# NEW OBSERVATIONS ON THE INDEX FOSSIL ALGA *DISTICHOPLAX* PIA FROM LAKI (LOWER EOCENE) BEDS OF THE PUNJAB SALT RANGE

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## ABSTRACT

A new species of the index fossil alga *Distichoplax* Pia has been described from Laki (Lower Eocene) beds of the Punjab Salt Range and named *D. raoi* after Professor S. R. N. Rao. One of the sections indicates the type of conceptacle possessed by the new species. The presence of conceptacle in *Distichoplax* is being recorded for the first time and the type of conceptacle possessed by this genus also indicates the correctness of its inclusion under Melobesieae.

## INTRODUCTION

LIMESTONES containing algae were collected by Professor S. R. N. Rao of the Lucknow University in 1946 from the Sakesar limestone (Middle to Lower Eocene) bed exposed at Nammal Gorge (32°40′ : 71°48′) in the Punjab Salt Range (W. PAKISTAN). The limestones are compact, of a whitish grey colour, and have yielded a rich algal flora. All the genera recovered from these limestones so far belong to Red Algae family Corallinaceae and subfamily Melobesieae. I have already described a number of forms representing the genera *Archaeolithothamnium* (1952), *Mesophyllum* (1953), *Lithophyllum* (1953) and *Solenomeris* (RAO & VARMA, 1953).

The forms regarded by Dietrich (1927) to belong to the perithallial parts of *Lithothamnium* which he named *Lithothamnium biserialis* have been recognized by Pia (1934) to belong to a new genus which he named *Distichoplax* and described it as *Distichoplax biserialis* after the type species of Dietrich. Giving a detailed description of the genus he considers it to be a member of the subfamily Melobesieae indicating its resemblance with forms like *Lithoporella*. The genus has always been observed in thin sections and is defined to have a platy thallus having a thickness of about 0·12 - 0·13 mm. The thallus is made up of two layers of cells arranged along a main axis which may be curved or straight. In sections passing across the thallus, the cells are either exactly perpendicular to the main axis or they may be inclined. In the latter case cells on either side are inclined at an angle of about 50° with the axis. He suggested that the *A* and *B* type of Sections may have resulted from the same thallus when the latter is cut in planes at right angles to one another. The former type resulting when the section runs in the direction of tilting of the cells and the latter when it is twisted upon that nearly at right angles.

The former type of sections he calls *Type A* (PIA, 1934, TEXT-FIG. 5) and describes them as having straight or curved axis with a single row of inclined cells on either side. These are arranged somewhat opposite to each other. The angle of inclination of each cell with the axis is about 50° so that they together make an angle of about 100°. The individual cells are about two and half times as high as broad. In some of the specimens walls of the cells stick out sharply. This feature he regards to be due to decay. Thus here and there are found long sections with pinnate cells and often among the main cells are seen small cells near the axis or towards the outer edge.

He calls the second type of sections as *Type B* (PIA, 1934, TEXT-FIG. 6). These are markedly different from the first type. Here the cells stand perpendicularly to the main axis of the sections. They are really narrower than the first type, somewhat 5 times as high as broad. The axis makes a clear zigzag line. The arrangement of cells on either side of the axis is not constant.

On the basis of a long section Pia (1934, TEXT-FIG. 7) considers that the two types of sections do not belong to two different species. He suggests a thallus in which the cells exhibited a frequent change in the direction of growth.

