

THE INARTICULATE BRACHIOPOD LARVAE OF THE INTERNATIONAL INDIAN OCEAN EXPEDITION*

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ABSTRACT

Inarticulate brachiopod larvae belonging to the families Discinidae and Lingulidae were found in several plankton samples of the International Indian Ocean Expedition. Present knowledge is insufficient to determine whether the discinid larvae belong to the genus *Discinisca* or *Pelagodiscus*. The lingulid larvae belong to *Lingula* sp. The discinid larvae were fully grown ones with pedicle and were ready to settle to a sedentary life. Most of the *Lingula* larvae had well developed pedicle and appeared to be old larvae unable to find suitable substratum to settle on.

The occurrence of the larvae and the stage of development of the *Lingula* larvae are dealt with in detail based on samples from 63 IIOE stations.

INTRODUCTION

BRACHIOPOD larvae belonging to the family Discinidae and the genus *Lingula* were often found together in plankton hauls (Yatsu, 1902; Ashworth, 1915; Helmcke, 1940; Sudarsan, 1968). Previous records of these two kinds of larvae from the Indian Ocean include those of Ashworth (1915), Helmcke (1940) and Sudarsan (1968), while *Lingula* larvae alone were reported by Sewell (1912).

The present study is based on material sorted from the plankton hauls made by the research vessels of the various countries, participating in the International Indian Ocean Expedition. Thanks are due to the Indian Ocean Biological Centre for giving me an opportunity to work on these brachiopod larvae.

MATERIALS AND METHODS

Brachiopod larvae sorted out of the plankton samples from the following stations were studied:-

22 stations of Cruise No. 1, 3 stations of Cruise No. 4A, 2 stations of Cruise No. 7, 1 station of Cruise No. 8 of R.V. "*Anton Bruun*"; 1 station of Cruise No. 2 of R.V. "*Diamantina*"; 3 stations of Cruise No. 1 and 7 stations of Cruise No. 3 of R.V. "*Discovery*"; 1 station of Cruise No. 1 of R.V. "*Gilchrist*"; 10 stations of Cruise No. 2 of R.V. "*Kistna*"; 7 stations of Cruise No. 1 of R.V. "*Meteor*"; 1 station of Cruise No. 104 of R.V. "*Varuna*"; and 2 stations of Cruise No. 35 of R.V. "*Vityaz*".

Most of the samples examined contained only *Lingula* larvae. Samples from 2 stations contained both discinid and *Lingula* larvae, while those from 4 stations contained only discinid larvae. Sorted samples from stations 26-167.

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55, 64, 66 and 81 of 'Anton Bruun' Cruise No. 1; Station 196 of 'Anton Bruun' Cruise No. 4A; Station 5089 of 'Discovery' Cruise No. 3; Station 131 of 'Kistna' Cruise No. 5 and Station 527 of 'Kistna' Cruise No. 20 were found to lack brachiopod larvae.

The dimensions of the shell valves of both discinid and *Lingula* larvae were measured with a calibrated ocular micrometer under the microscope. The number of pairs of cirri on the larvae was counted. The setae, the size of the pedicle and other important morphological features were noted.

GEOGRAPHICAL AND SEASONAL DISTRIBUTION OF THE LARVAE

The occurrences of discinid and *Lingula* larvae in the samples from the various stations and cruises are summarized in Table 1. The geographical distribution of the larval finds, illustrated in Fig 1 (Brinton and Tranter, 1969) seems to indicate more frequent occurrences in the Bay of Bengal and the Arabian Sea. While brachiopod larvae occurred at stations spread over the greater part of the Bay of Bengal,

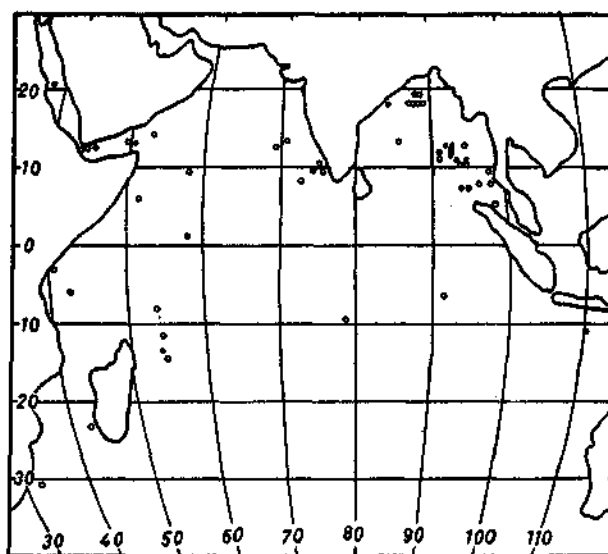


Fig. 1. Distribution of discinid larvae (dots) and *Lingula* larvae (circles) of the International Indian Ocean Expedition.

