

STUDIES ON THE CEPHALOCHORDATES OF MADRAS COAST

I. TAXONOMIC STUDY*

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THE records of the occurrence of the lancelets of the genus *Branchiostoma* from the Indian waters are few. Hitherto, four species of the genus had been known to occur from the coastal areas of India and Ceylon. They are *Branchiostoma belchei*, *B. lanceolatum*, *B. indicum* and *B. tattersalli*. There has been no uniformity of thought on the occurrence of *B. lanceolatum* in Indian waters (see Franz, 1922; Hubbs, 1922) and statistical data on the characters of taxonomic importance are lacking for the species *B. indicum* and *B. tattersalli*. Since, the taxonomy of the Cephalochordates has been studied elaborately (Bigelow and Farfante, 1948; Webb, 1955, 1956a, 1956b, 1956c, 1957 and Boschung and Gunter, 1962) it was thought worthwhile to describe the Indian forms, *B. lanceolatum*, *B. indicum* and *B. tattersalli* fully on the same taxonomic pattern as has been established for the European species.

KEY TO THE SPECIES OF THE GENUS *BRANCHIOSTOMA*—FROM INDIAN WATERS

- 1a. Dorsal and ventral extremities of the caudal fin considerably higher than that of dorsal and ventral fins.
 - 2a. anus outside the caudal lobe.
 - 3a. Myotomes anterior to atriopore are more than 39 and prolonged rostrum.....*indicum*
 - 3b. Myotomes anterior to atriopore are less than 37 and an angular short rostrum.....*lanceolatum*
 - 2b. anus inside the caudal lobe.
 - 4a. anus near the centre of the lower lobe of caudal fin
 - 5a. Myotomes anterior to atriopore ranges between 37-40.....*tattersalli*

***Branchiostoma lanceolatum* (Pallas)**

Occurrence : The inshore dredge collections of the author yielded about 997 lancelets. Of these, 941 were identified as belonging to *B. lanceolatum*. The present account is based not only on these but also on the study of 446 specimens collected during 1938-1939 by Samuel in the course of her work on bottom fauna. In this collection there were 254 *B. lanceolatum*.

* This paper formed a part of the thesis submitted for the Degree of Master of Science at the University of Madras.

Habitat and habits : The sand in which they occur has 5.22% of broken shell.

1.00%	of sand grains	<	1.981 mm.	in diameter
11.00%	1.98 mm.	<	0.991 mm.	„ „
64.8%	0.991 mm.	<	0.495 mm.	„ „
11.20%	0.495 mm.	<	0.246 mm.	„ „
5.544%	0.246 mm.	<	0.124 mm.	„ „
1.174%	0.124 mm.	<	0.061 mm.	and 0.002% less than 0.061 mm.

Samuel (1944) has distinguished two distinct communities as '*Branchiostoma-toreumaticus* community' and '*Branchiostoma-marmorata* community'. However, there appears to be no distinct community associated with each species. It may be stated that *B. lanceolatum* was dredged along with *Lovenia elongata*, *Ophiocnemis morata*, *littorina* sp., *Oliva oliva*, *Oliva nebulosa*, *Cardium* sp., *Turbo* sp. *Hydroides norvegica*, *Nebalia* sp., *Gammarus* sp., *Cumaciae*, *Eumice* sp. *Dendalium* sp., soil nematodes, Foraminifera and a good number of broken shells with tube dwelling polychaetes.

The lancelets live buried in the sand, protruding only the buccal region above the sand level. If disturbed, they either withdraw their cephalic end or emerge from the sand and swim actively with a sinuous eel-like motion for sometime and then slowly sink down without any sinuous action of the muscles. If it happens to sink with the tail end down, the sharp tip pierces the sand with a wriggling motion, leaving the buccal end above the sand level. Sometimes it plunges down head foremost and penetrates the sand, turns round and comes up with the head foremost. During their forward movement they rotate round their own axis and move in a spiralling manner. When an animal is introduced into a glass tube it can be seen that it is able to swim backwards or forwards with equal rapidity. Close observations show that the lateral flexions of the body, aided by the broad caudal fin, help to displace the water backwards in swimming. It will be of interest to study the functional aspects of the caudal fin and the metapleural folds in bringing about the rotation of the body round their own axis while swimming since the dorsal and ventral fin chambers are known to be storage chambers (Azariah, 1965). The lancelets swim away from light.

This species has two breeding seasons in an year ; one during July to August and the other during December and February (Azariah, 1965).

Size : Out of the total 1195 specimens of the species examined, the largest measured 33 mm. from the tip of the rostrum to the tip of the tail. Since these were fully grown adults, it can be inferred that these tropical forms at Madras do not grow large. This is of interest since Kirkaldy (1895) has recorded 58 mm. as the maximum length and 48 mm. being the average length of the forms of the European species.

Colour : These lancelets are whitish translucent. They become opaque after preservation. In diffused light the myotomes appear opalescent. The anterior myotomes (close to the velum) however, are iridescent even in preserved specimens. These differences in appearance may be due to the texture of the fascia covering the muscles, since they are not related to the more superficial tissue. The oral hood along with the membranes between the cirri exhibit a beautiful parrot green (local

colour) while the skeletal ring of the oral hood and the rods of the cirri are of a pink colour. The notochord of the juveniles is silvery white and becomes transformed into golden yellow in the adult. These differences in colour are not due to any pigment cells and since the same differences are noted in other species, they must be related to the chemical composition of the tissue. Further work is in progress.

