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ON THE LITTLE KNOWN CHAETOGNATHA *SAGITTA BOMBAYENSIS* LELE AND GAE (1936) FROM INDIAN WATERS*

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INTRODUCTION

THE need for a redescription of the little known Chaetognatha *Sagitta bombayensis* Lele and Gae (1936) first described from the Bombay Harbour and subsequently recorded by Rao and Kelly (1962) from Lawson's Bay, Waltair, is evident from the recent review of 'Chaetognaths' by Alvarino (1965). George (1949, 1952) considered *S. bombayensis* a synonym of *S. robusta* Doncaster (1903), but Rao and Kelly (1962) have drawn attention to a few differences between these two species, at the same time also recognising three stages of maturity which are inadequately described. Apparently the types, one mature and two immature specimens, have not been saved, as Lele and Gae (1936) do not mention of these being deposited in any recognised collection. Hence, in November 1966 one of us (E.G.S.) made special plankton collections from the Bombay Harbour using a half-metre ringnet of No. 20 Swiss Silk Bolting cloth for obtaining topotypes of *S. bombayensis* to enable a redescription of the species as well as for a taxonomical reappraisal of it. A graded series of the specimens obtained has enabled us to recognise five stages of maturity (including 0-stage) all of which are described and illustrated in this account. The topotypes are deposited in the research collection of the Central Marine Fisheries Research Institute, Mandapam Camp.

Since *S. bombayensis* has been confused with *S. robusta* and its affinities to *S. regularis* has also been mentioned by earlier authors, we have taken this opportunity to compare our material with the latter two species. The specimens of *S. regularis* have been obtained in the same plankton hauls from the Bombay Harbour, and *S. robusta* from the plankton collections made during the cruises of the Research Vessel *VARUNA* off the south-west coast of India.

Sagitta bombayensis Lele and Gae (1936)

Sagitta bombayensis Lele and Gae, 1936. *J. Univ. Bombay*, 4 (5) : 111-113, pl. 1. fig. 3, text-fig. 3a-c (Type locality : Bombay Harbour, India) ; Rao, 1958, *Andhra Univ. Mem. Oceanogr.*, 2 : 137 (Lawson's Bay, Waltair : name only) ; Rao and Kelly, 1962. *J. zool. Soc. India*, 14 (2) : 226-229 (Lawson's Bay, Waltair : brief description and notes) ; Alvarino, 1965. *Oceanogr. Mar. Biol. Ann. Rev.*, 3 : 115 194 (name only in Table I) ; Tokioka, 1965. *Publ. Seto Mar. Biol. Lab.*, 12 (5) : 344 (Name only).

Sagitta robusta George, 1949 (*nec* Doncaster, 1903). *Curr. Sci.*, 18 (12) : 448-449 ; George, 1952. *Proc. Natl. Inst. Sci., India*, 18 (6) : 668-669.

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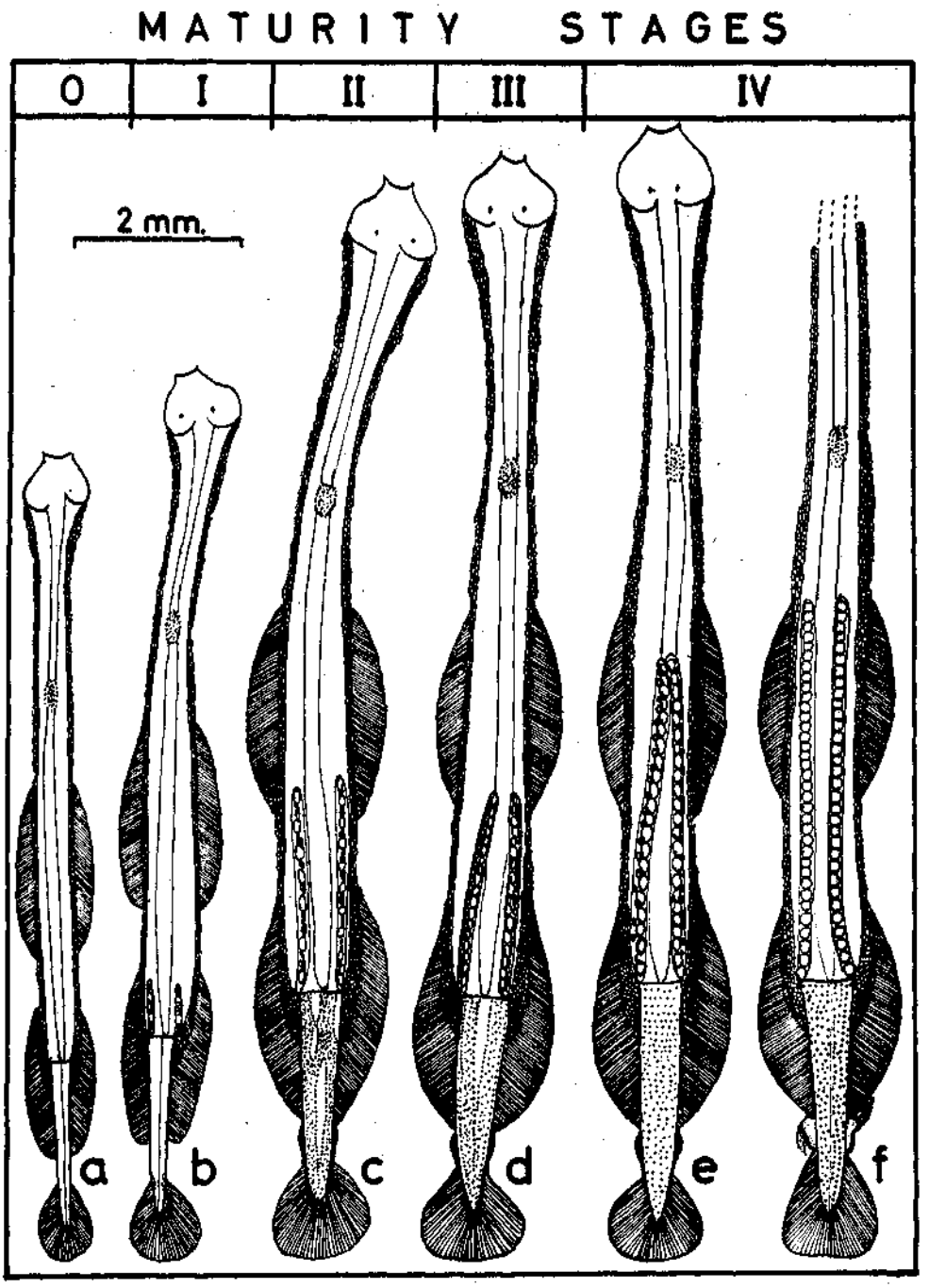

