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STUDY OF CERIOPORES (BRYOZOA) FROM UPPER CRETACEOUS SEDIMENTS OF THE BAGH GROUP (MADHYA PRADESH) AND THE ARIYALUR GROUP (TAMIL NADU).

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ABSTRACT

Ceriopores (Bryozoa) dominate over other microfossils and are abundant in the Upper Cretaceous sediments of the Man River Valley, Madhya Pradesh, type area of the Bagh Group. A study of large number of colonial fragments belonging to the genus *Ceriopora* shows that *Ceriopora dimorphopora* Chiplonkar, 1939, *C. conoformis* Chiplonkar, 1939 and *C. ellipsopora* Chiplonkar, 1939, reported from the same locality and horizon, belong to one species, *Ceriopora dimorphopora* Chiplonkar, 1939. This species is redescribed with all details. Since the type material is lost a neotype is designated.

Ceriopora dispar Stoliczka, 1872 is of not a very common occurrence in the bryozoan microfaunule of the Maastrichtian Limestone horizon of the Ariyalur Group, around Ariyalur, Tamil Nadu. A detailed investigation on its morphology, both external and internal, has been carried out.

INTRODUCTION

Bryozoa are one of the common microfossils in the Upper Cretaceous calcareous sediments of the Bagh Group, Madhya Pradesh and the Ariyalur Group of Ariyalur, Tamil Nadu. In the former area, they are found to occur in all the fossiliferous beds, being abundant in the Chirakhan Limestone (Deola Chirakhan Marl and Coralline Limestone). In Ariyalur they are restricted to the Maastrichtian horizon (associated with *Siderolites* and *Orbitoides*) of the Upper Ariyalur.

In the Bagh sediments ceriopores dominate over other bryozoan species while they are not of a very common occurrence in the Ariyalur. Stoliczka (1872) described *Ceriopora dispar* from the South Indian Cretaceous sediments. Later, Bose (1884) recorded its presence in the Narmada Valley Cretaceous. Chiplonkar (1939) recognised three new species of *Ceriopora* from the Bagh sediments of Madhya Pradesh. They are *C. dimorphopora, C. conoformis* and *C. ellipsopora.*

A study of large number of ceriopore zoarial fragments obtained from the two localities (Bagh and Ariyalur) have made redescription and review of the above taxa necessary. All the ceriopores collected from the Bagh sediments are placed under *Ceriopora dimorphopora* Chiplonkar, 1939. Since the type material for the above species is lost, a neotype is designated. *Ceriopora dispar* Stoliczka, 1872 from the Ariyalur sediments is redescribed.

SYSTEMATIC DESCRIPTION

Phylum Bryozoa
Class Gymnolaemata
Order Cyclostomata
Family Heteroporidae WATERS, 1880
Genus *Ceriopora* GOLDFUSS, 1827

Ceriopora dimorphopora CHIPLONKAR, 1939

(Pl. I—2-8 ; Fig. 1b)

Ceriopora dimorphopora Chiplonkar, 1939, p 99; pl 3, fig. 5; pl. 4, figs. 2-3 *C. Conoformis* Chiplonkar, 1939, p. 100, pl. 3, fig. 3; pl. 4, figs. 1 and 5. *C. ellipsopora* Chiplonkar, 1939, p. 101, pl. 4, fig. 4.

Description : Zoaria erect, dichotomously branching; cross section varying from circular to oval or elliptical. Zoarial tips both bluntly rounded and conically pointed (Pl. I—4). Thick zoarial branches often develop tuberosities and corrugations (Pl. I—2). On the zoarial surface the zooecial boundaries are subpolygonal with subrounded to elongate oval orifices (Fig. 1b). Mature zooecial openings associated with those of abortive zooceia, resulting in a heteroparid aspect (Pl. I—3a & 3b). In slender zoaria the arrangement of longer diameter of orifices (of mature zooecia) is subparallel and regular while in regions of branching and in thicker zoaria, this regularity is disturbed. Zooecial tubes vary in length and width with the diameter of zoaria. Packing of zooecia very irregular. Near the central part of the zoarium the walls of adjacent zooecial tubes are either close and fused together or leave an empty space bordered by a thin wall. Near the periphery abortive or immature zooecia are present in between the zooecial openings. (Pl. I—3b). Morphologically, abortive zooecia are very similar to mature zooecia but are decidedly smaller in size. The outer margin of the tubes is subpolygonal

