long and has a well developed neck. The collarette is absent at the neck region but seen as a thick layer around the ventral ganglion region, at the tail septum and at the tip of the tail segment.

Prehensile hooks vary from 10 to 13, long, slender with broad base, straight tip and orange colour. There is only one set of teeth on either side of the head.

Eyes.—The eyes are large, oval with a central pigmented region.

Tail segment.—This occupies $\frac{1}{4}$ th of the animal length and varies from 22 to 27% of the animal. The constriction at the tail septum is clear.

Ventral ganglion.—This is situated a little behind the $\frac{1}{4}$ th distance from the anterior end of the animal.

Lateral fins.—These fins originate at the anterior region of the ventral ganglion and extend to the seminal vesicles. Anterior $\frac{3}{4}$ length of the fins are rayless.

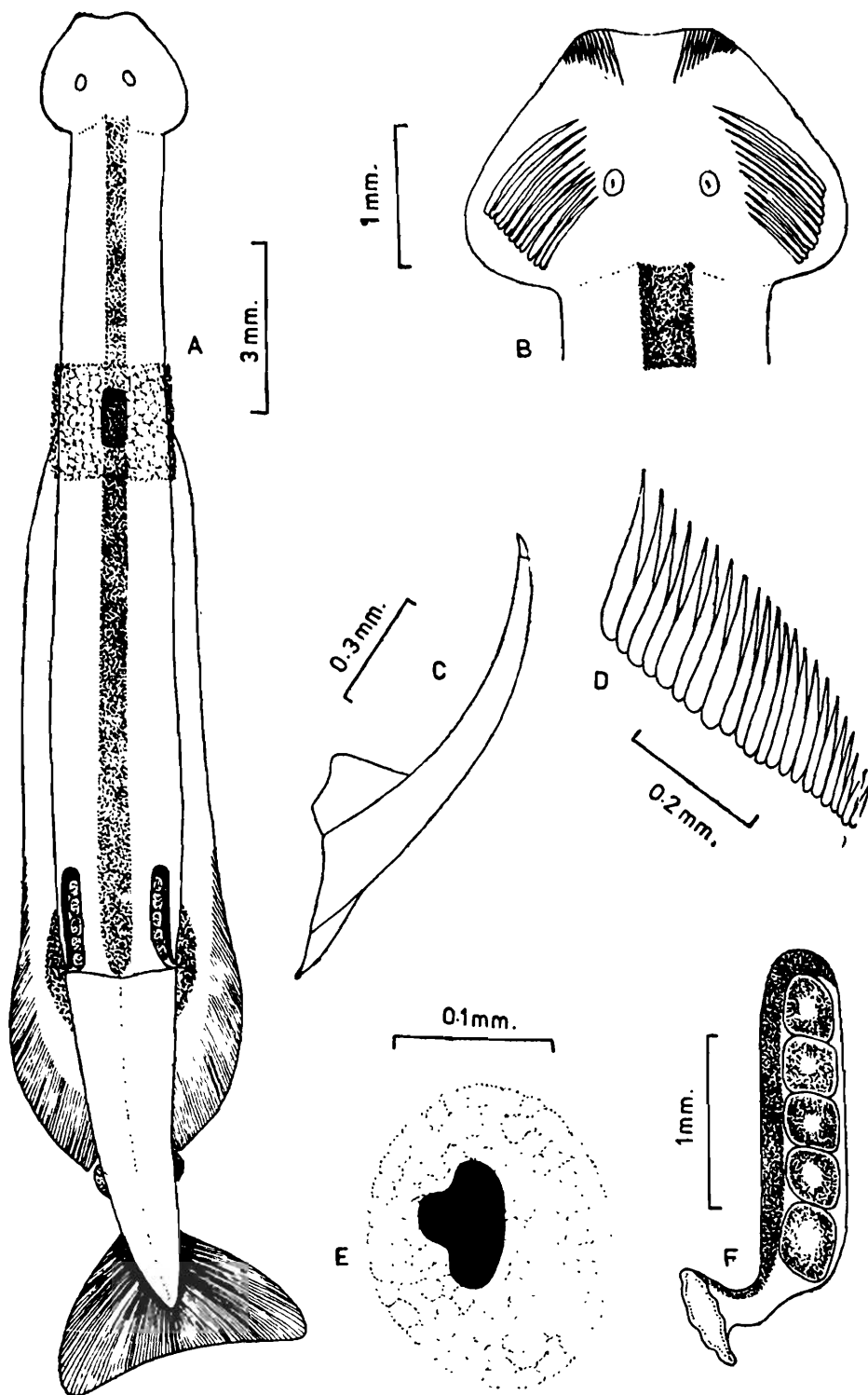


Fig. 22. *Eukrohnia fowleri*—A. Dorsal view; B. Head; C. Hook; D. Arrangement of teeth; E. Eye; F. Arrangement of ova in the ovary.