FIG. 1. *Sagitta bombayensis* Lele and Gae. *a-f*: Dorsal view of the five maturity stages. Head is not shown in figure *f* of stage IV.

Material : All specimens mentioned below were collected on 3-11-1966 from Bombay Harbour as follows : 103 specimens in 10 minutes oblique haul from 10 m. to surface at 07.30 hours ; 1 specimen in 10 minutes oblique haul from 9 m. to surface at 07.45 hours ; and 1 specimen from vertical haul from 10 m. at 08.10 hours.

Description : We are able to recognise five maturity stages including the 0-stage of *S. bombayensis* as shown in table I. The maturity stages are also illustrated to indicate specially the nature and disposition of the seminal vesicles, ovaries and maturing ova. Spent specimens corresponding to Stage V were not obtained in these collections though the plankton samples had several extruded eggs apparently belonging to this species.

TABLE I

Stages of maturity	Male organ	Female organ	Figure reference
O	Testes not developed	Ovaries not developed	Fig. 1*a*, Fig. 2*a*.
I	Testes begin to appear with few sperms towards tail-end, but seminal vesicles wanting.	Ovaries seen as thin tubes not extending beyond anterior end of posterior fins. Ova minute, except a few slightly enlarged ones.	Fig. 1*b*, Fig. 2*b*, and Fig. 3*a*.
II	Tail not completely filled with sperms; seminal vesicles make their appearance as lateral ridges, slightly more prominent anteriorly.	Ovaries reach middle of anterior fins; developing ova usually oval in shape and large number of minute undeveloped ova present between these.	Fig. 1*c*, Fig. 2*c*, and Fig. 3*b*.
III	Tail more or less completely filled with sperms ; seminal vesicles laterally enlarged.	Ovaries will not extend beyond beginning of anterior fins ; ova of most advance mode large, oval to rounded, uniserial, and compactly arranged touching each other ; undeveloped ova present as a continuous string laterally.	Fig. 1*d*, Fig. 2*d* and Fig. 3*c*.
IV	Tail completely filled with sperms and seminal vesicles greatly enlarged, anteriorly spout-shaped when discharging.	Ovaries do not extend beyond ventral ganglion ; ova greatly enlarged, round, compactly uniserially arranged with minute undeveloped ova placed in small clusters between large ova along base.	Fig. 1*e*, *f*, Fig. 2*e* ; and Fig. 3*d*.

The frequency of occurrence of the hooks, the anterior and posterior teeth in relation to the maturity stages in *S. bombayensis* is given in table II.