in cross section while the inner, bordering the lumen, is elongate oval to subrounded. As a result, the wall thickness varies considerably within a single zooecium. In general, each zooecial tube has a short ascending part at the centre of the colony, parallel to the axis of zoarial growth, and a comparatively longer reclined part, transverse to the earlier direction (Pl. I—7 and 8). The wall thickness increases towards the zoarial surface, where the tubes are funnel-shaped. Zooecial wall non-vesicular, duplex in nature ; made up of minute calcareous prisms, arranged aborally. In the reclined part of the zooecia, the outer boundary of the zooecial wall is transversely and irregulary corrugated, while the inner lining of the lumen is smooth and often with a secondary thickening. This corrugation makes the suture lines between adjacent tubes serrated. In section, sometimes the outer boundaries of zooecial tubes are superimposed indicating an irregularity in wall corrugation. Pores interconnecting zooecial cavities wide and more abundant in the marginal region of zoarium (Fig. 1b). Pores in the wall either connect mature zooecia, or terminate in the inter-zooecial cavity or in an abortive zooecium. The arrangement of pores is oral in the peripheral part, i.e., they ascend diagonally from the lumen in such a manner that pores of adjacent zooecia converge upwards orally. Zonal lines have not been observed. In section, zoecial surface irregularities and communiate pores, abundant at the zoarial periphery, give the impression of zonal lines of growth near the inflection points of tubes (Pl. I—7 and 8). But these are very much discontinuous with zooecial tubes piercing through these zones. This

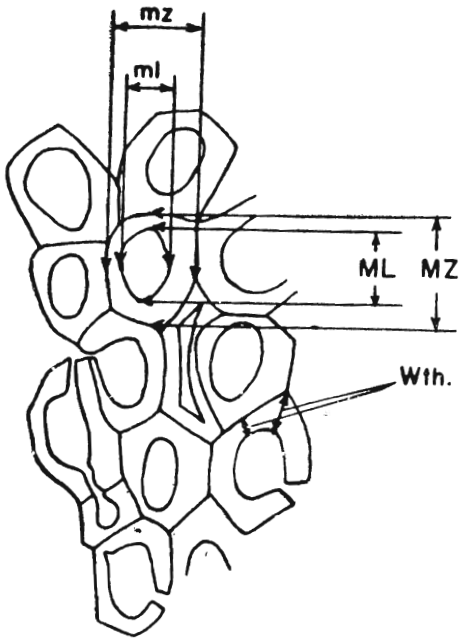


Fig. 1b. *Ceriopora dimorphopora;* ×50. Zooecial outline drawn from tangential section. For MZ, Mz, ML and Ml see Table 1 (foot note). Wth= Zooecial wall thickness.

is a common feature in sections of thick zoarial fragments, particularly in areas near branching. Budding is peripheral. Zooecial tubes may originate at any place inside the zoarium, that develops from an encrusting base (Pl. I—6). A study of the internal structures of different zoarial branches has revealed that there is little or no difference in the morphology of the zooecia excepting the variation in the length of tubes which are shorter in slender branches and longer in more thicker ones.