they seemed to be scarce near the middle part of the Arabian Sea, especially at great distances from the shores. This tendency of occurrences to be restricted to stations near the shore was also apparent in the South-West Indian Ocean, where most larval finds were at stations off the shores of Africa and Madagascar.

Lingula larvae

The *Lingula* larvae were obtained from stations in widely separated regions of the Indian Ocean. Their larval valves varied widely in size, ranging from 693 μ to 1955 μ in length and from 757 μ to 1658 μ in width. These size variations

are due partly to the difference in the age of the larvae, which is evident from the number of pairs of cirri, the size of the pedicle, the number of setae and other morphological features.

TABLE 1. Occurrence of discinid and *Lingula* larvae in plankton samples of the International Indian Ocean Expedition

Cruise No.	Station No.	Date	Size of Subsample	No. of Discinid	larvae of <i>Lingula</i>	stage of development of <i>Lingula</i> larvae in pairs of cirri
A. Bruun 1	14-77	19. 3.1963		0	8	10-12
"	14-81	20. 3.1963	1/16	0	5	10-11
"	16-92	20. 3.1963	1/32	0	1	10
"	17-096	21. 3.1963	1/32	0	1	11
"	18-101	21. 3.1963	1/64	0	1	11
"	19	23. 3.1963	75%	0	2	12?
"	19-137	23. 3.1963	1/64	0	1	11?
"	20	23. 3.1963	100%	0	0	
"	20	23. 3.1963	75%	0	1?	
"	25-161			1	0	
"	27-172			2	0	
"	56	8. 4.1963	75%	0	1	15
"	64-327	10. 4.1963	1/32	1	0	
"	76-367	18. 4.1963	1/16	1	0	
"	33	29. 3.1963	50%	0	1	14
"	57	8. 4.1963	50%	0	1?	
"	58	9. 4.1963	75%	0	1	
"	85	22. 4.1963	50%	0	1?	
"	96	30. 4.1963	100%	0	1	
A. Bruun 4 A	163	22. 9.1963	100%	0	1	14
"	164	28. 9.1963	25%	0	1	13
A. Bruun 7	366	12. 8.1964	25%	0	1	13
"	388	6. 9.1964	75%	0	1	14
A. Bruun 8	420	5. 11.1964	100%	0	1	15
Diamantina 2	75	26. 5.1963	15%	0	1	
Discovery 1	5002	16. 4.1963	50%	0	1	
"	5014	27. 6.1963	15%	0	1	14
Discovery 3	5251	8. 3.1964	10%	1	1	
"	5265	14. 3.1964	40%	0	1	15
"	5275	19. 3.1964	20%	0	1	14?
"	5381	19. 5.1964	100%	0	1	15
"	5500	17. 7.1964	50%	0	2	15
"	5514	24. 7.1964	20%	0	1	15
"	5546	15. 8.1964	10%	0	1	15?
Gilchrist 1	2	6. 4.1962	90%	0	1	14
INSKistna 2	3	5. 11.1962	100%	0	1	
"	3	5. 2.1962	100%	0	14	12-14
"	4	107 A	100%	0	1	14
"	14	344	50%	0	1	14?
"	14	345	50%	0	2	
"	17	433	50%	0	1	15
"	17	440	20%	0	1	
"	20	528	90%	0	1	15
F.S. Meteor 1	49	30. 11.1964	50%	0	3	13-14
"	53	1. 12.1964	30%	0	3	12-14
"	53	1. 12.1964	60%	0	1	12
"	53	1. 12.1964	100%	0	2	14
"	62(M.314)	4. 12.1964	20%	0	1	
"	62 (S.315)	4. 12.1964	5%	0	2	8? & 13
"	189	10. 2.1965	100%	0	3	14-15
"	201	18. 2.1965	20%	0	1	
R. V. Varuna 104	2003	4. 11.1963	90%	0	1	18
R.V. Vityaz 35	5211	1962	25%	0	1	
"	5321	15. 9.1962	60%	1	2	13

A. Bruun=Anton Bruun.

[3]

The larvae from the Bay of Bengal of 'Anton Bruun' Cruise No. 1 and 'Kistna'-Cruises Nos. 14 and 17 had 10 to 15 pairs of cirri. During the 10 p.c. (pairs-of-cirri) stage, the larval shell length varied from 820 μ to 952 μ . The pedicle, which had already appeared, varied in shape from a globular bud to a short cylinder. The setae were either absent or had already appeared in the posterior half of the mantle border and in some cases were spread out to occupy the posterior two-thirds of the lateral mantle border.

