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A NEW SPECIES OF *DRAPARNALDIOPSIS* (*DRAPARNALDIOPSIS INDICA* SP.NOV.)

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(With Plate VIII and 2 figures in the text)

THE material upon which the following communication is based was found on the leaves of grasses and sedges growing in the shallower water of a pond at Benares, India, in August, 1931. It formed a thin gelatinous pale green covering from which numerous long mucilaginous threads projected freely into the surrounding water. These threads are from 800 to 1800 μ thick (average about 1 mm.).

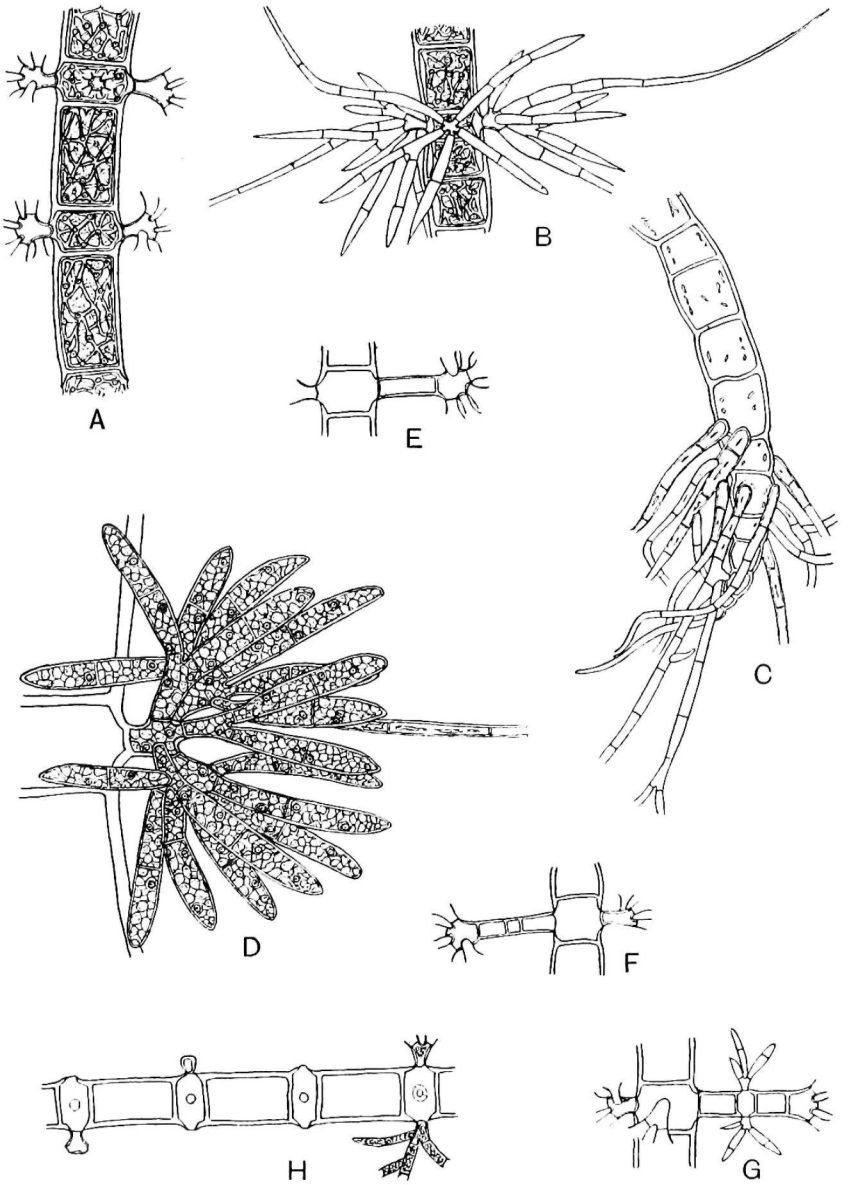
The principal axes are differentiated into elongate cylindrical, sometimes barrel-shaped internodal cells and short discoidal barrel-shaped nodal cells which alternate with one another in a very regular fashion (Text-fig. 1 A; Pl. VIII, fig. 1). The internodal cells are usually about 2–3 times as long as the nodal cells which are always slightly broader than the former except when the internodal cells are barrel-shaped. The greater part of the main axis is of more or less uniform breadth, but the apex and base are attenuated. The basal cells taper gradually, the lowest being usually prolonged into a rhizoid (Text-figs. 1 C, and 2 A and B), whilst the others give rise to numerous rhizoidal branches which fix the plant firmly to the substratum. In some cases the branching of the rhizoids is so profuse that they form a dense cortex around the base of the main axis (Pl. VIII, fig. 3). There is practically no differentiation into nodal and internodal cells in the basal part of the main axis. Normally every nodal cell bears lateral branches and there are typically four of them, although they exhibit varied differentiation as the following account will show.