Male gonad.—The seminal vesicles are located close to the lateral fins, oval in shape and break open along the lateral margins, through which the sperms are liberated.

Female gonad.—Ovarian tubes are short, stout and stumpy. Ova are large spherical and arranged in two rows.

Distribution.—This is a cosmopolitan oceanic species, seen in the bathypelagic waters of the Atlantic, Indian and Pacific Oceans.

Ecology.—This is a stenohaline, Oceanic species, usually seen in abundance below 1000 m depth. This is always associated with cold waters of low temperature, low oxygen and high salinity. From the west coast of India this has been reported below 600 m depth. But the specimens are seen in large numbers in the samples collected from 1200 m depth (Silas and Srinivasan, 1969). From the Pacific Ocean Sund (1961) has reported from 430 m depth where the temperature was 8.9°C and salinity was 34.65‰.

Eukrohnia minuta Silas and Srinivasan, 1969

(Fig. 23)

Srinivasan, 1972.

Size.—This is the smallest species of the genus *Eukrohnia* and the length of the specimens varies from 5.6 to 12.0 mm. The other species of this genus are much larger (more than 25 mm) in size.

Body.—The body is slender, opaque and firm due to strong and wavy longitudinal muscles. The intestinal diverticula are absent.

Head.—The head is prominent, wider than long, its width being more than 1.5 times or more than its length. Papillae are seen at the tip of the head. The head is clearly demarcated from the trunk by a fragile neck because of which usually the head breaks off from the trunk. The collarette is not seen at the neck region, but seen as a thin layer at the tail segment and at the origin of the tail fin.

The prehensile hooks number from 7 to 9 on either side of the head. The tip of the hooks are straight and not curved as in *E. bathypelagica* and *E. hamata*. Small serrations are noted on the inner margin of these hooks. The number of serrated hooks and the number of serrations in each hook varies according to the maturity stages. As the animal grows, a decrease in the number of serrated hooks out of the total number of hooks and the number of serrations in each hooks is seen (Silas and Srinivasan, 1969). In fully matured specimen only one or two serrated hooks are seen and each with one to three serrations.

Only one set of teeth is seen on either side of the head and the teeth number in each set varies from 8 to 14.

Eyes.—The eyes are minute, oval, unpigmented and its length is more than 1.5 times of its width.

Tail segment.—This occupies 27 to 35% of the animal length and a clear constriction is seen at tail septum. In matured specimens the tail segment is robust, filled with sperms and anteriorly bulges into the trunk as two lobes.

Ventral ganglion.—This is seen at $\frac{1}{4}$ th distance from the anterior end of the animal. The length of the ganglion is greater than the width of the body at the ganglion region.

Lateral fins.—These fins originate at the level of the middle region of ventral ganglion and extend to the anterior $\frac{1}{3}$ of the tail segment. They are broader at the region of tail septum. Only the posterior $\frac{1}{3}$ of the fins are rayed. The rayed portion of the fins is very thin, delicate and the fin rays are sparsely arranged. The tip of the fins are free from the tail segment.

Male gonad.—Seminal vesicles are not prominent and situated closer to the lateral fins, than the caudal fin. They are elongated and break open along the lateral margin, through which the sperms are liberated.

Female gonad.—Ovarian tubes are short, thin and less than 10% of the animal length. Ova are small, spherical and arranged in a single row.