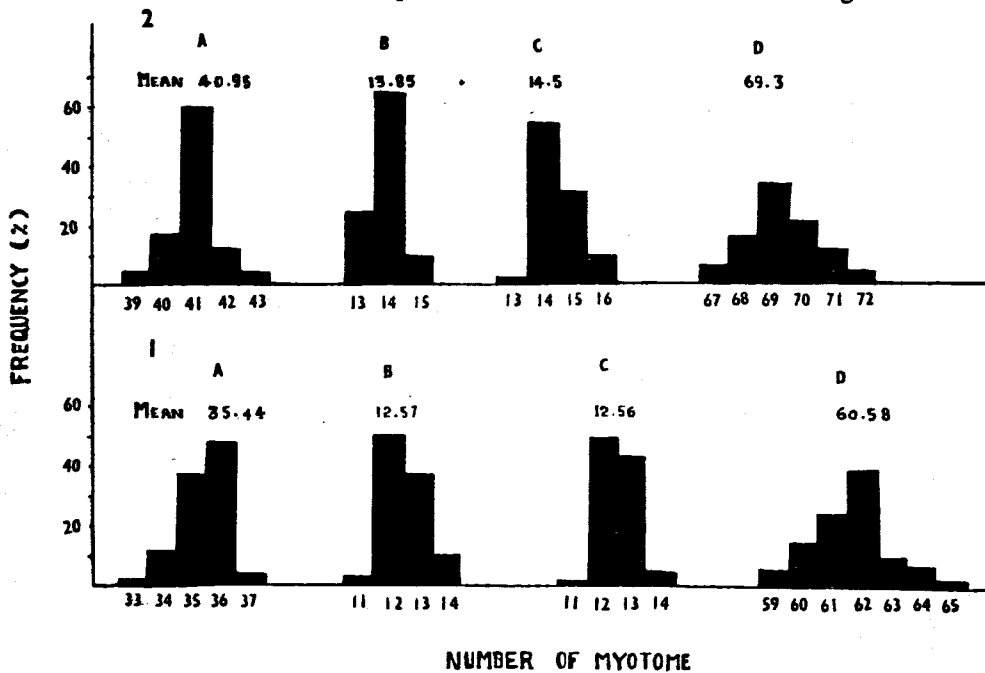
Diagnosis : In the following diagnosis counts and measurements were made on 100 specimens and the results are submitted statistically.

1. Dorsal fin chambers number 221-288 : Mean 251.74 : Standard Deviation (SD) 15.58 : S.D.=6.19 per cent of the Mean.
2. Ventral fin chambers number 30-62 : Mean 48.1 : S.D. 5.1 : S.D.=10.6 per cent of the Mean.
3. Tallest of dorsal fin chambers 1.5-4.5 times as high as broad : Mean 2.54 : S.D. 0.59 : S.D.=23.13 per cent of the Mean.
4. Height of the dorsal fin contained 8-16 times in the depth of the body in the mid-atrial region : Mean 10.41 : S.D. 0.215 : S.D.=2.11 per cent of the Mean.
5. Post-atrioporal region 0.4-0.68 the length of the pre-atrioporal region : Mean 0.47 : S.D. 0.08 : S.D.=17.02 per cent of the Mean.
6. Myotomes from cephalic end to atriopore 33-37 : Mean 35.44 : S.D. 0.79 : S.D.=2.25 per cent of the Mean.
7. Myotomes from atriopore to anus 11-14 : Mean 12.57 : S.D. 0.61 : S.D.=4.85 per cent of the Mean.
8. Myotomes posterior to anus 11-14. Mean 12.56 : S.D. 0.74 : S.D.=5.89 per cent of the Mean.
9. Total myotomes 59-65 : Mean 60.58. S.D. 1.26 : S.D.=2.06 per cent of Mean.

Among the other characters which are of importance from the morphological point of view, but not covered by the above diagnosis are the notochord, shape of fins and preoral organs.

The notochord (Fig. 1.NTC) begins from inside the rostral tip of the body and extends behind to the tip of the caudal fin (CF) where the nerve tube ends. Under the low power it shows vertical lines about 2μ apart which are the external markings of the notochordal cells. Apart from the usual notochord, where the anterior tip of the notochord is slightly dilated in most of the forms, a few show different types of terminations. Two forms showed a conspicuous dilation extending from about 13μ to 135μ length (Fig. 2) such as has been described in *Heteropleon cutolum*. In four forms the anterior tip appears branched in various ways as shown in figs. 3-6. In one form the tip is pointed and spike like (Fig. 7), while in another, this spiked type at the tip flattens into a disk as an umbel (Fig. 8). In one form while combining the dilated and forked condition, the branches being four, tips of the branches are thrown into slender filaments (Fig. 10). Forking is also noticed in one specimen at the posterior end (Fig. 11). These fluctuations in the forms of the notochord support the general conclusion that there is considerable variability

in the details of structure which are not necessarily correlated with function or taxonomy. Among the fins, the ventral and caudal fins show variations in shape. Some of the variations in the shape of the ventral fin are illustrated in figures 35-37.