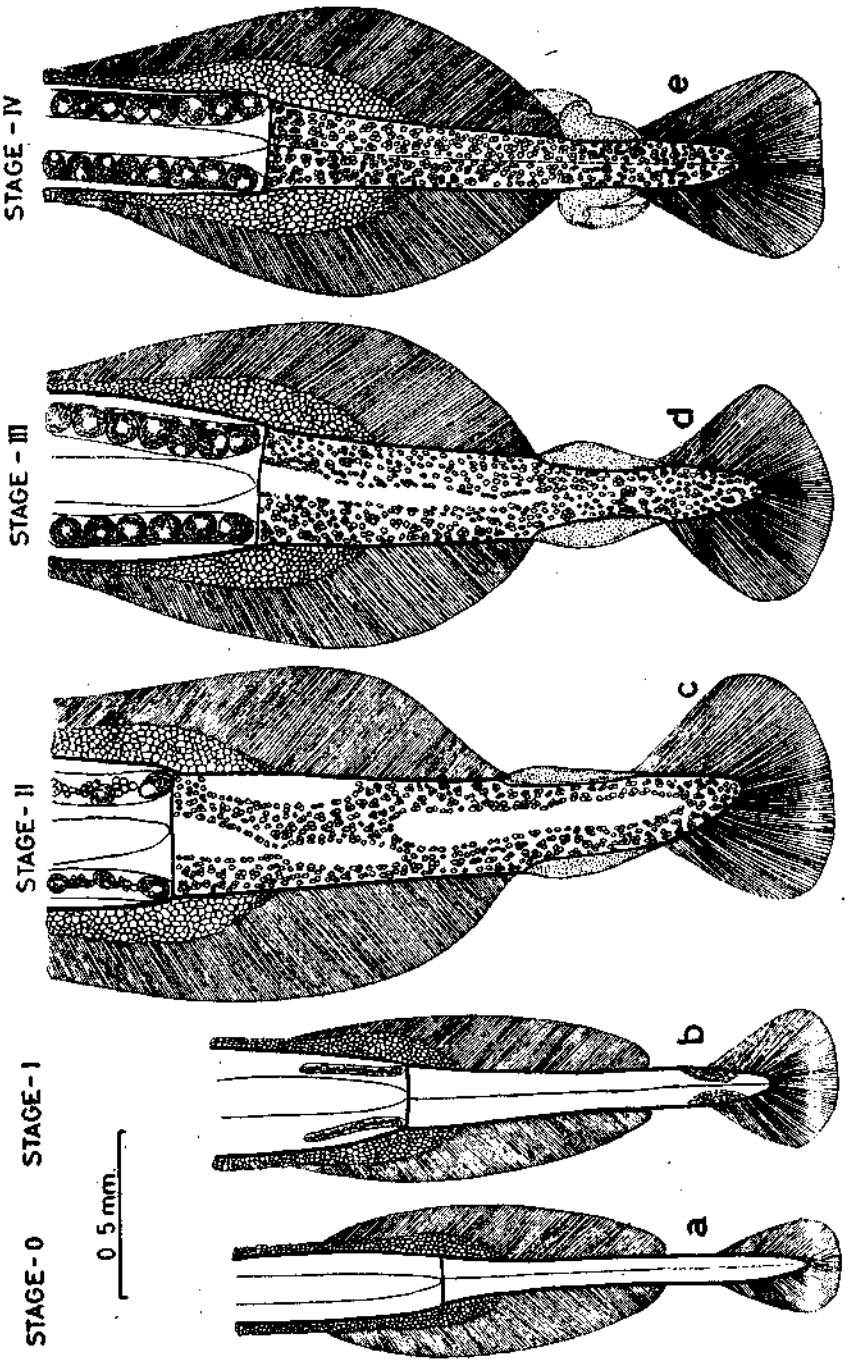

FIG. 2. *Sagitta bombayensis* Lele and Gae. *a-e*. Tail segment in five maturity stages.

TABLE II

Frequency of occurrence of hooks and teeth in S. bombayensis *Lele and Gae*

Stages of maturity	No. of Hooks		No of Anterior teeth						No. of Posterior teeth									
	9	10	5	6	7	8	9	10	14	15	16	17	18	19	20	21	22	23
0	1	2	—	2	1	—	—	—	1	—	1	1	—	—	—	—	—	—
I	—	3	1	1	—	1	—	—	2	—	—	—	1	—	—	—	—	—
II	4	6	—	—	—	5	4	1	—	—	1	1	3	4	—	—	1	—
III	3	7	—	—	—	5	2	3	—	—	—	1	2	2	5	—	—	—
IV	10	15	—	—	—	—	11	13	—	—	—	—	3	1	5	8	6	1

The total length and three other body measurements for 51 specimens of *S. bombayensis* referable to the five maturity stages are given in Table III.