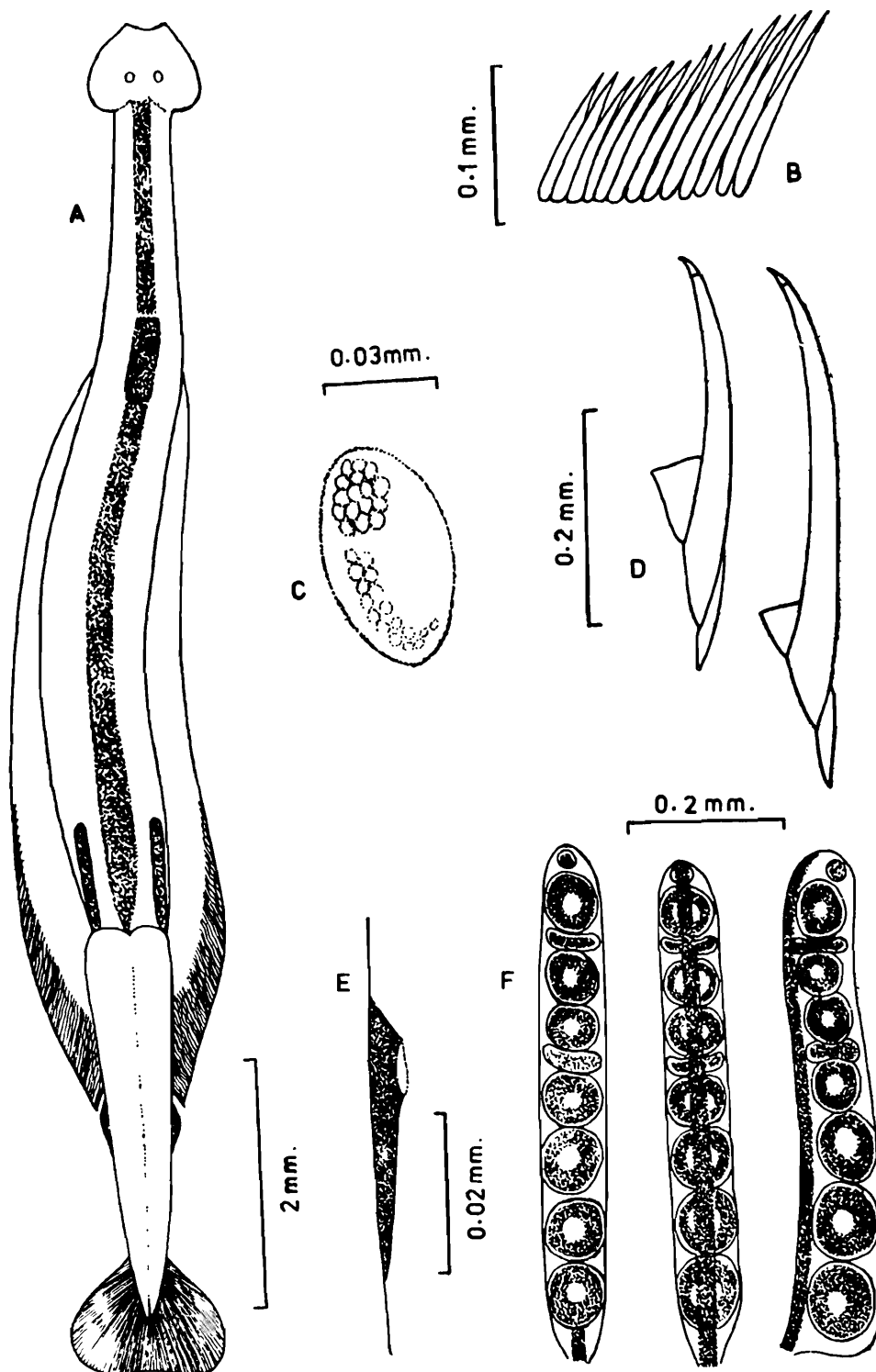


Fig. 23. *Eukrohnia minuta*—A. Dorsal view; B. Arrangement of teeth; C. Eye; D. Hooks; E. Seminal Vesicles; F. Dorsal Ventral and lateral views of ovary.

Distribution.—This is an endemic species, reported from the meso-pelagic realms of the west-coast of India (Silas and Srinivasan, 1969; Srinivasan, 1972).

Ecology.—This is an oceanic species, found in the subsurface cold waters with low temperature, low oxygen content and high salinity. The minimum depth from which this species was obtained is 350 m. This clearly indicates the meso-pelagic habitat of this species.

POSSIBLE USE OF CHAETOGNATHS AS INDICATOR ORGANISMS

As stated earlier, emphasis is laid on the studies of Chaetognatha, in view of their close association with particular watermasses. As stated by Russel (1935) this association appears very useful in identifying a particular watermass in a region where there are several bodies of water whose salinity differences are not well marked. As such only the planktonic species could provide information on the origin of such waters.