Measurements :

The dimensions of zooecial tubes measure are their maximum and minimum diameters, zoarial thickness, wall thickness and width of pores. The abundance of abortive zooecia and the nature of the colony necessitate a selection of only mature zooecial cross sections. The measurements are accurate up to 5 microns when they are taken from thin sections and up to 12.5 microns when taken from zoarial surface. Measurements (in mm) of zooecial dimensions and wall thickness are given in Table 1. It is clear that cross section of zooecial cavities are oval. The fact that zooecial tubes increase in diameter towards the zoarial surface is obvious from the sample AF1 where the mean of maximum diameter increases from 0.228 mm to 0.274 mm. Tuberosities on three different fragments of A518 show nearly similar values for Mz and mz. The variation in the wall thickness in a single zooecium is more prominent when this is measured from thin sections. It is observed that at the ascending part of the tubes zooecial walls are thin (0.011 to 0.017 mm). Moreover, this range in wall thickness becomes so wide, when a complete zoarial fragment is considered, that any possibility of differentiation of zoarial types on this feature is remote. The diameter of porosity on the zooecial wall varies from 0.006 mm to 0.022 mm.

Remarks : Chiplonkar (1939) reported three species namely *C. dimorphopora*, *C. conoformis* and *C. ellipsopora* from the same area. Since the type material of Chiplonkar is lost, the original description and figures were the only available tools for comparison. A classified comparative account of the characters (after Chiplonkar, pp. 100-101) of the three species is given in the Appendix.

A survey of the above table will at once reveal that the major difference between them lies in the shape of zoaria supplemented by some differentiation in the size of apertures. In the present collection, there are a large number of zoarial fragments belonging to this genus. A detailed study of these has shown that it is difficult to recognise the three species on the basis of zoarial shape alone as there are many intermediate forms. Majority of the fragments are cylindrical to subcylindrical in habit with varying length and thickness. The terminals of this type are both conical and smoothly rounded (Pl. I—4). The conical form of zoarial branches is mostly short

Table—1 Measurements (in mm) of *Ceriopora dimorphopora* Chiplonkar

Ref. No.	Sample No.	Zoarial diam	No. of readings	MZ — ×	MZ Actual Range	mz — ×	mz Actual Range	mz/MZ — ×	mz/MZ Actual Range	ML — ×	ML Actual Range	ml × —	ml Actual Range	ml/ML + —	ml/ML Actual Range	Wall Thickness in single zooecium	Remarks
1.	AF1	4.1	10	.274	.250—.325	.248	.213—.288	.906	.833—1.00	.145	.113—.175	.109	.088—.150	.753	.638—.885	.063—.125	From the zoarial surface
2.	H93	2.1	6	.308	.250—.375	.274	.200—.325	.854	.800—.923	.175	.150—.200	.138	.100—.150	.784	.667—.857	.050—.100	From the zoarial surface
3.	A518	4.7	7	.307	.225—.350	.268	.225—.300	.885	.643—1.00	.186	.175—.225	.143	.125—.150	.781	.625—1.00		From the zoarial surface
4.	A518	1.8	6	.250	.200—.275	.213	.200—.250	.857	.727—1.00							.050—.100	From the surface of a tuberose portion.
5.	A518	1.7	6	.254	.225—.275	.217	.200—.250	.856	.727—1.00							.050—.075	From the surface of a tuberose portion.
6.	A 518	2.1	6	.254	.250—.275	.208	.175—.225	.820	.700—.900							.025—.075	From the surface of a tuberose portion.
7.	A518	3.4	8	.266	.246—.308	.259	.224—.286	.905	.845—.955	.143	.107—.179	.091	.078—.107	.625	.567—.697	.022—.118	From the tangential section.
8.	A518	1.3	10	.237	.196—.263	.225	.201—.252	.913	.829—.981	.132	.107—.151	.103	.084—.117	.755	.664—.944	.028—.117	From the tangential section.
9.	A521	2.1	7	.285	.258—.308	.229	.190—.263	.803	.664—.921	.161	.146—.174	.096	.090—.101	.603	.517—.692	.045—.084	From the tangential section.
10.	A458	3.1	6	.388	.342—.465	.289	.235—.347	.749	.599—.885	.203	.145—.235	.116	.095—.146	.593	.430—.848	.078—.112	From the cross section of a tuberose portion.
11.	AF1	4.1	7	.228	.202—.246	.186	.168—.213	.817	.777—.866	.133	.112—.157	.092	.073—.118	.698	.521—.804	.028—.056	From the longitudinal section.