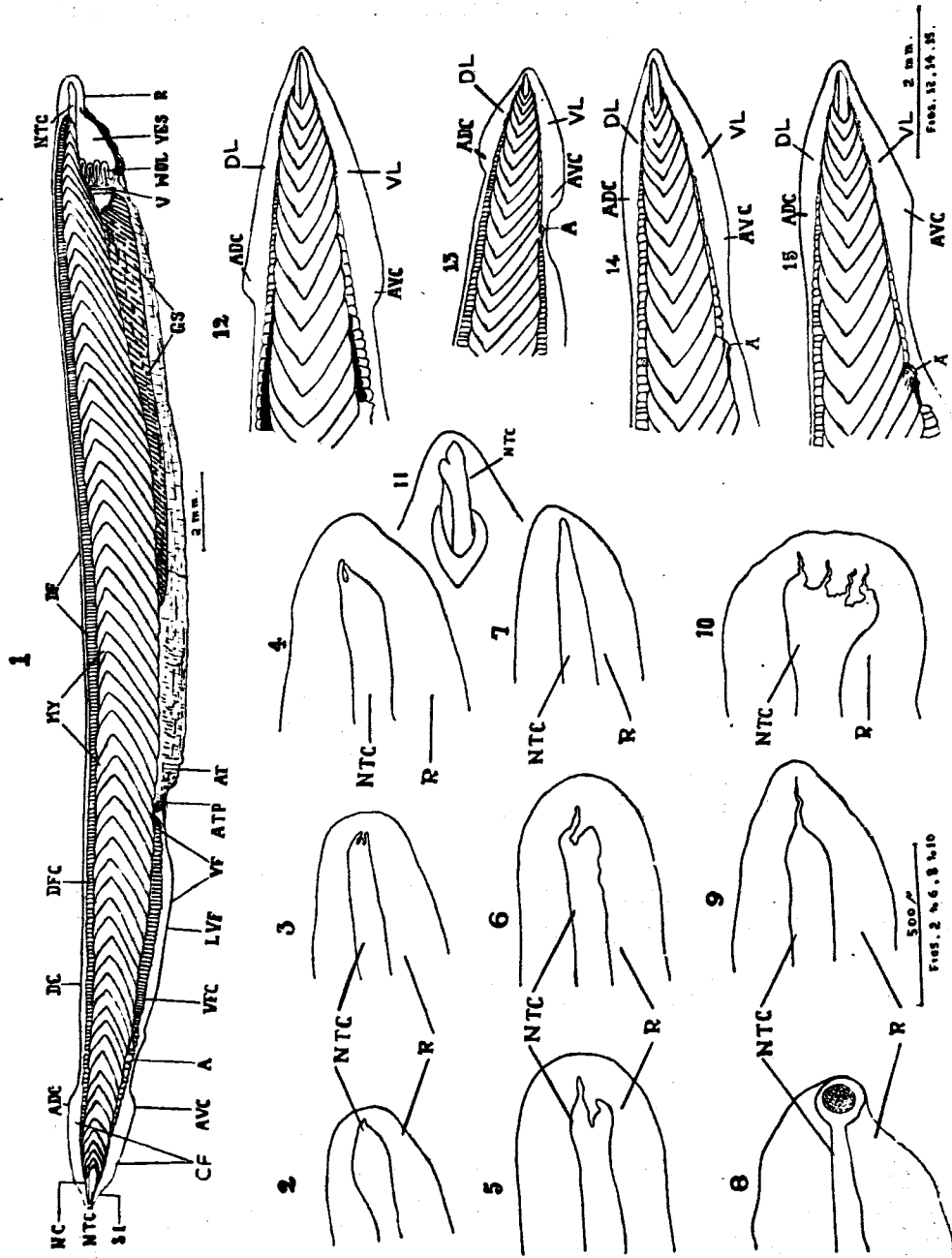


HISTOGRAM. 1. Myotome frequency in *B. lanceolatum*.

HISTOGRAM. 2. Myotome frequency in *B. indicum*.

- A. Myotome from cephalic end to the atriopore.
- B. Myotomes from atriopore to anus.
- C. Myotomes posterior to anus.
- D. Total number of myotomes.

The caudal fin (Fig. 1.CF), which is the post-anal prolongation of the dorsal and ventral fins, shows the following variations. In the young, i.e. 8-12 mm. long lancelets, there is no indication of any boundary, but in the older, fully grown forms (27 mm.), there are notches making the anterior limits (ADC & AVC) of the dorsal lobe (DL) and the ventral lobe (VL) of the caudal fin. This notch occurs typically posterior to anus and both the anterior extremities are placed at the same line, making the caudal fin perfectly symmetrical (Fig. 12) in about 28% of the lancelets. This notch makes its appearance when the lancelets are 19 to 24 mm. long. The caudal fin grows with age. In some forms, about 22%, the dorsal notch may occur behind the commencement of the anterior extremity of the ventral lobe making the caudal fin asymmetrical (Fig. 13). In about 50% of the adults the notch may be shallow though the commencement of the caudal fin is distinct (Fig. 14). In these also we have both asymmetrical and symmetrical forms depending on the place of occurrence of the notch. Minor variations are of the same nature as those met with notochord (Fig. 15). A small subterminal sent (SI) on both the lobes of the caudal fin about the region of last myotome is of taxonomic significance (Webb, 1955). But in the present form, these dents are found in the younger forms, though in the older forms the dents become filled out.

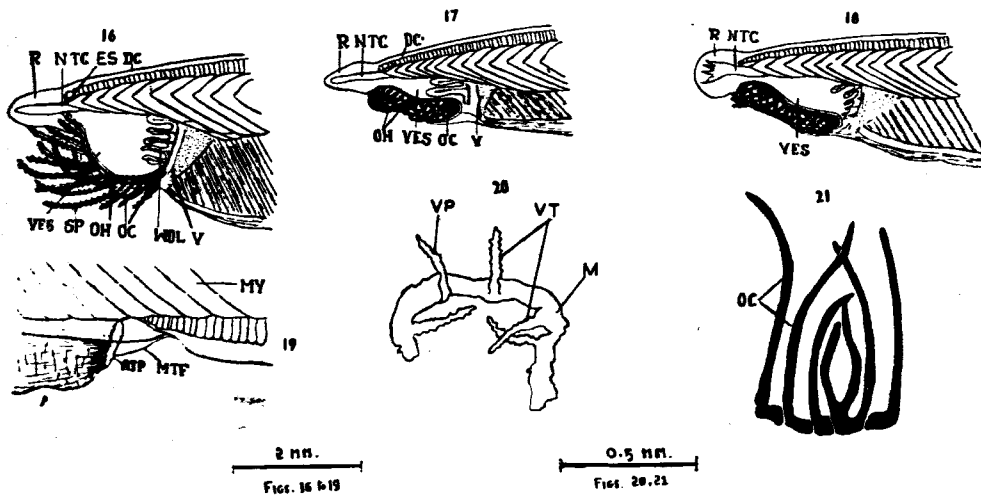


FIGS. 1. Lateral view of *B. lanceolatum*. 2-11. Variations on the terminations of the notochord.