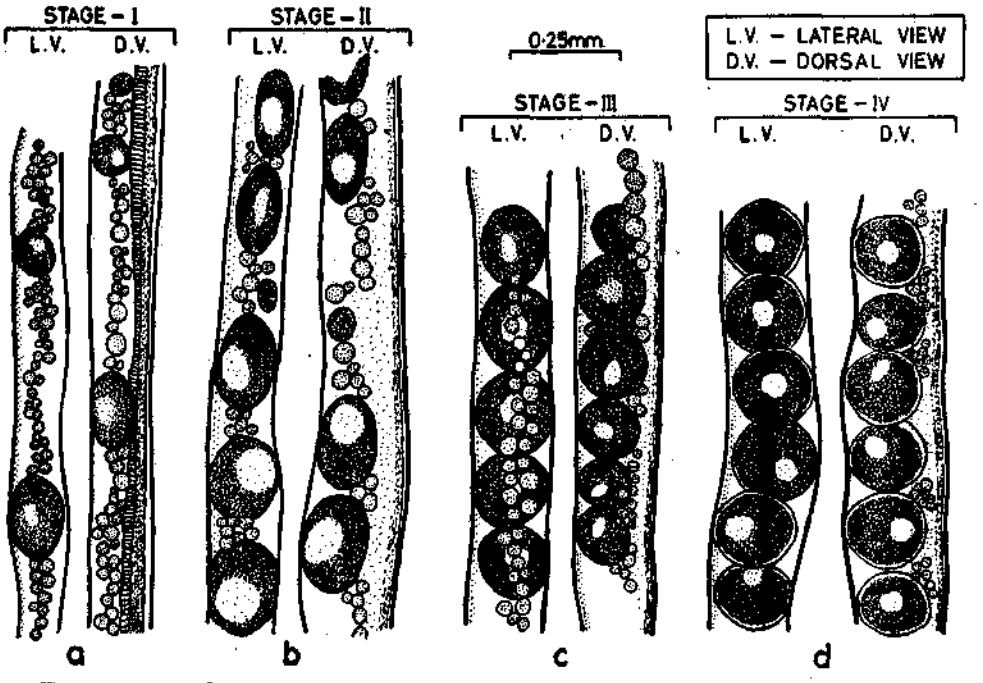

FIG. 3. *Sagitta bombayensis* Lele and Gae. *a-d.* Lateral and dorsal views of part of ovary in maturity stages I to IV.

TABLE III

Measurements of S. bombayensis *Lele and Gae*

Characters	Maturity stages**				
	O	I	II	III	IV
Total length	3 : 7.8-8.1 (7.96)	3 : 7.8-12.5 (9.43)	10 : 12.0-15.0 (13.2)	10 : 12.0-15.0 (13.23)	25 : 12.4-15.2 (13.91)
Tail length	3 : 1.9-2.1 (2.0)	3 : 1.9-3.2 (2.40)	10 : 3.0-4.0 (3.4)	10 : 3.0-4.0 (3.4)	25 : 3.1-4.0 (3.57)
L. of ant. fin	3 : 1.5-1.62 (1.56)	3 : 1.56-2.5 (1.9)	10 : 2.0-2.56 (2.27)	10 : 2.3-2.56 (2.47)	25 : 2.16-2.8 (2.46)
L. of post. fin	3 : 1.3-1.4 (1.3)	3 : 1.36-2.2 (1.66)	10 : 2.2-2.8 (2.5)	10 : 2.48-2.8 (2.66)	25 : 2.24-3.04 (2.62)

** The number of specimens followed by their range, and the mean in parenthesis are indicated. All measurements are in millimetres.

There is an overlap in the total length of specimens belonging to the maturity stages II, III, and IV and a corresponding overlap in the tail length in these species,

The anterior and posterior fins show differential growth with age, the latter which are relatively smaller in stages 0 and I are larger than the anterior fins in mature specimens.

Other details pertaining to the redescription of *S. bombayensis* are given in the ensuing section.

Specific Characters of *S. BOMBAYENSIS* and *S. ROBUSTA*

1. *Total length :* Lele and Gae (1936) remark that their specimens of *S. bombayensis* '. . . vary from 4 mm. to 13 mm. in length,' while they describe one adult of 13 mm. and two immature specimens of 8 and 5 mm. respectively. Rao and Kelly (1962) give the maximum size of *S. bombayensis* from off Waltair Coast as 10 mm. which is too small a size when compared to our Bombay Harbour material, the mature specimens of which are 12.4 to 15.2 mm. In fact, as could be seen from table III, the 10 mm. size corresponds with the size of our specimens in the first stage of maturity. A similar size difference is also noticeable in *S. robusta* the mature size of which was given as 16 mm. by Doncaster (1903), and a maximum size of 17 mm. by George (1952). Rao and Kelly (1962) mention 15 mm. as the maximum length for specimens off Waltair Coast, while specimens from off the south west coast of India are 9.0 to 13.7 mm. *S. robusta* in the Pacific Ocean appears to be still smaller as Alvarino (1962) gives the size of mature specimens as 8 to 12 mm. Apparently the sizes of mature specimens in these two species differ from place to place and show overlap to some extent, making the total length of mature specimens not an effective character for separating the two species. The considerable difference seen in the total lengths of the topotypes and the Waltair Coast material of *S. bombayensis* if holds good should be of interest.