Abbreviations : MZ= Maximum diameter of the zooecial tube including the zooecial wall
mz= Minimum diameter of the zooecial tube including the zooecial wall
ML= Maximum diameter of the zooecial cavity (lumen) excluding the zooecial wall
ml= Minimum diameter of the zoecial cavity (lumen) excluding the zooecial wall

and slender. These indicate that they are the terminals of colonies which may have a different shape. Few fragments show elliptical cross section while in many cases they are compressed at one end having a circular cross section at the other (Pl. I—5). Both the zoaria with circular cross section and elliptical cross section have been found to possess terminals of conical shape. In all zoarial fragments present in this collection abortive zooecial openings are seen with varying abundance.

An attempt was made to see whether fragments can be separated on the basis of other morphological characters, internal or external. For this, zoarial fragments of different shapes and sizes were taken. Besides the increase in zooecial length with the increase in zoarial diameter no significant distinction exists in the zooecial characters, either external or internal, which has any relation with either the shape or the size of zoaria. Canu and Bassler (1926, p. 20) recognised the role of structure and thickness of zooecial walls in speciation of the ceriopores. The intrazooecial variation of wall thickness in the present form prevents any specific differentiation on this basis while the structure of zooecial wall is same in zoaria of different shapes and sizes.

So, it may be concluded that there is only one species belonging to the genus *Ceriopora* in the stratigraphic horizon in question and not three as proposed by Chiplonkar. All the fragments have been grouped under the species *C. dimorphopora* which is the first one described by him and the other two have been kept in the synonymy.

Canu and Bassler (1926) described a few species, all new ones, belonging to the genus *Ceriopora* from the Aptian of Faringdon, England, and the Valangian of Sainte-Croix, Switzerland. Of the above *C. dimorphocella* (p. 29, pl. 24, figs. 1-6 ; pl. 31, figs. 7-8) and *C. lobifera* (p. 27, pl. 23, figs. 11-17) have some resemblance to *C. dimorphopora* as regards the shape of zoarium, feature of zoarial surface, and tuberosities. But the present form differs from *C. dimorphocella* in having oval to elongate oval aperture, and in the absence of any tongue on the aperture. *C. lobifera* has thin tubes with polygonal and very regular apertures. Moreover, the zooecial walls are thin and vesicular, diaphragms and zonal lines are present in the above European species.

Neotype : One zoarial fragment (sample No. H93) near a cross-branching with tuberosities, four in number (Fig. 2). The cross section is cylindrical with a maximum thickness of 3.56 mm. The horizon is fossliferous argillaceous limestone (marl) of Chirakhan Formation (Deola—Chirakhan Marl and Coralline Limestone) of Chirakhan (22°23' : 75°07') Neotype No. AKG/BRT/H93.

Measurements of Neotype (in mm) :

MZ=0.250—0.388 ; mz=0.200—0.313
ML=0.138—0.200 ; ml=0.100—0.150 ;
Wth=0.063—0.100.

Material and distribution : An entire colony has not been encountered. The present collection comprises 534 zoarial fragments of which a majority (about 400) are short and slender (around 1 mm in diameter). This possibly points to the anastomosis of thin terminals of dichotomously branching colonies. The specimens are obtained mostly from argillaceous limestone (marl) beds belonging to the Chirakhan Limestone of the Bagh Group. The localities are Chirakhan, Kheri, Borlai, Deora, Mowali, Karondia, Aural, Chakrud and Ajantar, all in the Man River Valley areas, Dhar District, Madhya Pradesh. For its distinguishing internal structure its presence in the thin section of hard limestones of the same formation, where it is of common occurrence, can easily be recognised. For the major part of the Karondia (Nodular) Limestone, this is rare ; in passage beds between the Nimar Sandstone and Karondia Limestone at Amlipura and the Bagh Caves, it is abundant. Apart from his own collection, the author had the privilege to examine the collection of Shri P. R. Chandra, G. S. I., Calcutta.