12-15. Variations of the caudal fin.

Typically the rostrum (R) is short, cylindrical and bluntly round but as in other features of morphology considerable variations are met with (Figs. 16-18), nor are these different shapes correlated with the types of notochord endings. There are 30 to 32 oral cirri extending round the opening of the vestibule. As in other features of morphology, some of the cirri show variation, being forked (Fig. 21). These oral cirri bear well-developed conical sense papillae (SP).

While the typical vestibule is spacious, bounded by the large oral hood and a perfectly oval skeletal ring, in a few forms the skeletal ring supporting the oral cirri is not oval but laterally compressed and the external aperture appears to be twisted to one side. In these forms the vestibule is not spacious. As a result the wheel organ is reduced (Figs. 17 & 18).



FIGS. 16-18. Variations of the pre-oral regions. 19. Lateral view of the atrioporal region. 20. Lateral view of velum with its tentacles. 21. Branching of the oral cirri skeleton.

From the circular ridge of the wheel organ, radiate about 10-12 wheel organ lobes extending forwards and outwards. The number of the radial ridges appears not to be constant in all the lancelets. It is of interest to note in a few forms of the present species, in which the oral hood is asymmetrical, there are only 2 to 3 radial ridges on each side (Fig. 17). This reduction in number is probably related to the reduced size of the vestibule in these abnormal forms. The velar membrane is drawn into 5 to 6 backwardly tapering tentacles which bear on the edges triangular papillae. The anus extends over a space of two myotomes usually varying between 46 & 50.

Remarks: That the 941 specimens collected in Madras really belong to *B. lanceolatum* described by Webb (1955) can be seen by comparing the range of the nine characters with that of the European specimens—the range of characters is given in the Table. It will be seen that there are no differences in the characters 1, 2, 4, 6 and 9 and in others the range is sufficiently wide to include both. From the present study it would appear that Tattersall's specimens from Ceylon also belong to *B. lanceolatum*. This fact establishes the cosmopolitan distribution of these lancelets and solves the difference of opinion between Franz (1922) and Hubbs (1922) on the occurrence of *B. lanceolatum* in Indian waters.

It is of interest to point out that Webb (1956) recorded three different shapes of caudal fin in *B. lanceolatum* from three different populations. However, in Indian representatives all the three types occur in single type population.

Branchiostoma indicum (Willey)

Dolichorhynchus indicus Willey (1901)

B.indicum Tattersall (1903)

Dolichoramphus indicum Hubbs (1922)

The inshore dredge collections made about two miles from the shore yielded about 55 specimens of *B.indicum*. The percentage composition of the substratum is similar to that of *B.lanceolatum*.

165 specimens collected between 1938-1939 from the same type locality, and stocked in the laboratory were also examined.

Size and colour : Mature adults ranged from 13 mm. to 31.5 mm. The colour of this species is similar to that of *B. lanceolatum*.

Habits : This species inhabits the same ecological area as *B. lanceolatum* and has more or less the same habits in swimming, burrowing and reaction to light. However, the present species appears to breed a few months later than the former species. The peak of the breeding season being in April, information gathered regarding the occurrence of mature forms during the rest of the year is not conclusive.

Diagnosis : Fort specimens were used in the following diagnosis and the results are treated statistically.

1. Dorsal fin chambers number 304-395 : Mean 326.15 ; Standard Deviation (S.D.) 18.21 : S.D.=5.58 per cent of the Mean.
2. Ventral fin chambers number 40-63 ; Mean 49.35 : S.D. 5.95 S.D.=1.21 per cent of the Mean.
3. Tallest of dorsal fin chambers 2.0-4.5 times as high as broad : Mean 3.42 : S.D. 0.63 ; S.D.=1.84 per cent of the Mean.
4. Height of the dorsal fin contained 9-14 times in the depth of the body in the mid atrial region : Mean 10.92 ; S.D. 1.59 ; S.D.=1.46 per cent of the Mean.
5. Post-atrionoporal region 0.4-0.5 the length of the pre-atrionoporal region : Mean 0.42 : S.D. 0.11 : S.D.=26.19 per cent of the Mean.
6. Myotomes from cephalic end to atrionopore 39-43 : Mean 40.95 : S.D. 0.85 : S.D.=2.08 per cent of the Mean.
7. Myotomes from atrionopore to anus 13-15 Mean 13.85 : S.D. 0.19 : S.D.=1.37 per cent of the Mean.
8. Myotomes posterior to anus 13-16 : Mean 14.50 : S.D. 0.23 : S.D.=1.58 per cent of the Mean.
9. Total myotomes 67-72 : Mean 69.30 : S.D. 1.27 : S.D.=1.83 per cent of Mean.

The following non-statistical features are of morphological importance:

The notochord (Fig. 22, NTC) is exactly as in the other species, *B. lanceolatum* but extends more in front within the prolonged rostrum (R), than in the other species. The anterior tip of the notochord ends in different ways as shown in figures 23-25.

In the dorsal fin the anterior few fin ray chambers, which lie about the first two myotomes, are shorter in height making the crest (DC) above them relatively broader. From the third myotome upto the fortieth myotome the dorsal crest is narrower because the fin ray chambers are taller. Behind the fortieth myotomes, however, the chambers are of less height and the crest (DC) appears broader and gradually increases to be merged with the dorsal lobe of the caudal fin.