## DESCRIPTION

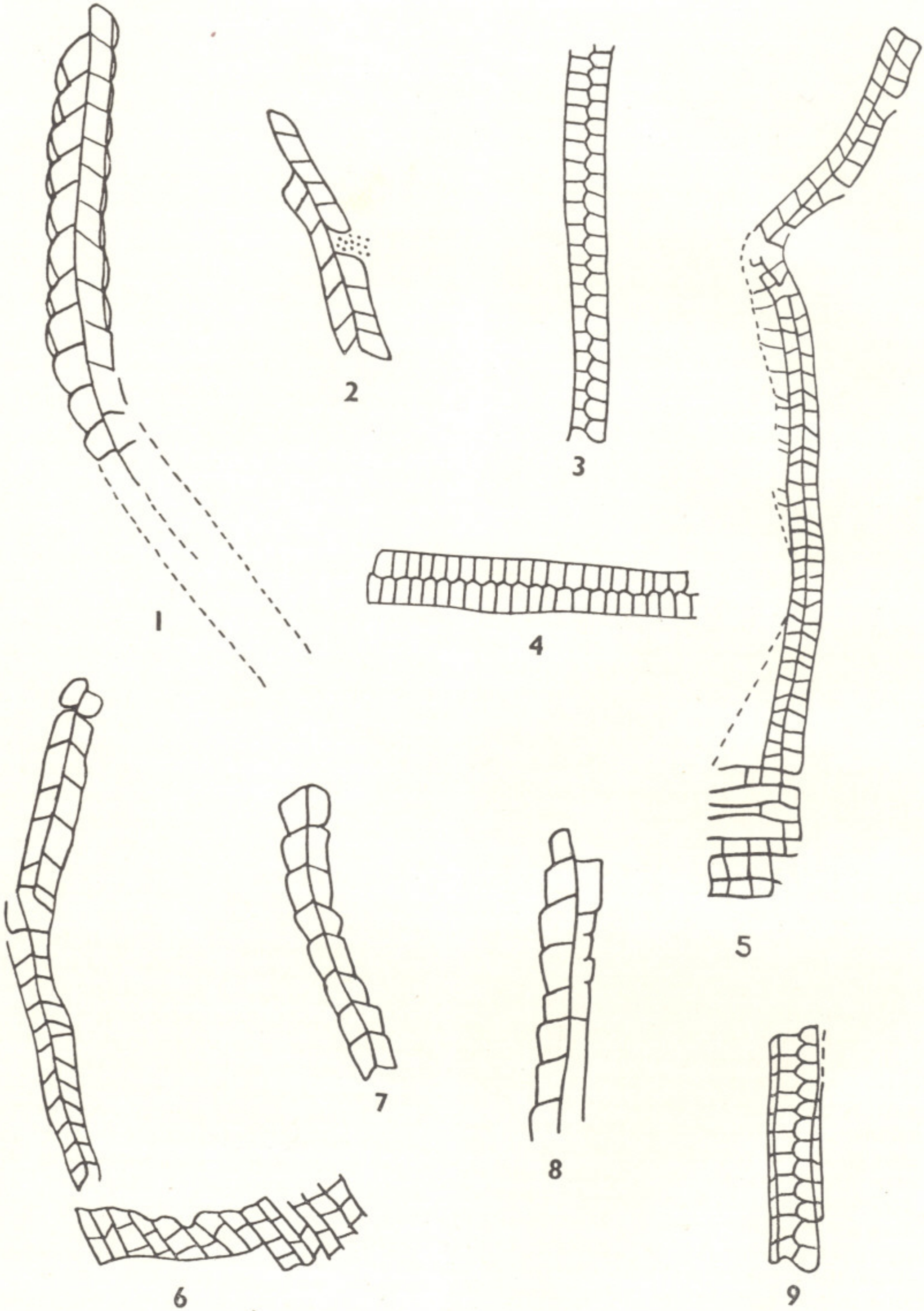
*Distichoplax raoi* sp. nov.

*Diagnosis* — Horizontally lying, flat, platy, encrusting or free floating thalli. Mostly two-, sometimes three- (or more ?) cell thick. Cystocarpic or tetrasporic thalli showing two rows of cells arranged on either side of a straight or curved smooth axis. The cells are inclined at an angle of 50-60° (sometimes up to 65°). Each cell 19-36 μ wide and 18-32 μ high. Male (?) thalli (*Type B*) showing two rows of cells arranged perpendicularly on the zigzag axis. Each cell 13-18 μ wide and 19-26 μ high. Observed total thickness of thalli not more than 65 μ.

*Description* — The sakesar limestones (Middle to Lower Eocene) were also studied in thin rock slices and have yielded the usual two types of sections of *Distichoplax*.