During the 11 p.c. stage the larval shell valves varied from 909 μ to 1107 μ in length. The pedicle was generally short. The mantle setae varied in extent: in some they occurred along the posterior third of the mantle border, while in others, almost along the entire mantle border.

During the 12 p.c. stage the larval shell valves varied in length from 935 μ to 1148 μ . The pedicle was a long coiled cylinder. The setae occurred along the entire mantle border.

One 14 p.c. stage larva had a shell length of 1403 μ . Three 15 p.c. stage larvae measured 1445 μ to 1831 μ in shell length and had distinct posterior adductors.

It is not possible at present to identify the species of *Lingula*, to which the larvae in the present study belong. This is due partly to the great mobility and the long duration of the planktonic larval stage of *Lingula*, partly to the lack of information on the *Lingula* species along the shores bordering the Indian Ocean, and also partly to the absence of published description and statistics based on a large number of larvae.

To facilitate future comparison of the dimensions of the protegula, the mean length and the mean width of the protegula from stations in the Bay of Bengal during 'Anton Bruun' Cruise No. 1 and 'Kistna' Cruises Nos. 14 and 17 were calculated. The available dorsal protegula, 12 in number, ranged between 119 μ and 153 μ in length and between 272 μ and 347 μ in width. They had a mean length of $133.5 \mu \pm 8.8 \mu$ and a mean width of $306.9 \mu \pm 21.1 \mu$. The ventral protegula, 16 in number and ranging between 115 μ and 140 μ in length and between 276 μ and 319 μ in width, had a mean length of $129.1 \mu \pm 8.0 \mu$ and a mean width of $302.2 \mu \pm 14.2 \mu$.

The protegula from the other regions of the Indian Ocean were not included in the calculation because it seems unlikely that these would belong to the same species. It is not possible to affirm that the larvae from the Bay of Bengal belonged to the same *Lingula* species.

With regard to the morphological features of the larvae there is little to add to the descriptions of Yatsu (1902), Sewell (1912), Ashworth (1915) and others. The larval valves near the posterior edge in samples of 13 p.c. larvae obtained northeast of Madagascar were blue-green in shade, while the mantle setae had not yet appeared.

DISCINID LARVAE

Discinid larvae occurred at 6 stations. Of these, 4 were in the Bay of Bengal with 3 off the Andaman Islands and 1 off the coast of the northeastern part of the

Indian state of Andhra Pradesh. Of the remaining 2 stations, one was at the eastern end of the Gulf of Aden and the other off the northeastern part of Madagascar.

The discinid larvae examined totalled 7 in number. They showed the size difference between the two shell valves, the dorsal valve being larger than the ventral. In all shell valves measured the lateral diameter is greater than the antero-posterior diameter. The ventral valves varied in lateral diameter from 425μ to 561μ and in the antero-posterior diameter from 340μ to 472μ . The dorsal valves varied in lateral diameter from 459μ to 608μ , and in the anteroposterior diameter from 425μ to 578μ . All the ventral valves showed the usual posterior bay as is usual with discinid larvae at this stage of development.

The pedicle in these larvae was well developed, and appeared long and slender. The lophophore had a median tentacle and the usual 4 pairs of cirri. The larvae appeared to be old larvae. They had two kinds of setae. These comprised the early larval setae, which were stout, strongly curved and widely spaced, and the late larval setae, which were finer, shorter and more closely packed.

DISCUSSION

The occurrence of *Lingula* larvae throughout the year seems to indicate that in the Indian Ocean, as off Singapore (Chuang, 1959), spawning is not restricted to a particular time of the year, since the development from the egg stage to the 15 p.c. (pairs-of-cirri) larvae took only $1\frac{1}{2}$ months (Yatsu, 1902). Sewell (1912) found, however, that off the Burma coast there were probably two breeding seasons during the year, one in the summer months of July and August, and a second from December to February.