2. *Tail length in relation to total length :* Lele and Gae (1936) remark that the tail in *S. bombayensis* is one-fourth of the body length, while Rao and Kelly (1962) give the range as 24.4 to 27.92 per cent. The topotypes in our collection show a range of 25.0 to 26.3 per cent (mean=25.51 per cent). In 25 mature specimens of *S. robusta* we have examined the tail is 26.4 to 28.94 per cent of the total length (mean =27.54 per cent), and Alvarino (1962) gives the average for the Pacific Ocean material of *S. robusta* as 27.5 per cent. For 10 specimens from Indian waters, George (1952) gives the range as 25.0 to 30.5 per cent (mean=26.26 per cent). However, Rao and Kelly (1962) give the range as 22.87 to 24.5 per cent which is misleading especially as this low range for *S. robusta* agrees to some extent with that of *S. bombayensis.* In this connection, specimens of *S. robusta* from the Waltair Coast would need re-examination. The tail length in relation to the total length is greater in *S. robusta* than in *S. bombayensis.*

3. The *head* in *S. bombayensis* is moderately large, but is not as broad as in *S. robusta.* In five mature specimens of each species the average percentage of width of head in relation to total length is 8.8 per cent and 10.8 per cent respectively.

4. *Width of body :* Body in *S. bombayensis* is elongate and slender, its width at mid-length being about 6.7 per cent (range 6.1 to 7.1 per cent) in total length. In *S. robusta* it is about 8 per cent (range 7.6 to 8.4 per cent). Unlike in *S. bombayensis,* the body wall in *S. robusta* is more opaque due to the presence of strong longitudinal muscles.

5. *The collarette* in *S. bombayensis* is well developed and very conspicuous in live specimens extending from the head to slightly behind the middle of the posterior

fins and of more or less uniform width except just ahead of the anterior fins and close to the tail septum. In preserved material, the collarette shrinks to about one-third