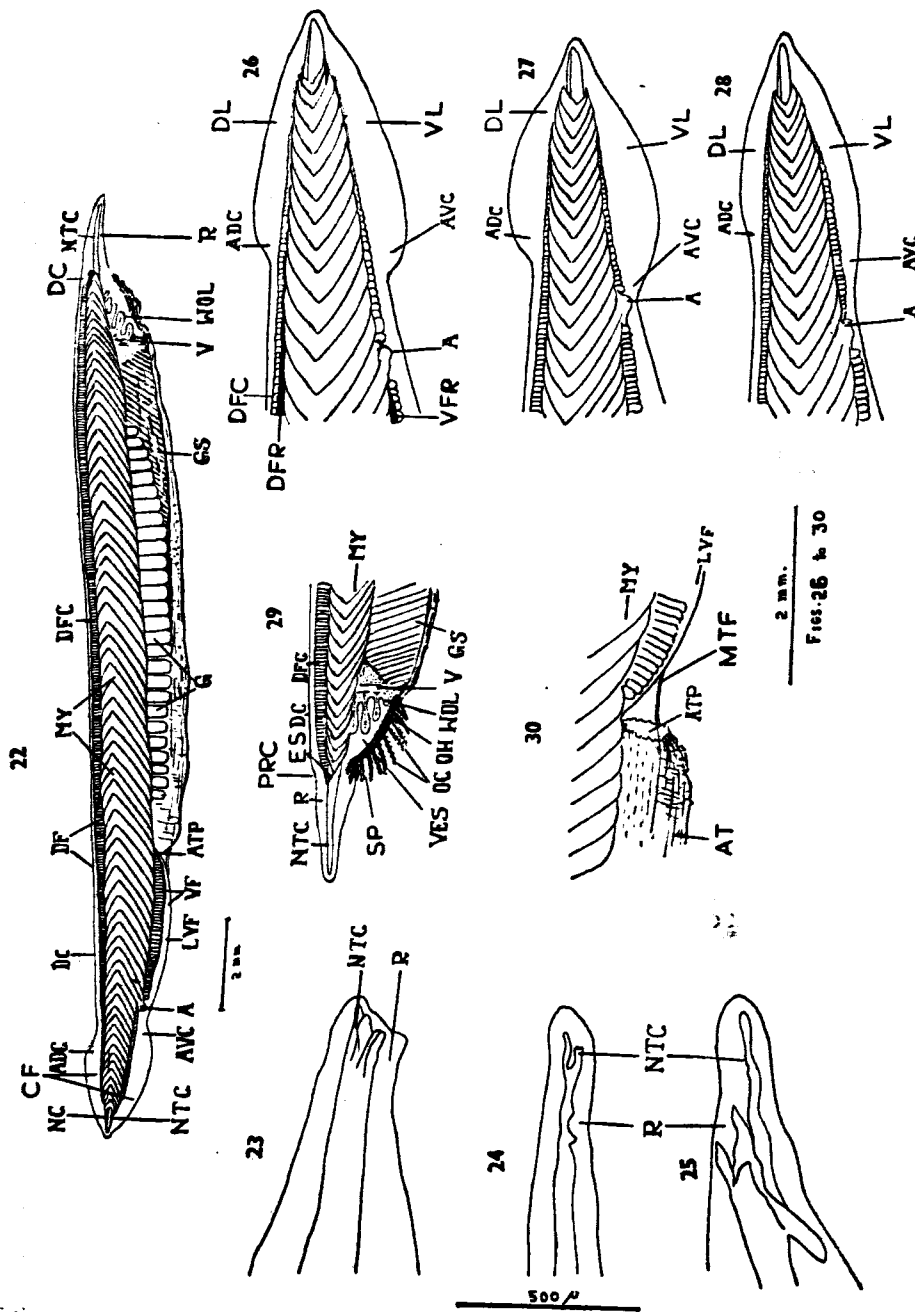
The dorsal caudal lobe (DL), which is narrower than the ventral caudal lobe (VL), has its anterior extremity (ADC) just above the apex of the sixth myotome of the post-anal region. The infra caudal lobe also starts from the same region in a symmetrical fin (Fig. 26). But in an asymmetrical fin the infra caudal lobe originates in a line with the apex of the fifth myotome from the anus (Fig. 27). Apart from these two types, a third type can also be noticed where the anterior extremities of the two caudal lobes are not well marked, except an elevation (Fig. 28). The shapes of the caudal fins vary in a continuous intergrading fashion in different individuals. The upper and lower ends of the caudal fin are supported by fin ray chambers of much smaller magnitude extending beyond the middle of the caudal fin.

The fin ray (Fig. 26, DFR & VFR) occurs within the chambers even in specimens of 13 mm. length. In very young lancelets i.e. below 13 mm. there are no fin rays. But as the lancelets grow in length, fin rays 'grow' within the chambers from the ventral side upwards. These fin rays are deposition of reserve nutritive matter to be used during the breeding season. The appearance of the fin rays in the older forms does not follow a definite order. In some the fin rays of the middle chambers appear very late whereas in the anterior and posterior chambers they develop earlier. Just as in other species the appearance of fin ray is seasonal. Hence, the number of fully developed or the presence of the fin rays cannot, therefore serve as an index of age.

Rostrum (Fig. 29 R) is the anterior expansion of the dorsal fin crest (DC), separated by a post-rostral cleft (PRC). The rostrum is broader at the base and narrower at the tip and increases with length and age of the lancelets.

Behind the rostrum, commencing from the first myotome the pre-oral lobe covers a distance of 7-8 myotomes. The vestibule (VES) is enclosed by the oral hood (OH) on either side, opens to the exterior by an egg shaped aperture on the ventral side and posteriorly leads to the pharynx through the mouth. The free edge of the oral hood is strengthened by a skeletal ring formed by 24 to 26 segments each one of which gives rise to an oral cirrus (OC), which is supported internally by a skeletal rod and clothed outside with well developed conical sense papillae (SP).

In this species as in *B. lanceolatum* the atriopore (ATP) is circular in outline and in preserved forms, where the two sides between the metapleural folds (NTF) have shrunk, the opening may be triangular as noted by Prashad (1934).