*Type A* — Sections of this type show a plane central axis with a row of inclined cells with smooth margins (TEXT-FIG. 2) or with cell walls projecting out sharply on either side (TEXT-FIGS. 1, 7, 8; PL. 1, FIG. 2). The angle of inclination of these cells generally varies between 50-60 degrees. Thickness of the thallus as revealed by these sections varies between 39-65 μ. Length of the thallus is unknown but sections up to 1·2 mm. have been observed. Sections of the pinnate type with projecting walls are quite common and seem to be well preserved, at any rate a large number of them do not appear to be decayed specimens. Each inclined cell, in sections across the thallus, is 18-36 μ along the axis (length or breadth) and 19-32 μ across the axis (height). Some rock sections represent the type of a thallus from which sections of the above type would have been derived (TEXT-FIGS. 5, 6; PL. 1, FIG. 4). One of the rock sections (PL. 1, FIG. 3) shows an arched dome-shaped structure (conceptacle) over a section of the *Type A* which in general displays features typically seen in many members of the Melobesieae specially in species belonging to *Lithothamnium*, *Lithophyllum*, *Mesophyllum* etc. From the roof of the conceptacle are seen some cells hanging down into the empty space. Some of the obliterated cells are seen still sticking with the broken portions of the section. Unfortunately no structure is present inside the conceptacle which may indicate its cystocarpic or tetrasporic nature. Also, the roof of the dome-shaped conceptacle does not show any opening. This absence of roof openings may not, in all likelihood, be a characteristic feature of the conceptacles of *Distichoplax* but may only be accidental, the section being cut in a plane devoid of opening or openings. Due to the lack of any more section showing conceptacles no definite information is at present available regarding the number of pores possessed by the conceptacles. But this section is important inasmuch as it shows for the first time the type of a conceptacle possessed by this genus and it also indicates the correctness of its inclusion under Melobesieae. But a lack of knowledge about the number of openings in the roof does not lead us any further in judging its affinities with one or the other genus included in this subfamily. Another interesting section (PL. 1, FIG. 2) shows three cells thick thallus, the features being observed more convincingly in the small fragment lying on the left side. In interpreting this section I have examined the possibility if it could have resulted by the partial overlapping of two sections of the *Type A* in such a way that one row of cells of each sections coincides with one another. The above possibility is ruled out seeing the direction of inclination of the row of cells on the right side which otherwise should have been directed in such a way so as to give the appearance of a typical section of the *Type A* when considered in relation with the middle row of cells. Thus it is either to be interpreted as a section passing through the thickness of the thallus or that it is a somewhat oblique horizontal section passing through a part of the thallus showing the cell mosaic. If the latter case be nearer truth (and even otherwise), we can expect the two rowed sections to have resulted also by the detachment of individual two rowed filamentous units forming the parent thallus, probably for vegetative reproduction (a mode of reproduction which is a common feature in many algae). An indication to this possibility is also seen in Text-figs. 5 and 6. As regards the possibility of getting obliquely and transversely cut sections of these two rowed filamentous objects, the former type, if of some length, would appear more or less similar to the typical sections of the *Type A* while the latter would be very small looking somewhat like two rectangles lying on either side of the axis. These minute objects would generally escape notice. But certainly there is a possibility of discovering such sections in future. But by this statement I should not be misunderstood to support the rod-like habit of *Distichoplax* (which is essentially a thalloid form) because it may only be a devise for vegetative reproduction.

The thalloid nature of the alga is now well established by the discovery in the Salt Range material (*D. raoi*) of sections passing




TEXT-FIG. 1

through the thalli showing the cell mosaic. As far as the present section (PL. 1, FIG. 2) is concerned, I am inclined (in absence of more data on this point) to believe it as a section passing through the thickness of a three cells thick thallus of *D. raoi*. Thus the diagnosis of *Distichoplax,* which is so far known only through a single species *D. biserialis,* needs emendment to include forms with three cells thick thalli.