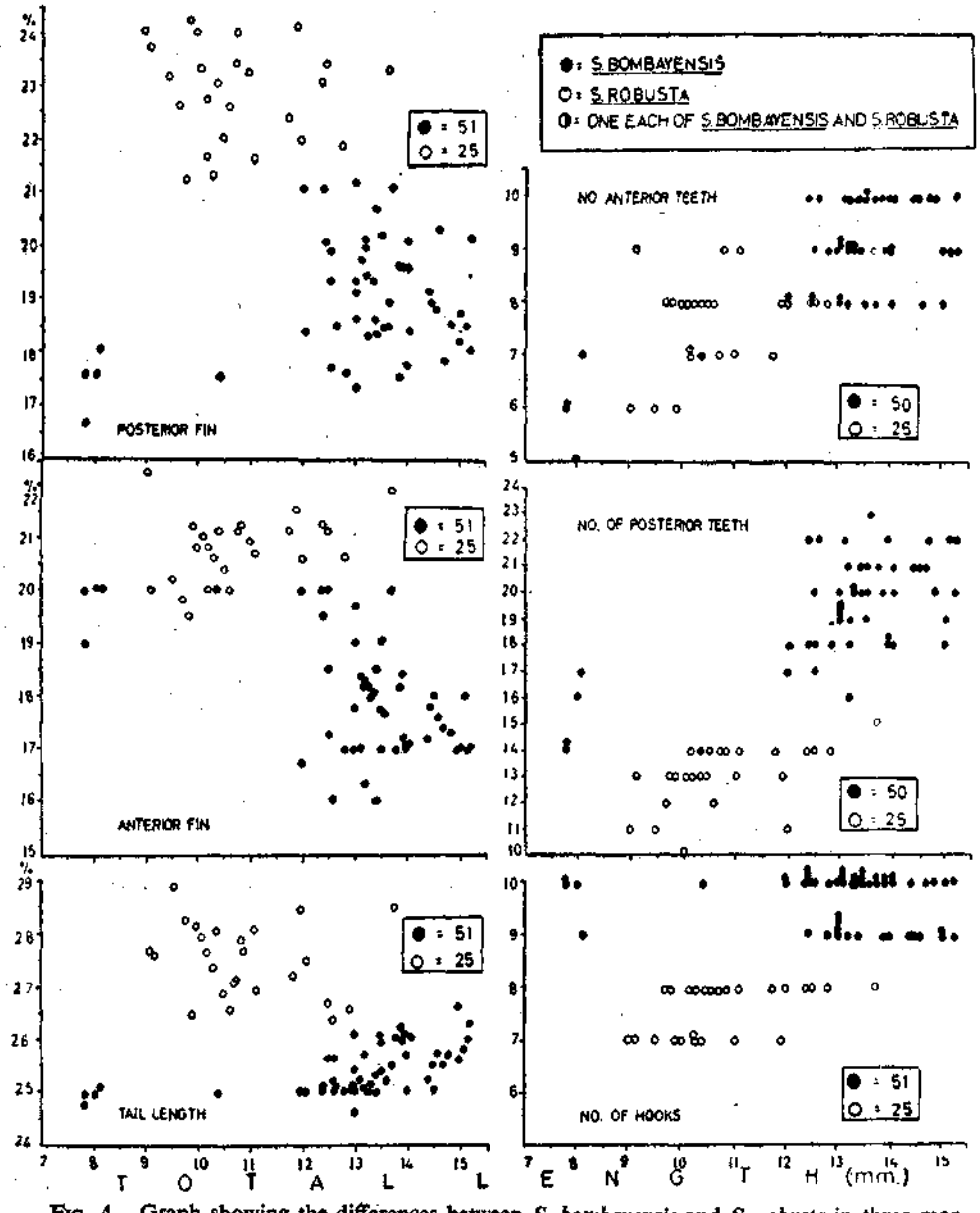

FIG. 4. Graph showing the differences between *S. bombayensis* and *S. robusta* in three morphometric and three meristic characters.

its original width. In *S. robusta* the collarette gradually decreases in width ending at the origin of the anterior fins and appears once again just ahead of the seminal vesicles, but well behind the tail septum (Fig. 5 b, c).

6. The *corona ciliata* in *S. bombayensis* is long, slightly sinuous and a little broad anteriorly beginning a little in front of the eyes and extending backward for two-thirds of the body in front of the ventral ganglion (Lele and Gae, 1936). In preserved material we have not been able to see it clearly. In *S. robusta* it is said to be long and narrow and elliptic in shape beginning in front of the eyes.

7. The *eye pigment* in *S. bombayensis* is concentrated more or less in the form of a square with the inner side slightly convex. The unpigmented area is oval in shape, the elongation being in the antero-lateral axis (Fig. 5 h). In *S. robusta* of comparable size, the eye is nearly twice as large as in *S. bombayensis* and the eye pigment concentrated in an ellipse (Fig. 5 i).

8. *Intestinal diverticula* is absent in *S. bombayensis* while it is present and very clearly seen as a clove-shaped structure in *S. robusta*.

9. *The ventral ganglion* in *S. bombayensis* is small, elliptical in shape and situated distinctly ahead of the anterior fins. In *S. robusta* it is moderately large, rectangular in shape and situated at the origin of the anterior fins.

10. *The anterior fins* in *S. bombayensis* is 16.0 to 20.4 per cent of total length (mean=17.7 per cent), while in the adult holotype as measured from the figure given by Lele and Gae (1936) the anterior fin is 22.5 per cent of total length. Rao and Kelly (1962) mention the range as 16.6 to 22.5 per cent. In *S. robusta* our material shows that the anterior fin in total length is 19.5 to 22.2 per cent (mean=20.8 per cent), while Rao and Kelly (1962) give the range for this species as 28.0 to 30.98 per cent and George (1952) as 28.02 to 30.0 per cent (mean=29.04 per cent). Incidentally, Alvarino (1965) has indicated that George's material is partly also referable to *S. ferox* Doncaster.

11. *The posterior fins* in *S. bombayensis* is 17.2 to 21.0 per cent of total length (mean=18.85 per cent), while in the adult holotype as measured from the figure given by Lele and Gae (1936) the posterior fin is 22.8 per cent of the total length. Rao and Kelly (1962) give the range as 20.83 to 26.25 per cent. In *S. robusta* our material shows that the posterior fin in total length is 21.2 to 24.2 per cent (mean= 22.9 per cent), while Rao and Kelly (1962) give the range for this species as 26.3 to 28.5 per cent and George (1952) as 27.6 to 30.0 per cent (mean =28.73 per cent). The posterior fins are thus smaller in *S. bombayensis* than in *S. robusta*.

12. *The ovaries* in *S. bombayensis* appear to be shorter, not extending beyond the ventral ganglion in fully mature specimens in our collection. In *S. robusta* the ovaries in fully mature specimens reach anteriorly the neck, the condition being clearly illustrated by Alvarino (1962) (Figure 5a shows a specimen of *S. robusta* in our collection in which the ovaries do not reach up to the neck, but extend to much ahead of the ventral ganglion).

13. *The seminal vesicles* in *S. bombayensis* make their first appearance in Stage II as lateral ridges slightly more prominent anteriorly. In Stage IV they are anteriorly spout-shaped when discharging, the openings being lateral (Fig. 2 e). In *S. robusta* seminal vesicles are conspicuous even in Stage I, and in mature specimens they are differentiated into a well-developed head and a voluminous posterior sperm-sac (Figure 5 c).