Repository : Department of Geology and Geophysics, IIT, Kharagpur.

Ceriopora dispar STOLICZKA, 1872
(Pl. I—9-13 ; Fig. 1a)

Description : Zoarial fragments medium to large in size, cylindrical to elliptical in cross section. Zoarial development and branching quite irregular. Terminals blunt, thinner (around 1 mm in diameter) zoarial tips absent. Corrugations and tuberosities on the zoarial surface frequent. Colony rising from an encrusting base takes all shapes between lamellar to cylindrical, the last being of commoner occurrence. On the zoarial surface, layers of zooecia are exfoliated indicating the presence of peripheral zonal growth (Pl. I—10). Apertures closely packed on the surface (Pl. I—9a), slightly depressed, subrounded to well rounded in cross section (Pl. I—9b ; Fig. 1a). Zooecial tubes are sub-

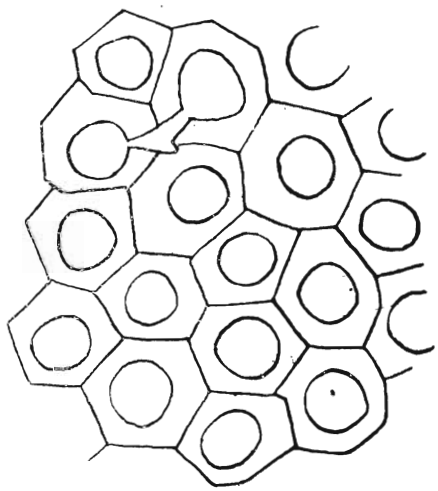


Fig. 1a. *Ceriopora dispar;* ×40. Sketch of zooecial outline drawn from tangential sections.

polygonal in section with varying wall thickness. Abortive zooecial openings rare or absent. Profile of apertures slightly funnel shaped. Zooecial walls are of duplex nature ; composed of minute calcite needles, arranged aborally. The growth lines on the walls are feeble and parallel to the apertural margin. Both the outer and inner linings of zooecial wall are smooth and so also the common suture between adjacent zooecia, Communication pores in the walls are wide but few in number.

At the centre of the zoarium, zooecial tubes have a shorter erect path, parallel to the major axis of growth, and a longer reclined part ; the former being almost indistinct in peripheral layers, where tubes are much smaller in length (Pl. I—11). Zonal lines, observed in almost all the zoarial fragments, are for the most part continuous (Pl. I—11-13). Their number varies from one in the inner branches to four in thicker ones, placed successively on the inner core. The zooecial length decreases regularly from the inner core to the peripheral zones, the outermost layer being composed of shortest tubes. Apertures of inner layers are plugged by basal lamellae of outer zones. In the outer layers the erect ascending part of zooecial tubes is indistinct to absent. In the longitudinal sections of cylindrical zoarium, parallel to the major axis of growth, the inner core shows gently curved long zooecia, with both erect and reclined attitudes, and outer zones have short, more or less reclined tubes, slightly curved distally.

Measurements (in mm) :

Zoarial diam.	2.75	to	23.83
Zooecial diam.	0.33	to	0.4
Apertural diam.	0.15	to	0.23
Wall thickness	0.08	to	0.14

Remarks : The present material agrees with the original description (1872, pp. 25-26, pl. 111, figs. 1-3) and type material (G.S.I. type Nos. 1618-1620) of Stoliczka kept in the repository of Geological Survey of India, Calcutta. The distinguishing characters of this species are its regularity in the arrangement of apertures, irregular growth of colony with peripheral zonal lines and smoothness of zooecial surface. With respect to the nature of zonal lines, it resembles *Ceriopora ovoidea* Canu & Bassler 1926 (pp. 21-22, pl. 22, figs. 2-5) and *C. solida* Canu & Bassler, 1926 (p. 29 pl. 22, figs. 6-8) described from the Valangian of Sainte-Croix, Switzerland. But it differs from them in zoarial shape, wall structure and by the absence of diaphragms. From *Ceriopora dimorphopora* Chiplonkar, 1939, it differs in lacking abortive zooecia in between ordinary ones ; and in having zonal lines, smooth walled zooecia, infrequent communication pores, regularity in the arrangement of apertures.