Figs. 22. Lateral view of *B. indicum*. 23-25. Variations of the termination of notochord. 26-28. Variations of the caudal fin. 29. Lateral view of cephalic region. 30. Lateral view of atrioporal region.

The gonads begin to appear even in a specimen of 13 mm. length. The development of the gonads is same as that of *B. lanceolatum*. The gonads are rectangular in shape and vary from 20 to 29 on each side. The testis is whitish in colour and the ovary is slightly pinkish in colour.

Remarks : The following features of taxonomic importance are well defined in *B. indicum*, namely the total number of fin ray chambers, pre-atrial myotomes, as well as the shape of the rostrum and the position of the anus. Secondly it differs from *B. lanceolatum* in the large number of pre-atrial myotomes which in turn alters the ratio of the length of the pre-atrial region with that of the post-atrial region. The total number of dorsal fin ray chambers always ranges above 300, whereas, in *B. lanceolatum* it never exceeds 300. It also differs from *B. tattersalli* in the position of the anus, in the fewer post-anal myotomes. *B. indicum* is distinct from *B. lanceolatum* and *B. tattersalli* in the rostral shape and in body proportions. The above three considerations make *B. indicum* a valid species. In the definition of the species by Willey, characters like the numerical range of fin ray chambers, the range of the proportion of the dorsal fin to the body, the proportion of the breadth and length of the fin ray chambers and the pre-atrial body length could not be mentioned and hence *B. indicum* may be redefined as follows :

B. indicum, a cephalochordata, with a myotomal range of 39-43 in the pre-atrioporal region, 13-15 in the pre-anal, 13-16 in the post-anal regions has a high number of dorsal fin ray chambers (304-395) and above 40 fin ray chambers in the ventral fin. The ratio of the post-atrial region to the pre-atrial region never exceeds 0.5. The anus is outside the caudal lobe.

Branchiostoma tattersalli (Hubbs)

B. californiense Tattersall (1903).

B. tattersalli Hubbs (1922).

B. gravelyi Prashad (1934).

Occurrence : Two specimens were dredged from the inshore area on 2nd April 1962. The rest of the collections did not yield even a single specimen of the species. Seven other specimens included in the description were from the collections taken from the departmental Museum, made on 17-10-1938 and 9-10-1939 reported by Samuel (1944).

The two live specimens and the 7 preserved specimens examined were collected from the same sandy bottom as yielded the other two species, *B. lanceolatum* and *B. indicum*. Therefore, ecologically the features of substratum and the animal community of which it is a part are the same as for *B. lanceolatum* and *B. indicum*.

Habits : The two live specimens studied in the laboratory moved, burrowed and reacted to light in the same way as the other two. Nothing can be said positively of the breeding season.

Size : The largest of the 9 forms examined has a length of 42 mm. Since Prashad (1934) has recorded 44 mm. as the largest, this length can be taken as the maximum size of the species occurring in Indian waters. The smallest in the present collection happens to be 15 mm.

Colour : In the live state the body is opalescent the other two species. It, however, becomes opaque in reserved specimens.

Diagnosis : The following statistical treatment was done on 7 specimens.

1. Dorsal fin chambers number 310-330 : Mean 319.14 ; Standard Deviation (S.D.) 12.85 : S. D=4.03 per cent of the Mean.

2. Ventral fin chambers number 73-78 : Mean 79.56 ; S.D. 5.66 : S.D=7.11 per cent of the Mean.

3. Tallest of dorsal fin chambers 2.9-5.2 times as high as broad : Mean 3.67 ; S.D. 1.38 : S.D=37.6 per cent of the Mean.

4. Height of the dorsal fin contained 9-13 times in the depth of the body in the mid atrial region : Mean 10.57 : S.D. 2.15 : S.D=20.34 per cent of the Mean.

5. Post-atrioporal region 0.34-0.47 the length of the pre-atrioporal region : Mean 0.42 : S.D. 0.039 : S.D=9.29 per cent of the Mean.