14. *The hooks :* In the description of the holotype, Lele and Gae (1936) give the number of hooks in *S. bombayensis* as 9 or 10, while in a table containing

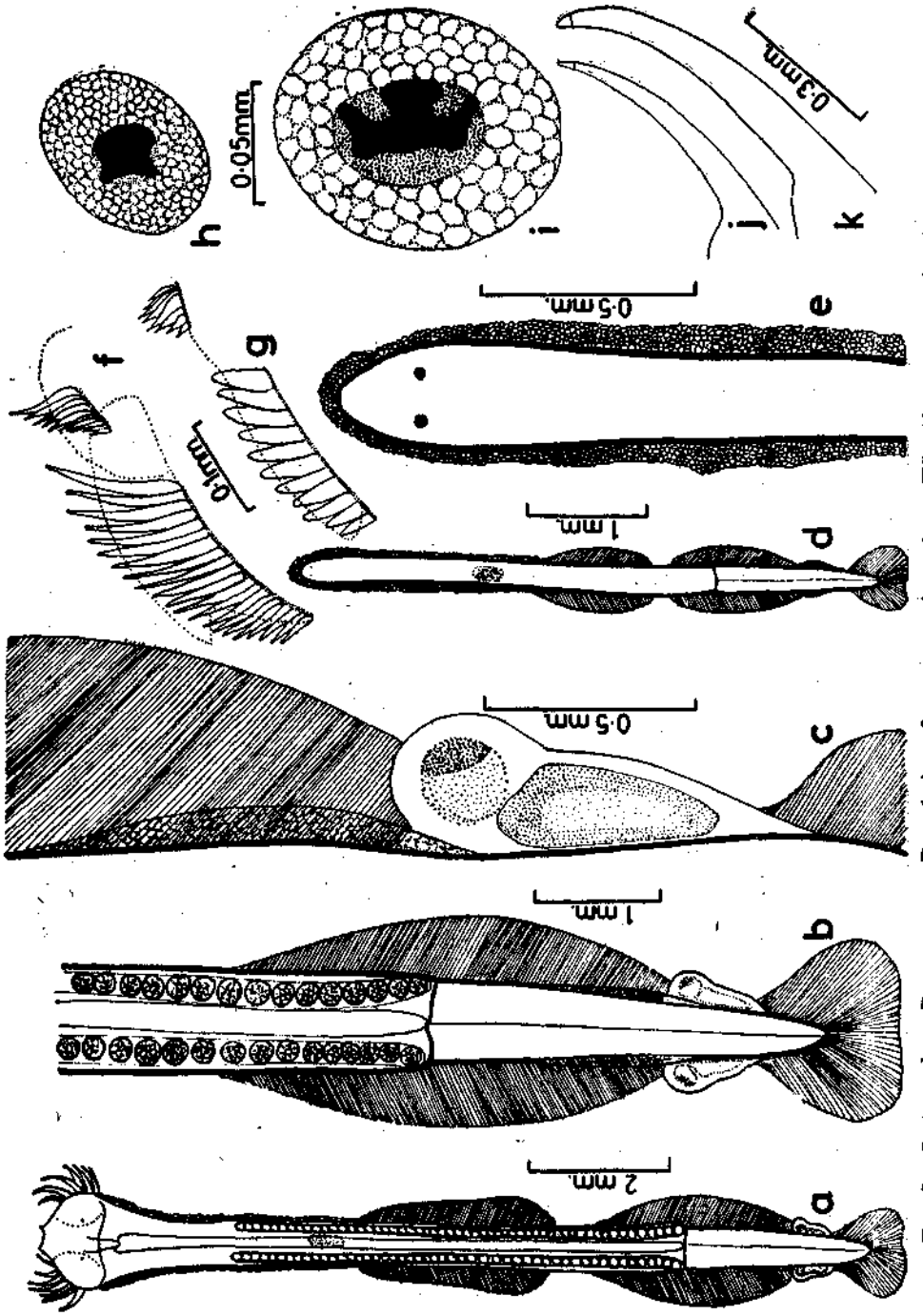

FIG. 5. *Sagitta robusta* Doncaster. *a*. Dorsal view of mature specimen (stage IV) : 12 mm. long ; *b*. tail segment of same ; *c*. enlarged seminal vesicle of same ; *Sagitta regularis* Aida. *d*. dorsal view of a specimen : 4.75 mm. long ; *e*. enlarged view of anterior part of the body showing the nature of collarette ; *f*, *h*, *j*. anterior and posterior teeth, eye and hook respectively in *S. bombayensis* 13.1 mm. long ; *g*, *i*, *k*. anterior and posterior teeth, eye and hook respectively in *S. robusta* 12.5 mm. long.

the details of two more immature specimens they indicate the '.... prehensile spines' as only 8 in all three specimens, but their drawing of the holotype shows at least 9 hooks. Rao and Kelly (1962) who have unfortunately not illustrated their material of *S. bombayensis* mention 8 hooks on either side. Topotypes in our collection indicate that in fully mature specimens the hooks number 9 or 10 (mean for 25 specimens being 9.6). In *S. robusta* on the other hand we find 7 or 8 hooks (mean for 25 specimens being 7.6) which is also the usual range for the species in the Pacific Ocean (Alvarino, 1962). George (1952) mentions 6 to 9 hooks for *S. robusta*, and Rao and Kelly (1962) mention the range as 6 or 7. *S. bombayensis* is thus characterised by a greater number of hooks than *S. robusta* and the hooks in the former are slender, accuminate and slightly smaller than in the latter (figure 5 j-k) in specimens of comparable size.