Material and distribution : The present collection comprises of medium to large sized zoarial fragments only. Slender zoaria (around 1 mm in diameter) are rare to absent. This is possibly due to the non-anastomosing type of zoarial development and zonal growth. A large number of zoarial fragments have been obtained from the Maastrichtian horizon of the Ariyalur sediments. The sandy shell limestone of Pallakaveri and Kallar River bed, about 3 km north of Ariyalur town, have yielded the majority of specimens. Few fragments have been obtained from the same beds of Chhokkanathapuram, 5 km west of Sendurai town, and Periyanagulur, 7 km east of Ariyalur.

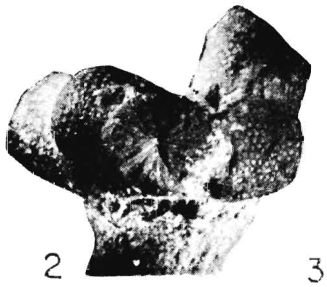
SUMMARY

The zoarial development of *Ceriopora dimorphopora* is typified by the regularity of dichotomous branching, probably terminating into a network of slender tips, The surface has a heteroporid aspect formed by smaller openings of abortive zooecia arranged in quincunxial order around the ordinary zooecial aperture, subrounded to elongate oval in cross section. Colony increases in thickness by lengthening of zooecial tubes, which has an irregular growth in thicker branches. Adjacent zooecia are frequently connected by pores in the wall, which abound in the zoarial periphery. The outer walls of tubes are transversely crenulated. This ceriopore is of common occurrence in all the fossiliferous beds of the Bagh sediments and dominate over other bryozoans.

On the other hand, *Ceriopora dispar* has medium to large sized colonies with blunt terminals. The apertures, subrounded to well rounded in cross section, are closely spaced on zoarial surface, and in superposed layers circumscribing an inner core. Abortive zooecia are rare to absent. Colony increases in thickness by regular development of zonal lines transformed into basal lamellae for outer layers, varying in number from one to four. Communication pores are few. Outer zooecial surface smooth. *C. dispar* is not a very commonly occurring form in the bryozoan microfaunule of the Maastrichtian horizon of the Upper Ariyalur sediments.