This quality of associating with specific hydrographic features of the watermasses cannot be attributed to all the species of the Phylum Chaetognatha. Among the chaetognaths, only a few species are confined to one watermass. Species of Chaetognatha, could be divided into 3 types on the basis of their association with the watermasses (Sund, 1961).

The first type includes (epiplanktonic) species like *S. bedoti*, *S. ferox*, *S. pacifica*, *S. robusta*, *K. pacifica* and *P. draco*, that are confined to only one watermass. Meso and bathy-planktonic species like *S. decipiens*, *S. macrocephala*, *S. maxima*, *E. fowleri*, *S. lyra* and *E. minuta* are grouped under the second type. These species are associated with more than one type of watermasses, and restricted to deep waters. The third type includes the cosmopolitan species like *S. inflata* which is not at all confined to any specific watermass. This species can tolerate a wide salinity range and as this is not confined to any particular watermass, this species has no value as an indicator of a particular watermass and its movements.

Atlantic species like *S. elegans* and *S. setosa* are coming under the first type. Russel (1935) has very clearly pointed out that *S. elegans* lives in a body of watermass that is different from the watermass in which *S. setosa* lives. *S. elegans* is an oceanic species, whereas *S. setosa* is a neritic species. The possible use of *S. elegans* as an indicator of incursion of oceanic waters into the English Channel has been well pointed out by Russel (1935).

Along the west coast of India, *S. hexaptera*, *S. hispida*, *S. pacifica*, *S. regularis*, *S. robusta*, *K. pacifica* and *P. draco* show a rhythmical movement from one season to another season. These species are widely distributed in the continental shelf and adjacent oceanic waters during the premonsoon (February–April) and post-monsoon (October–December) periods, whereas during the South-West monsoon period (June–August) they are sparsely distributed or absent particularly in the shelf waters (Srinivasan, 1976).

Recently Srinivasan (1976) has pointed out the possible use of *S. decipiens* as an indicator of upwelling along the west coast of India. This is a mesoplanktonic species seen in subsurface cold waters with low temperature, low oxygen and high salinity. In the tropical waters, this species is usually seen below 150 m depth.

While examining the zooplankton samples collected within the continental shelf and outside the shelf areas of the west coast of India, (samples were collected from 200 m in the areas outside the shelf and from 5 m above the bottom in the shelf areas) *S. decipiens* was noticed in all the samples collected from the areas outside the continental shelf areas. Whereas, in the samples collected from the areas within the continental shelf this species was noticed only in the samples collected during October and December (Srinivasan, 1976). As already stated, *S. decipiens* is a mesoplanktonic species usually seen below 150 m depth. So the presence of this species along the west coast of India, within the continental shelf region at very shallow depth (40 m) appears to be of interest. When the hydrographic features of the water samples obtained from this depth was analysed, it was found that the temperature was very low (22°C at 40 m depth and 10°C at 90 m depth). But during other months of the same year the temperatures at these depths were well above 28 and 25°C respectively (Fig. 24).