15. *The anterior teeth* in *S. bombayensis* is given by Lele and Gae (1936) as 8 to 12, while the holotype is indicated as having 10 anterior teeth, and the two immature paratypes as having 4 or 5 only. Rao and Kelly (1962) give the anterior teeth count as 8 or 9. Even in immature specimens we find the minimum number of anterior teeth to be 5, while in fully mature (Stage IV) specimens it is 9 or 10 (mean=9.54) (Fig. 5 f). In *S. robusta* that we have examined, the anterior teeth are 6 to 9 (mean=7.8), and the same range is also noted by Rao and Kelly (1962) and Alvarino (1962) for this species, while George (1952) mentions the counts as 7 to 9. As in the case of the hooks, *S. bombayensis* shows a higher count of anterior teeth.

16. *The posterior teeth* count is given by Lele and Gae (1936) as 16 to 25 in *S. bombayensis*, while in a table they have indicated 26 for the mature holotype and 8 and 11 for the immature paratypes. Rao and Kelly (1962) give the range as 17 or 18. In the topotypes we find the counts to vary from 18 to 23 (mean=20.66). In *S. robusta*, Rao and Kelly (1962), and Alvarino (1962) give the range as 10 to 13, and 10 to 15 respectively, while George (1952) mentions the counts to vary from 10 to 17. In the material of *S. robusta* that we have examined the posterior teeth number 10 to 15 (mean=13) which shows agreement with the range given by Alvarino (1962). Thus, *S. bombayensis* is characterised by a distinctly large number of posterior teeth, which are relatively long and slender (Figure 5 f-g).

Lele and Gae (1936) remarked on the similarity of the 'thickened epidermis' (collarette) of *S. bombayensis* and *S. regularis* Aida (1897). We may mention here that these two species are very different even in the nature and disposition of the collarette and other characters as will be evident from the figure of the latter species (Figure 5 d-e) given here.

Remarks

Tokioka (1965) while presenting a revised classification for Chaetognatha assigns *S. bombayensis* under the genus '*Sagitta* sensu stricto' and *S. robusta* under a new genus '*Parasagitta*'. While this System may not find general acceptance, this is further evidence that *S. bombayensis* is at least specifically different from *S. robusta*. A perusal of the literature relating to *S. robusta*, especially from the Indian Ocean, indicates the desirability of a taxonomic reappraisal of this species, as earlier suggested by Thomson (1947). We feel that geographical variations occur in this widely distributed species giving rise to localised differences in morphometric and meristic characters from area to area as becomes evident from the descriptions of the species given by various authors.

Three species of *Sagitta*, namely *S. gardineri* Doncaster, *S. bedoti* Beraneck, and *S. bombayensis* were recorded by Lele and Gae (1936) from the Bombay Harbour. Of these, the first mentioned species is a synonym of *S. enflata* Grassi. George (1949, 1952) recorded the following five species from Bombay Waters including Bombay Harbour : *S. bedoti, S. neglecta* Aida, *S. pulchra* Doncaster, *S. robusta*, and *S. tenuis* Conant, but as earlier indicated, his *S. robusta* (*nec* Doncaster) is part synonym of *S. ferox* Doncaster, and *S. bombayensis* Lele and Gae. The following six species belonging to two genera were present in the three plankton hauls made from the Bombay Harbour on 3-11-1966 :

	Species	*No. of specimens*	*Percentage*
1.	*Sagitta bedoti* Beraneck (1895) ..	204	7.42
2.	*Sagitta bombayensis* Lele and Gae (1936) ..	105	3.82
3.	*Sagitta enflata* Grassi (1881) ..	2419	88.02
4.	*Sagitta pulchra* Doncaster (1903) ..	11	0.40
5.	*Sagitta regularis* Aida (1897) ..	7	0.25
6.	*Krohnitta pacifica* Aida (1897) ..	2	0.07

It is interesting to note that our collections also indicate the same order of abundance of species of *Sagitta* in the Bombay Harbour viz., *S. enflata, S. bedoti*, and *S. bombayensis* respectively as observed nearly thirty years earlier by Lele and Gae (1936). However, more detailed studies are called for to understand the effect of harbour pollution on the seasonal abundance and fluctuations of these species.

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