6. Myotomes from cephalic end to atriopore 37-40 : Mean 38.42 : S.D. 1.29 : S.D=3.36 per cent of Mean.

7. Myotomes from atriopore to anus 16-18 : Mean 16.85 : S.D. 0.43 : S.D=2.55 per cent of the Mean.

8. Myotomes posterior to anus 8-9 : Mean 8.42 : S.D. 1.33 : S.D=2.09 per cent of the Mean.

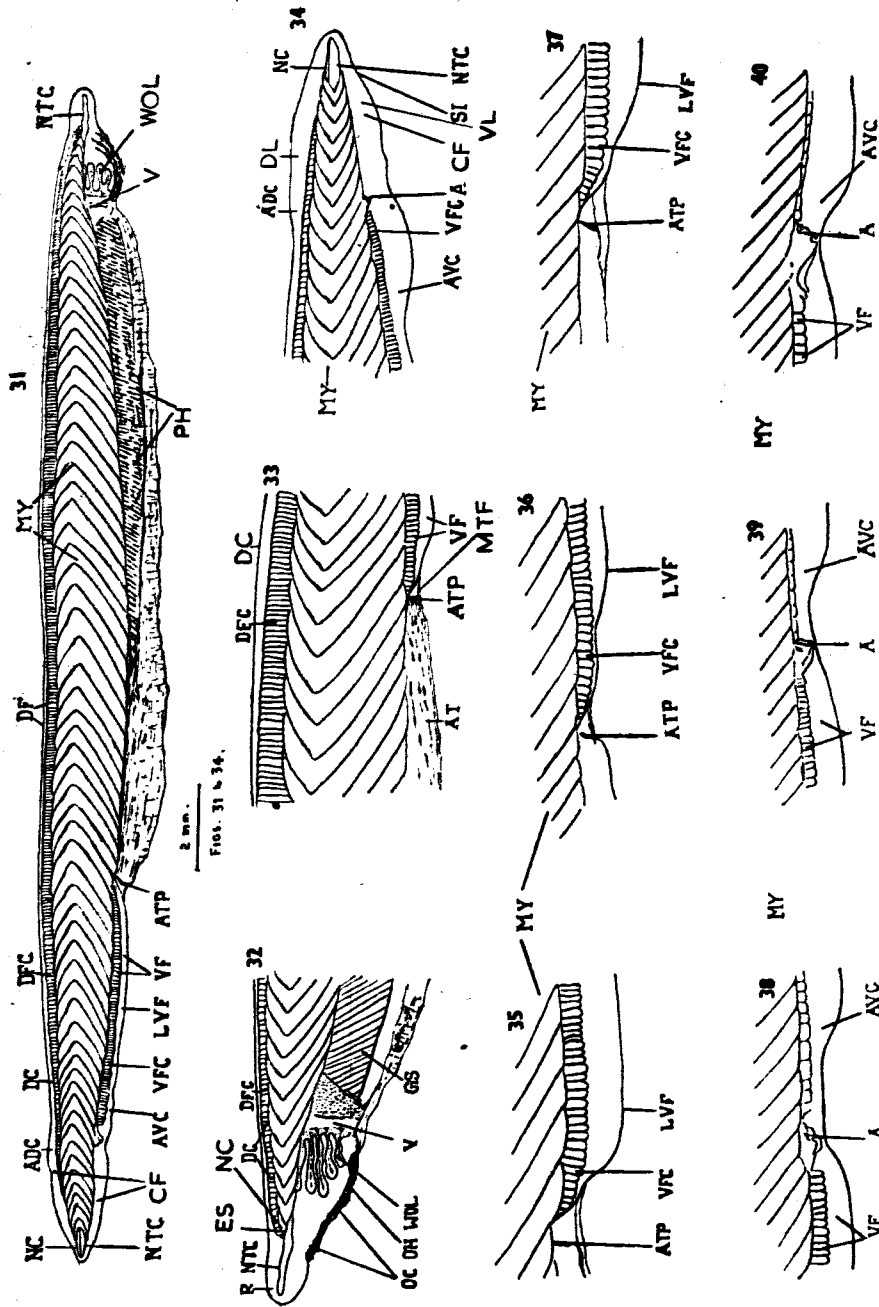
9. Total number of myotomes 62-65 : Mean 63.71 : S.D. 1.33 : S.D=2.09 per cent of the Mean.

The following non-numerical characters are of morphological interest. In the nine specimens examined the author could not make out any of the different types of terminations described in the other two forms. However, in all the nine forms it was found the first myotome and the tip of the nerve cord was inclined upwards (Fig. 31). This feature was not met with in the other two species and may be peculiar to this species.

In the region of the first three myotomes and also behind the atriopore, i.e. about the 44th myotome the fin ray chambers of the dorsal fin are short leaving a relatively broader part of the fin distinguished as the crest (DC). In the rest of the body, i.e. 3rd to 44th myotomes the fin chambers are tall and the crest is not noticeable.

As the chambers of the ventral fin are uniformly shorter the ventral fin is uniformly broader. Since the fin ray chambers are fully formed in the young specimens the ventral fin does not appear so broad as in the older forms in which the fin is far broader than the fin chambers. The fin ray chambers are not extended post-anally, a character at variance with the other two species.

The anterior limits (Fig. 34, ADC & DVC) of the caudal fin (CF) are demarked by a well dent behind the fins on the dorsal and ventral lobes (DL & VL) of the caudal fin. Distinct from the previous two species the ventral half of the caudal fin appears



FIGS. 31. Lateral view of *B. tattersalli*. 32. Lateral view of cephalic end. 33. Lateral view of atrial end. 34. Lateral view of caudal end. 35-37. Variations of the ventral fin. 38-40. Variations in the position of anus from the anterior ventral extremity of the infra-caudal lobe in *B. lanceolatum*.

to extend more in front because of the shifting back of the anus. Unique among the Indian lancelets is this inclusion of the anus within the caudal fin since in the two species the caudal fin is post-anal. That the fin ray chambers (DFC) extend only on the dorsal lobe of the caudal fin and not beyond the anus in the ventral lobe, is a noteworthy feature and is of taxonomic importance. The symmetry of the caudal fin is altered by the commencement of the dorsal and ventral extremities of the lobes being varying.

The rostrum (R) of the present species resembles that of *B. lanceolatum* in being short and round. In the present form the breadth of the rostrum is $2/3$ of its length. In this respect *B. lanceolatum* and *B. tattersalli* are distinct from *B. indicum*.

The anus (Fig. 34, A) is a broad triangular opening extending for about two myotomes. It occurs to the left of the ventral median line, about the 51st and 52nd myotome. Since the anus is being shifted so far back, it is unique among the Indian lancelets. The Indian representatives of *B. lanceolatum* differ from those recorded elsewhere in this respect and the present forms having the anus included within the caudal fin is, therefore, a feature which though noteworthy may not be of much taxonomic significance.

Of the nine specimens examined only one happened to have gonads. There were 28 pairs of gonads only in the 42 mm. preserved form. The shape of the gonad appears more circular in outline. Since the collections were made in the month of October, the breeding season may be during September and November.