The main axis usually bears a number of lateral branches of unlimited growth, repeating its structure and ultimately attaining the same size. These branches arise from the median portion of some of the nodal cells which may produce from one to four such branches each.

Both the main axis and the laterals of unlimited growth bear richly ramified short branches of limited growth, arising as opposite pairs or in whorls of four from the median portion of the nodal cells. The same nodal cell may bear both branches of unlimited and limited growth. As an exception both kinds of branches may originate a little above or below the middle of the nodal cell.

The laterals of limited growth are set at right angles to the main axis and are broadly orbicular in outline owing to the spreading character of their branches (Text-fig. 1 D). There is no evidence of a main axis in these laterals. Their branches are subulate and the distal ends terminate in long hyaline hairs consisting of one or more greatly elongated cells in which the chloroplasts are disorganising or have totally disappeared (Text-figs. 1 B and D, 2 D; Pl. VIII, fig. 1). The basal cells of the laterals of limited growth bear from two to six sub-apical branches and are cuneiform in shape with a short cylindrical projection bearing each branch. The basal cell of each such primary branch generally has a similar shape and in its turn bears secondary branches at its upper end. All the cells of the laterals of limited growth are much narrower than those of the main axes. Similar short laterals may also be borne on some of the basal cells of the main axis that bear rhizoids, but such laterals do not always arise from the middle of the cell, nor do they always grow to their full size (Text-fig. 2 A and B). The entire thallus is enveloped in mucilage within which several blue-green algae were growing.

Growth is intercalary and new cells may be formed by division in any of the axes of unlimited growth, whilst laterals of both limited and unlimited growth may arise secondarily at any point in the thallus. An internodal cell in a long axis may divide transversely into two daughter cells which grow to the length of the mother cell. The lower cell of the pair then divides into two, the lower half again enlarging to the full size, whilst the upper remains small and constitutes a new nodal cell between the two internodal ones. In this way the characteristic alternation of internodal and nodal cells is maintained. In rare cases there is only one division and, of the two resulting cells, the lower develops into an internodal while the upper forms a nodal cell, so that two nodal cells come to lie adjacent to one



Text-fig. 1. *Draparnaldiopsis indica* sp.nov. A, portion of main axis with internodal and nodal cells showing chloroplasts. B, the same with short laterals. C, basal portion of axis with rhizoids. D, part of a nodal cell bearing a short lateral. E, F and G, stages in the development of a long lateral from one of limited growth. H, portion of main axis from which the short laterals have dropped off, leaving only scars or remains of branches on the nodal cells. (A–C and E–H × 220; D × 485.)