ACKNOWLEDGEMENT

Dr. B. K. Ghose has taken active interest in this work. Director General, Geological Survey of India, Calcutta permitted to examine the ceriopores from the Bagh sediments collected by Shri P. R. Chandra, and to study the type materials of Stoliczka. Authorities of I.I.T., Kharagpur have provided all facilities for this work. Shri B. N. Sircar has helped in preparation of drawings and Shri N. C. Roy in photography.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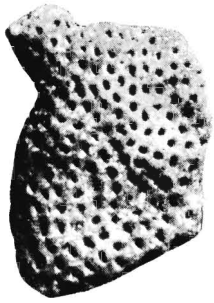
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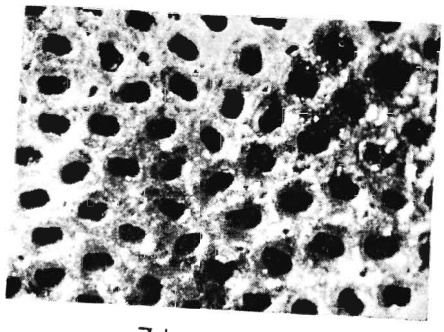
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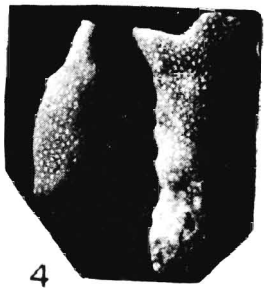
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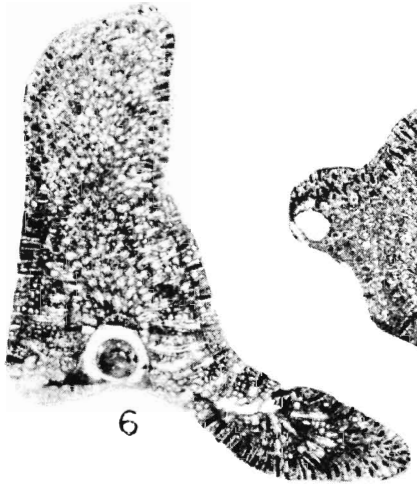
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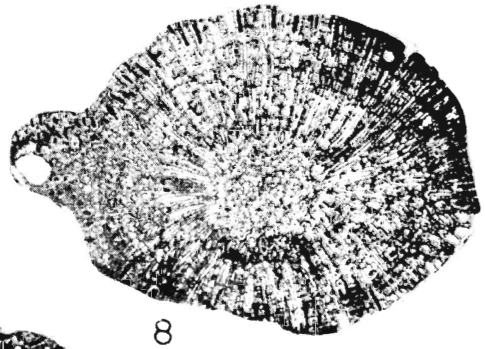
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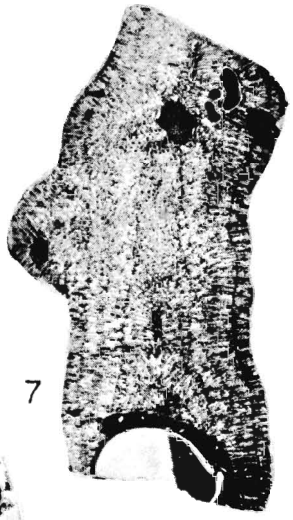
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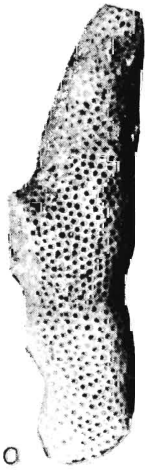
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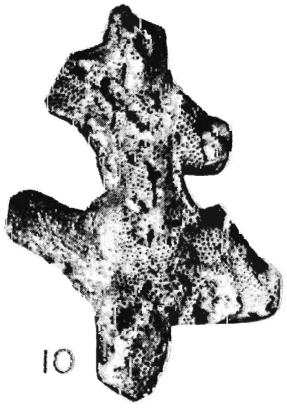
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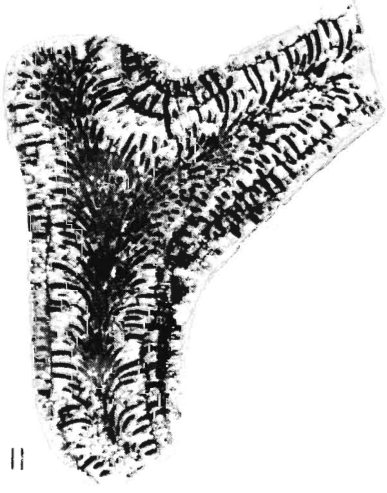
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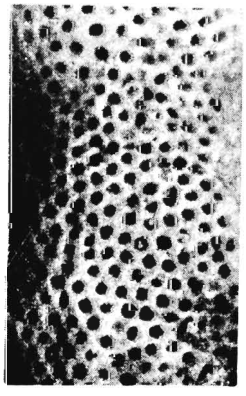
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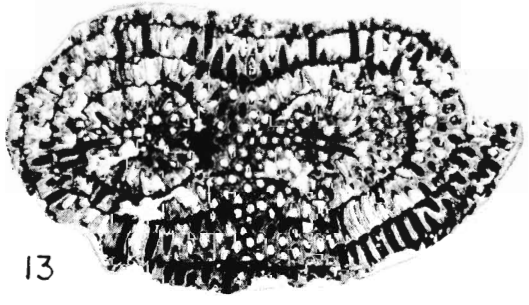
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APPENDIX—A classified comparative account of the characters (after Chiplonkar, 1939, pp. 100-101) of *Ceriopora dimorphopora, C. conoformis* and *C. ellipsopora*