Remarks : Since Hubbs (1922) has not described the species fully when he named it as *B. tattersalli*, a detailed comparison of the different characters are listed in the Table. It will be seen from the Table that the present form differs from

TABLE
Range of characters on some of the Lancelets of the world

Character number	<i>B. tattersalli</i>	<i>B. californiense</i>	<i>B. capense</i>	<i>B. elongatum</i>	<i>B. belcheri</i>	<i>B. lanceolatum</i> (European)
1	310-330	312-374	400-440	350-420	258-306	200-270
2	73-88	45-50	62-80	37-80	70-80	29-48
3	2.9-5.2	4.0-8.0	4.0-9.0	2.7-7.0	3.0-3.6	1.4-2.7
4	9-13	5-8	7-11	7-12	7-11	8-16
5	0.34-0.47	0.30-0.38	0.38-0.48	0.38-0.42	0.43-0.48	0.41-0.51
6	37-40	43-48	46-48	46-51	36-39	33-38
7	16-18	16-19	18-20	18-19	17-19	13-16
8	8-9	8-19	9-11	10-13	9-11	10-14
9	62-65	68-74	74-77	77-81	63-66	58-65
Maximum length	42 mm.	71 mm.	63 mm.	69 mm.	70 mm.	58 mm.
Location of the anus	Near the centre of the lobe	Far behind the centre of the lobe	Near the centre of the lobe	In advance of the centre of the lobe	In advance of the centre of the lobe	In advance of the centre of the lobe

B. californiense in characters 2, 4, 6 and 9 and agree only in 7 and 8. Therefore, Hubbs treating it a new species *B. tattersalli* distinct from *B. californiense*, is con-

firmed. It can be easily distinguished from *B. belcheri* by the location of anus, shape of anus, shape of caudal fin and the proportion of the dorsal fin chambers.

REMARKS ON THE TAXONOMY OF THE SPECIES OF THE GENUS *BRANCHIOSTOMA*

It is well known that there is considerable fluctuation in the morphological features of prochordates. This raises a problem with reference to the taxonomic criteria of a quantitative or numerical character. The range of variation in each character has to be established, and the features of the highest frequency is taken as typical of any one species. This however, can be done only when large numbers of specimens are available for such a statistical treatment. Webb (1955, 1956c) has done this for *B. nigeriense* and for *B. lanceolatum* of the European waters, collected from different localities; Boschung and Gunter (1962) have done it for *B. caribaeum*. Since large number of *B. lanceolatum* were collected in Madras during the present study, the characters are treated statistically.

Measurements of 100 specimens taken at random, with reference to the myotomes from the cephalic end to atriopore, from atriopore to anus, from the anus to the posterior tip and the total number of myotome are set forth in the Histogram I. It will be seen that there are 33 to 37 myotomes from the cephalic end to the atriopore. Though 48% have 36 myotomes and can be taken as typical, the mean is 35.44 since 37% have 35 myotomes. Similarly for the myotomes from atriopore to anus, the mean is 12.51 though 12 and 13 occur more frequently. The myotomes posterior to the anus are usually 12 and 13, the mean, however, is 12.56. The total number of myotomes is 61 in 39% of the forms and the mean is 60.58. It will be seen that *B. lanceolatum*, on such a computation, is different from *B. nigeriense* (Webb, 1955) whose means are 41.75 in the pre-atrial region, 15.15 in the region between atriopore and anus, 19.9 in the post-anal region and 67.8 as total mean, and in *B. caribaeum* the means are 36.1; 6.7 and 58.6 respectively. Statistical data of forty specimens of *B. indicum* have been worked out and the range and mean are set forth in the Histogram 2.

With reference to characters like the shape of the caudal fin, it may be mentioned that there are three different types described for *B. lanceolatum* and for the forms from Madras. Similar three types of caudal fin have been noticed in *B. indicum* from Madras and in *B. caribaeum* (Boschung and Gunter, 1962). In *B. tattersalli*, however, of which nine specimens are collected, only a single type of caudal fin was observed just as Webb found only a single type in *B. nigeriense*.

SUMMARY

1. *B. lanceolatum* (Pallas) which has not been recorded hitherto from the Indian waters, is fully described with statistical data. A redescription of the Indian species, *B. indicum* (Willey) and *B. tattersalli* (Hubbs) are also given.
2. A key to the above three species of the genus *Branchiostoma* is drawn.
3. An analysis of the variation of the nine characters (used by Webb for non-Indian species) is given for 100 specimens of *B. lanceolatum* 40 specimens of *B. indicum* and seven forms of *B. tattersalli*. A Table of features of taxonomic interest is given for purposes of comparison.

4. In view of the statistical conformity between the Indian representatives of *B. lanceolatum*, it can be taken as proved that the Indian specimens really belong to *B. lanceolatum*. The taxonomic significance of myotome number of *B. lanceolatum* and *B. indicum* is discussed and compared with *B. nigeriense* and *B. caribaeum*.

5. The variations with regard to the caudal and rostral fin shapes, fin rays and notochordal terminations met within the specimens of *B. lanceolatum* and *B. indicum* are reported as of no taxonomic significance.

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REMARKS

The present species agrees with *B. californiense* only with reference to 7 and 8 differs in 2, 4, 6, 9 and maximum length and overlaps in characters 3 and 5. The range given for *B. californiense* is so great that the present form does not fit into it.

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KEY TO LETTERING OF FIGURES

A. Anus. ADC. Anterior extremity of the dorsal caudal lobe. AT. Atrium. ATP. Atrio-pore. AVC. Anterior extremity of ventral caudal lobe. CF. Caudal fin. DC. Dorsal crest. DF. Dorsal fin. DFC. Dorsal fin chambers. DFR. Dorsal fin ray. DL. Dorsal lobe. ES. Eye spot. G. Gonad. GS. Gill slit. LVF. Lamina of the ventral fin. M. Muscle fibres. MTF. Metapleural folds. MY. Myotomes. NC. Nerve cord. NTC. Notochord. OC. Ora-cirri. OH. Oral hood. PH. Pharynx. PRC. Post Rostral cleft. R. Rostrum. SI. Subter-minal dent. SP. Sense papillae. V. Velum. VES. Vestibule. VF. Ventral fin. VFC. Ventral fin chambers. VFR. Ventral fin rays. VL. Ventral lobe. VP. Velar papillae. VT. Velar tentacles. WOL. Wheel organ lobes.