The larvae with 10-15 pairs of cirri already had pedicle and setae, and they were presumably ready to settle to a sedentary life if a suitable shallow substratum was available. Yatsu (1902) observed that larvae with 7 to 9 pairs of cirri settled down to a sedentary life. Chuang (1959) showed that in the narrow straits north of Singapore the larvae with 8 to 9 pairs of cirri were rare. Presumably the older larvae with 12 to 15 pairs of cirri in the present study were the ones that still floated in the plankton because they failed to find a suitable substratum to settle on.

Qureshi and Hashmi (1963) believed that there were 4 species of *Lingula* on the shores of Karachi. The dimensions of the shell of *Lingula* larvae from the Arabian Sea in this study were not analysed statistically, since the small size of the sample would render such an analysis pointless. The mean width of the protogula from the stations of 'Anton Bruun' Cruise No. 1 and 'Kistna' Cruises Nos. 14 and 17 is distinctly greater than that of *Lingula anatina* Lamarck (Chuang, 1962), while the mean length is distinctly shorter. From this comparison it may be presumed that the *Lingula* larvae from the Bay of Bengal do not belong to *L. anatina*. To which species they really belong must await future studies of the shells of postlarvae along the shores bordering the Bay of Bengal.

The first appearance of the pedicle in the *Lingula* larvae from the Bay of Bengal must have occurred before the 10 p.c. stage, at which stage the pedicle was already quite a big bulbous evagination. This would make these larvae comparable to those of Sewell (1912) in this respect. Ashworth (1915) however, found no trace of the pedicle in his 8-10 p.c. stage larvae but found it in his 11 p.c. stage larvae.

Sudarsan's larvae (1968) developed the pedicle at the 6 or 7 p.c. stage. From this it may be inferred that the *Lingula* larvae in this study resembled closely those of Sewell and less closely those of Ashworth but differed from those of Sudarsan.

The lengths and breadths of the protogula in Ashworth's *Lingula* larvae from the Red Sea fall within the range of those from the Bay of Bengal in this study. But because of the few observations made by him, it is not possible to state whether they belong to the same species.

The lengths and breadths of the *Lingula* larvae at the 10 and 11 p.c. stage off the south Burma coast (Sewell, 1912) are comparable to those from the Bay of Bengal in this study, while those of Ashworth (1915) are larger. From this it may be inferred that Sewell's specimens are very similar to those in this study, and this is to be expected because they were all from the Bay of Bengal.

The 7 discinid larvae examined are presumed to be old larvae well equipped to settle to a sedentary life, since comparison with those off Singapore (Chuang, 1968) indicated that the larvae in the present study equalled the oldest larvae off Singapore in both pedicle development and the presence of two kinds of larval setae. The larvae in the present study are larger in size than the larvae of *Pelagodiscus atlanticus* (King) found off the west coast of India (Sudarsan, 1968), although some of Sudarsan's specimens had both kinds of larval setae.

Pelagodiscus atlanticus (King) is a cosmopolitan deepwater species reported from North and South Atlantic, North and South Pacific, and off Antarctica (Dall, 1920; Hertlein and Grant IV, 1944; Odhner, 1960). It has been the custom to assign to this species all discinid larvae found in the plankton, since Blochmann (1898) first did so with his 10 larvae from the Rhio Straits. He also relegated Mueller's discinid larvae (1860, 1861) to the species. Ashworth (1915) also assigned the larvae from the Indian Ocean off Cape Comorin to the same species, as did Eichler (1911), Helmcke (1940) and Sudarsan (1968).

Fagetti (1964) distinguished 4 groups of discinid larvae with variations in the number of setae and differences in shell size off the Chilean coast. Realising that there are 3 different species of discinids found off Chile, she concluded that it was not possible to determine whether the larvae she examined belonged to two species or were developmental stages of one single species. Sudarsan (1968), however, assigned the youngest larvae he found off the west coast of India to *Discinisca* but relegated the older ones to *P. atlanticus*. He was unaware of the observations of Chuang (1968), who showed that during the larval life of a single discinid species there was a succession of three different kinds of setae. It is quite probable that the so-called *Discinisca* larvae of Sudarsan were the early larval stages of his *P. atlanticus* larvae.

Discinisca indica Dall was recorded from Bombay and Ceylon (Dall, 1920), but the larval shells of this species are unknown. It is therefore not possible to determine to which discinid species the larvae in this study belong.

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