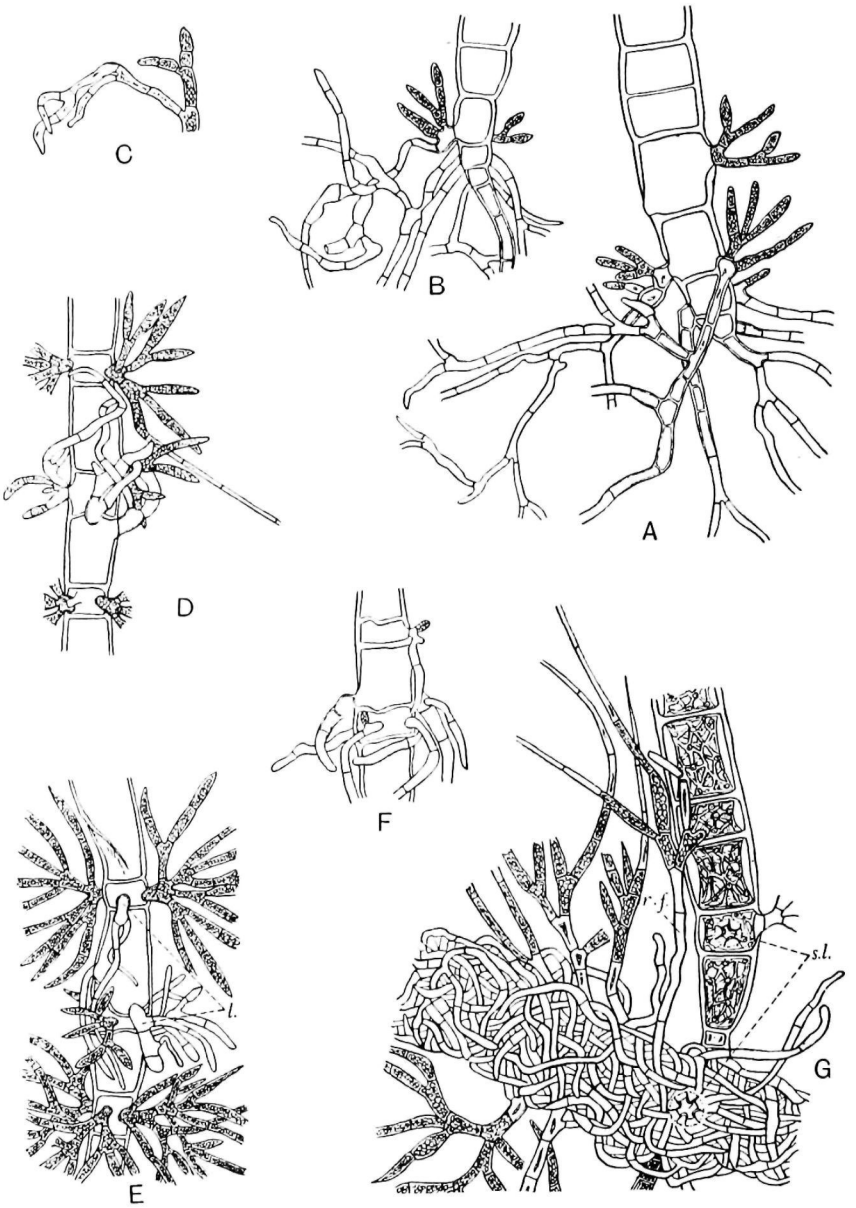
another. Sooner or later such nodal cells give rise to one or more laterals of limited growth. The first step in their formation is the development from the middle of the cell of a small cylindrical protuberance which subsequently becomes separated by a transverse wall and constitutes the first cell which then divides to form a row of two or three cells. At this stage the basal cell begins to form the primary branches. These first appear as short papillae which are soon cut off by a transverse wall.

The maximum number of laterals borne on a nodal cell is four, all of which may be of unlimited or limited growth (Text-fig. 1 B) or the laterals may be partly short and partly long. Moreover, one finds many transitions between the two types of branches. Certain of the short laterals possess two basal cells, either similar or the lower much longer than the upper (Text-fig. 1 E) which bears normal branches; others have three, and still others four basal cells (Text-fig. 1 F) of which the uppermost bears branches and the middle one of the lower three is short and nodal in character. In some of the laterals of the last type this nodal cell bears short branches (Text-fig. 1 G). In the same way short laterals are to be found with three internodal and two nodal cells at their base, the nodal cells bearing short branches. Between such cases and the typical lateral of unlimited growth there are many other transitions. It thus appears probable that the laterals of unlimited growth arise by basal growth of certain of the laterals of limited growth and that the former are but a modification of the latter. The growth of a long branch is initiated by the division of the basal cell of the short lateral into two, of which the lower subsequently divides into three, after which further elongation is effected by intercalary growth, the apical portion of the long lateral thus arising still preserving the original character of the branch of limited growth.

The rhizoids produced from the basal cells of the main axis generally arise as independent structures (Text-fig. 1 C), though in some cases they probably represent modified short laterals (Text-fig. 2 A and B) (cf. below). In the former case they originate in the same way as the branches of limited growth, but they may grow out from any part of the basal cells which, as already stated, are not usually differentiated into internodal and nodal cells (Text-fig. 1 C). The initial cell of the rhizoid divides repeatedly to form a comparatively long thread before lateral branches are produced; these branches arise at any point on the cell. The cells of the rhizoids are elongate and their chloroplasts gradually disorganise and ultimately almost disappear.

Apart from those formed by the basal cells of the main axis, similar branched rhizoids may develop from any part of a lateral of limited growth (Text-fig. 2 C) or may replace the whole of such a lateral (Text-fig. 2 E, *l.*). Such rhizoidal development may occur on any node, but it is invariably found on nodes which bear branches of unlimited growth (Pl. VIII, fig. 2). Sometimes, similar rhizoids also originate from internodal cells immediately adjoining nodes bearing rhizoids. In the former case one or more branches of a short lateral may develop as a rhizoid (Text-fig. 2 A–D; Pl. VIII, fig. 4) and all transitions are found between a lateral with only one or two rhizoidal branches and a lateral completely replaced by a branched rhizoid (Text-fig. 2 E, *l.*). Occasionally one meets with a long rhizoidal filament bearing a few normal branches at its apex (Text-fig. 2 G, *r.f.*). Sometimes a nodal cell bears branched rhizoids only in place of all of its short laterals (Text-fig. 2 F). These facts indicate that the rhizoids of this alga are most probably to be regarded as homologous with laterals of limited growth the branches of which, by repeated division and elongation of their cells, have become transformed either wholly or in part into long branched threads. Thus laterals of limited and unlimited growth and rhizoids are all homologous structures.