*Type B* — Sections of *Type B* are less common as compared to *Type A*. These show a marked difference from *Type A* in having a central zigzag axis on either side of which are arranged cells perfectly alternating each other. These cells are always arranged almost perpendicularly to the axis of the thallus. These cells in sections across the thallus show a pentagonal to somewhat rounded outline (PL. 1, FIG. 1; TEXT-FIGS. 3, 4, 9). The latter feature is generally seen when the difference between the height and width of the cells is very small and/or is accompanied by the bad visibility of the cell outlines. Margins of sections of this type are mostly smooth. Sometimes a few cells are seen capped by some narrow rectangular cells (TEXT-FIG. 9). Their real significance is unknown. Text-fig. 5 is interesting as it shows a thallus with which is continued a row of cells. Some of the cells show inclined walls similar to those of Pia's *Type A* while others show straight walls resembling the *Type B*. But the long axis on either side of which these cells are arranged is not running in a zigzag manner. A somewhat mixed aspect of this part of the thallus resembles very much with Pia's Text-fig. 7. In his Text-fig. 7 one can notice that some of the cells near the upper left flank indicate as if these cells have been torn away from the thallus. Such sections (found rarely) showing a combination of the two types of cell arrangements, in all likelihood, may only be due to the inconstant directions of growth of separation walls displayed by cells of the thallus of this genus. Thickness of the thallus yielding sections of the *Type B* varies between 39 and 52 $\mu$. Cell walls on the side perpendicular to the long axis range between 19 and 26 $\mu$ and on the side parallel to it, between 13 and 18 $\mu$. One section (PL. 1, FIG. 1) shows the type of athallus from which sections of the *Type B* have resulted. The somewhat horizontally cut thallus shows the cell mosaic. Some of the cell outlines are hexagonal, pentagonal or rectangular and the walls separating the two adjoining rows of cells are seen to be (mostly) zigzag or (occasionally) somewhat straight. But it is clear from this horizontal section that a majority of the cells are probably hexagonal and the adjoining cell walls run in a zigzag manner. The small fragment lying on the right side of the thallus is most probably not a section passing across the thallus. It simply represents a detached part of the thallus showing two adjacent rows of cells.

*Comparison* — The two types of sections described above are essentially similar to those of *Distichoplax* and they could, therefore, be easily identified as belonging to that genus. Though generically similar, the Salt Range form shows a considerable difference in the angle of inclination of cells and their size. Table 1 gives a comparative idea of the original form described by Dietrich, the type species, and the Indian representatives of this genus known from Assam (RAO, 1943) and the Salt Range.

Table 1 exhibits a marked difference between the Salt Range form and the *D. biserialis* known from Persia (DIETRICH, 1927), Czechoslovakia (PIA, 1934) and India (RAO, 1943). Apart from the above named places *D. biserialis* is also known from Eastern Alps (TRAUTH, 1918) and Pyrenees (cf. PIA, 1934), etc.

I am inclined to treat the Salt Range species as distinct from the type species mainly because the thickness of the thallus of this species is less than half that of the type and has in no case been observed to be more than 65 $\mu$. Moreover, here we have definite evidence that the two types of sections have resulted from two different types of thalli which are of nearly the same thickness. One of the sections (PL. 1, FIG. 2) even shows the possibility of its thallus being three cells thick

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TEXT-FIGS. 1-9 — *D. raoi*. sp. nov. 1, a section of the *Type A* showing a smooth curved axis with sharply pinnate cells. 2, section of the *Type A* with smooth axis and smooth outer walls. 3, section of the *Type B* with pentagonal to rounded cells with a zigzag axis. 4, section of the *Type B* with perfectly pentagonal cells with a zigzag axis; cells higher than broad. 5, part of a thallus of the *Type A* showing the inconstant direction of the septation walls. 6, part of a thallus of the *Type A*. Near this lies a biseriate structure of the *Type A* which may have been a part of the thallus lying below. 7, 8, some other sections referable to the *Type A*. 9, a section of the *Type B* showing rectangular structures (cells ?) capping the pentagonal cells. (All figures magnified about 150 times.)