C. dimorphopora (p. 100, pl. 3, fig. 5; pl. 4, figs. 2-3)	*C. conoformis* (p. 100, pl. 3, fig. 3; pl. 4, figs. 1, 5)	*C. ellipsopora* (p. 100, pl. 3, fig. 6; pl. 4, fig. 4)
Zoarium :		
'....large, free, subcylindrical with lateral branches; the surface has sometimes feebly developed tuberosities....in general the surface shows a heteroporid aspect'	'....conical with no lateral branches; the general surface gives a heteroporid appearance'	'....cylindrical pieces over 15 mm in length ....Branching not observed. Cross section of zoarium is broadly elliptical'.
Zooecium :		
'....zooecial tubes are polygonal with rather thick walls'	'....zooecial tubes are polygonal with rather thick walls'	'..zooecial tubes are polygonal with rather thick walls'
Aperture :		
'....rather small, elliptical and in two sizes; the larger apertures are often surrounded by the smaller ones; the larger apertures are more or less regularly arranged in quincunx'	'....small, elliptical and generally in two sizes. The larger apertures are surrounded by the smaller ones and are generally arranged in a roughly quincunxial order' '....apertures of a third size roughly intermediate between the two sizes'. '....this third size of aperture is in reality a modification of the larger ones'.	'..orifices are elliptical and arranged roughly in hexagonal pattern in such a way that every orifice is at the centre of a hexagon'
Zonal lines :		
'....Zonal lines are not much separated'.		
Dimensions (in mm) :		
'Long diam. of larger aperture =0.16	'Long diam. of larger aperture =0.17	'Long diam. of the orifice =0.16-0.19
Short diam. of larger aperture =0.10	Short diam. of larger aperture =0.12	Short diam. of the orifice =0.09-0.11'
Long diam. of smaller aperture =0.09	Long diam. of smaller aperture =0.10	
Short diam. of smaller aperture =0.06'	Long diam. of smaller aperture =0.06'	

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EXPLANATION OF PLATE

Plate I

Figures 2—8 *Ceriopora dimorphopora* Chiplonkar.

2. Neotype (AKG/BRT/H93); showing tuberosites at the region of branching; ×5.
3. Zoarial fragment with elliptical cross-section. 3a; ×11.5. 3b; enlarged to show the two types of zoecial openings; ×25.
4. Different terminals of zoarial fragments; ×5.
5. A zoarial fragment having circular c.s. at one end (bottom) and elliptical c.s. at other end (top); ×6.5.
6. L. S. of a zoarial fragment showing encrusting habit at the base around a bivlave shell; ×5.
7. L. S. of a branch with tuberosity showing short erect path and longer reclined part of zooecial tubes. Zooecial surface corrugations and porosity in the wall appear as growth lines; ×3.
8. C. S. of a branch with tuberosity. Structures same as in fig. 7; ×5.

Figures 9—13 *Ceriopora dispar* Stoliczka.

9. A terminal part of the colony with one type of apertures, subrounded to well rounded in outline. 9a; ×3.75. 9b; ×10.
10. A zoarium with irregular shape. Peripheral zonal layers of zooecial tubes are exposed by exfoliation; ×2.
11-12. L. S. of zoarial fragments showing growth lines. 11; ×4.5. 12; ×3.
13. C. S. of zoarium near branching; ×5.5.