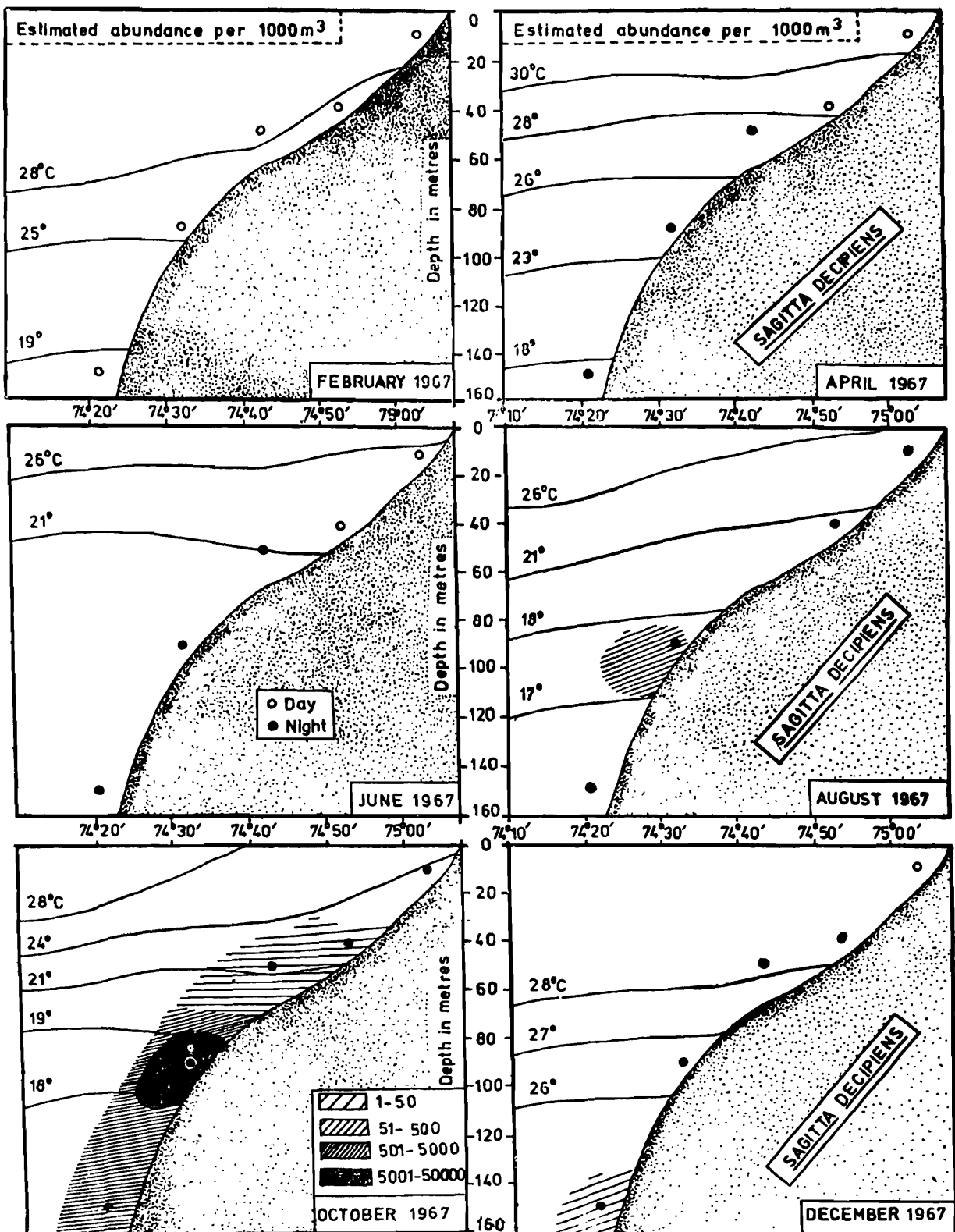


Fig. 24. Vertical Section of temperature plotted against the distribution of *S. decipiens* at 12° 12' N.

The presence of *S. decipiens* along the west coast of India at very low depths (40 m) during a particular period of an year, clearly shows that this species is not a permanent resident of this area and it has been brought to this shelf area only during a particular period. This leads one to conclude that the entire watermass has been transported from the subsurface cold water areas to the surface and along with the watermass, this species is also transported. As this species is always associated with a particular watermass of low temperature, low oxygen and high salinity,

this species could be used as an indicator for identifying the deep waters and their movements.

It has already been well established that upwelling off the south west coast of India starts with the onset of South-west monsoon (June) lasts throughout the monsoon (June–August) and the colder waters retreats during the later half of October (Banse, 1968; Ramamirtham and Jayaraman, 1961). So it is quite obvious that along with the upwelled cold waters, *S. decipiens* is also transported into the shelf region of the south west coast of India and when the colder waters retreat back this species is also transported back to its original meso-pelagic realm. This appears to be the possible explanation for the presence of this meso-planktonic species at this shallow depth for a brief period.

Further, Alvarino (1964, 1967) has pointed out the presence of *S. decipiens* in the upper 200 m off California indicates the process of upwelling. All these observations lead one to conclude that the occurrence of *S. decipiens* in early October, during the upwelling along the south west coast of India is significant and it could be used as a possible indicator of upwelling along the west coast of India.

However, further detailed investigations based on regular standard collections in these areas for successive years are essential to have a better understanding about the use of *S. decipiens* as an indicator of upwelling along the west coast of India.

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