TABLE 1

| NAME | CELL MEASUREMENTS IN μ. | TOTAL ANGLE OF INCLINATION | THICKNESS OF THE THALLUS IN μ | COUNTRY |
|---|---|---|---|---|
| *D.* ( *L. biserialis* Diet.) *biserialis* Pia | 30-40 (B) × 60-80 (h) | Not mentioned | 110-140 | East Persia |
| *D. biserialis* Pia | *Type A* — 2½ times higher than broad | 100° | 120-130 | Waag valley, Czechoslovakia |
| | *Type B* — 5 times higher than broad | 180° | 120-130 | |
| *D. biserialis* Pia | *Type A* — 20-30 (B) ×50-65 (h) | 125-120° | 90-130 | Assam |
| | *Type B* — 15-22 (B) ×50-62 (h) | 180° | 90-130 | India |
| *D. raoi* sp. nov. | *Type A* — 18-36 (B) ×19-32 (h) | 100-120° | 39-65 | Punjab Salt Range, |
| | *Type B* — 13-18 (B) ×19-26 (h) | 180° | 39-52 | Pakistan |

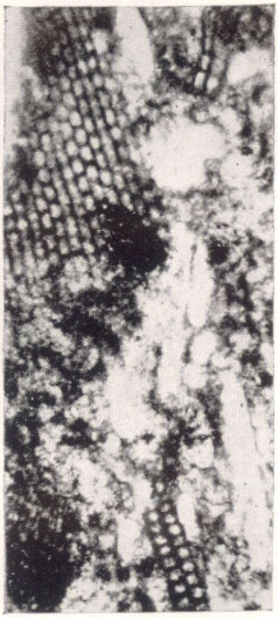
(though rarely) and a section of the *Type A* has also shown the dome-shaped conceptacle borne by this species. Whether identical features are present in *D. biserialis* is not yet known. Hence, I feel it would be safer to treat the Salt Range form as a new species and not as a dwarf variety of *D. biserialis* as I conceived earlier.

## DISCUSSION

Discovery of the two types of thalli in *D. raoi*, from which the sections of *Types A* and *B* have resulted, leads one to question whether they represent two different species or only the male and female plants of the same species. The latter possibility stands the test on the basis of whatever little evidence is available at present. Section of the *Type A* and *Type B* found at a particular locality are generally of the same thickness, mostly two-seriate, and have in most cases been found together though the latter always in lesser numbers. This fact easily indicates the probability of their belonging to one species exhibiting different sexes. This assumption is supported by the positive evidence of the discovery of conceptacle on a section belonging to a thallus of the *Type A*. Although the carpospores or tetraspores are unfortunately not preserved here, still the presence of a conceptacle does indicate the cystocarpic or tetrasporic nature of these thalli. Certainly at present there is no positive evidence at hand to prove the male nature of the thalli of the *Type B* but their comparative rarity and the presence of cap cells ( TEXT-FIG. 9 ) is quite indicative of it. These male thalli may have in most cases perished soon after liberating the male cells as is commonly found in many members of the red algae. Moreover, the occurrence of male and female plants is a common feature in Corallinaceae. While dealing with reproduction in red algae Fritsch (1945, p. 592) writes, " Many Florideae possess distinct male and female plants, although several Nemalionales and Corallinaceae, for example are monoecious (cf. 347, p. 236). Not uncommonly the male plants are smaller than the female (347, p. 231) and they often perish altogether or almost entirely after the liberation of male cells. The frequent ephemeral nature probably accounts for their rare discovery in diverse Florideae ( 1676, p. 385 )."

Thus the present study does indicate that the two types of sections are probably derived from male and female plants of the same species which have also attained the morphological distinction.

While dealing with the habit of *D. biserialis* Pia (1934, p. 16) states: " Die Gesamtform des Fossils müssen wir uns jedenfalls als plattenartig denken. Würde es sich um Stäbe handeln, so müssten zahlreiche ellipenförmige, längere und kürzere schnitte zu finden sein. Die Dicke der Platte ist etwa 0·12-0·13 mm., die Flachenausdehnung ist nach Fig. 7 mehr als 2 mm. Die symmetrische Anordnung der Zellen spricht dafür, dass die Platten aufrecht standen ". This erect habit pleaded by Pia is really very strange to expect in absence of any anchoring organs and if it is to be interpreted as an erect free floating thallus, then also it is not feasible for the small basal surface area to support the



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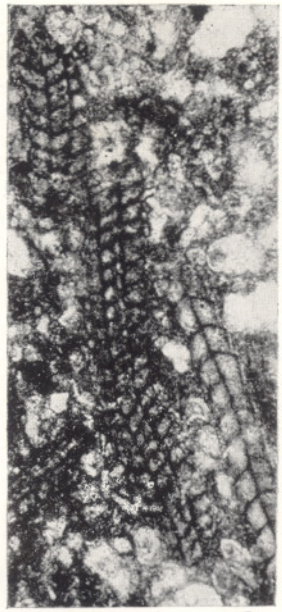

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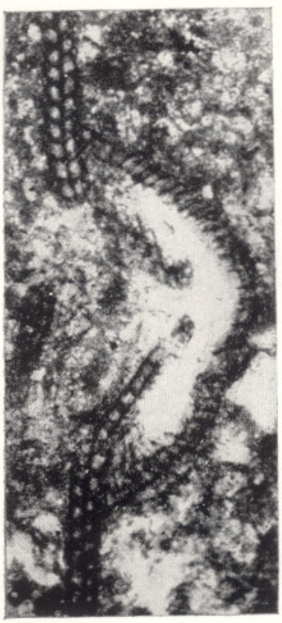

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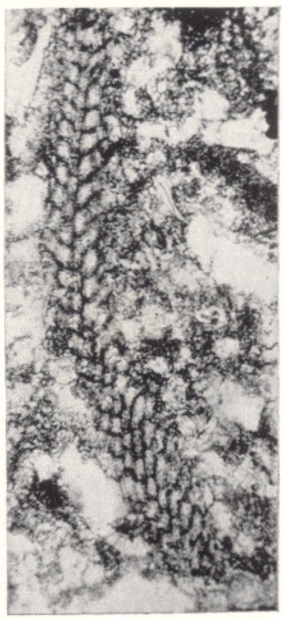

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two rowed platy thallus in its erect posture. On the other hand, I am inclined to believe that *Distichoplax* represents most probably a flat, encrusting or free-floating, reduced member of the melobesieae exhibiting morphologically and sexually different individuals which have completely lost their hypothallium probably due to their free-floating habit. The exact relationship with any member among *Lithoporella*, *Epilithon* and *Melobesia* or *Lithothamnium*, *Mesophyllum* and *Lithophyllum* should at present be left open in absence of a more detailed information regarding the methods of reproduction and the nature of its conceptacles.

*Stratigraphical significance of Distichoplax* — *Distichoplax*, so far known through a single species *D. biserialis*, has been reported from widely separated geographical areas such as Eastern Alps, Persia, Czechoslovakia, Pyrenees, India, etc. While showing a wide geographical distribution it shows a fairly limited geological range. From western countries *Distichoplax* is known from horizons ranging from Upper to Middle Eocene while from India it is known from beds of Lower Eocene (S. R. N. RAO, 1947; NAGAPPA, 1951) and Lower to Middle Eocene age (K. S. RAO, 1943, 1947). *D. raoi* the second species of this genus also comes from the Lower Eocene beds of Pakistan. The genus is so far not known from beds other than of Eocene age and the alga is, therefore, of great stratigraphic value as an index fossil.

*Emended Diagnosis of Distichoplax* — Platy, encrusting or free-floating thalli. Mostly two, rarely three cells thick. Up to 2 mm. or more (?) in length. Each species represented by two types of thalli. One showing the two upper and lower rows of cells arranged at an angle inclined to the smooth horizontal axis. The other showing the two upper and lower rows of cells arranged perpendicularly upon the zigzag horizontal axis.

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*Not consulted in original.


## EXPLANATION OF PLATE 1

*Distichoplax*

1. *D. raoi* sp. nov. A probable thallus of the *Type B*. on the right side is seen a section of the *Type B* with somewhat rounded cells ( due to defective preservation of the cell walls ). × 96.

2. *D. raoi* sp. nov. A section passing through the three cells thick thallus. Near about are seen typical sections of the *Type A* with sharply pinnate cells. × 96.

3. *D. raoi* sp. nov. A vertical section passing through the two cells thick thallus of the *Type A* possessing a dome-shaped conceptacle. × 80.

4. *D. raoi* sp. nov. Section showing a part of the thallus of the *Type A*. × 96.