Those rhizoids which originate from internodal cells, adjoining nodes bearing rhizoids, emerge in the neighbourhood of the septum (Text-fig. 2 D–F). Rhizoids originating on or in place of the laterals of limited growth on nodes bearing branches of unlimited growth develop only after the latter have reached a certain size; when the long laterals are young there is no trace of rhizoids. In rare cases rhizoids have also been observed to develop from the basal cells of the long laterals. The later development of rhizoids at these points may be so considerable owing to their profuse and dense branching that a thick cortical covering is formed around the axis, totally concealing both it and the bases of the branches of unlimited growth (Text-fig. 2 G; Pl. VIII, fig. 2). The rhizoids are sometimes so closely wound round the axis as to produce an appearance of compression, the cells at such points being much narrower than elsewhere. Such dense growths of rhizoids would appear to serve a mechanical function, no doubt materially strengthening the attachment of the freely projecting long laterals with the main axis. The rhizoids generally possess the same breadth as the cells of the branches of limited growth. Those produced on the basal cells of the main axis have slightly thicker walls than the others.



Text-fig. 2. *Draparnaldiopsis indica* sp.nov. A and B, basal portions of main axes showing rhizoids developed from portions of short laterals. C, short lateral with terminal cells transformed into a branched rhizoid. D–F, portions of axes bearing rhizoids on the nodal and internodal cells, the former appearing as partial or complete modifications of short laterals. G, portion of main axis concealed by a cortical covering of rhizoids formed near the place of origin of a long lateral. *l.* short lateral completely transformed into a branched rhizoid; *r.f.* rhizoidal filament bearing at its apex a few normal branches; *s.l.* base of short lateral not shown at its full length in the figure. (All × 220.)

Each cell of the long axes has a parietal chloroplast in the shape of a reticulate cylinder with entire margins and several pyrenoids, occupying the whole length of the cell (Text-figs. 1 A and B, and 2 G). In the cells of the branches of limited growth the chloroplasts are likewise parietal and reticulate, with one or sometimes two pyrenoids, and densely fill the cell (Text-fig. 1 D).

Zoospore or gamete formation has not been observed, but in material of old filaments, that had not been teased out, many of the nodal cells lacked branches of limited growth or only bore remains of such branches, sometimes merely the cuneiform basal cells (Text-fig. 1 H). This possibly implies that the branches of limited growth break away from the long axes either entirely or in part during the process of zoospore or gamete liberation.

In 1929 Smith and Klyver (3) published an account of an alga resembling that described above in most essential respects and created for it a new genus *Draparnaldiopsis* with the single species *D. alpinis*. The Indian alga agrees with this form in the following characters: (i) the alternation of long internodal and short nodal cells in the main axis and the other branches of unlimited growth, (ii) the origin of the branches of limited growth from the median portion of the nodal cells only, (iii) the cuneiform shape of the basal cells of the branches of limited growth and the fact that they always produce a number of branches near their apices, the basal cells of which branch in the same manner, (iv) the termination of these branches in long hairs consisting of one or more cells without chloroplasts, and (v) the envelopment of the thallus within a hyaline mucilaginous envelope. There are, however, some significant differences, viz. (*a*) the main axis usually bears a number of branches of unlimited growth which arise from the nodal cells and replace some of the short laterals; (*b*) the branches of limited growth arise not only in pairs but also usually in whorls of four and the basal cell of each bears 2–6 branches; (*c*) the chloroplasts, both in the cells of the main axis and in those of the branches of unlimited growth, are cylindrical and reticulate and do not constitute merely equatorial girdles, as in *D. alpinis*; (*d*) the chloroplasts in the cells of the branches of limited growth are of the same pattern and completely fill the cells, while Smith and Klyver describe the chloroplasts in similar cells in the American form as laminate and parietal, though the exact form of the chloroplast is not clear from their figures; (*e*) the attaching rhizoidal system is much more strongly developed; (*f*) rhizoids may develop on any of the branches of the laterals of limited growth or may altogether

replace them; (*g*) in rare cases rhizoids may also originate from internodal cells; and (*h*) the growth of rhizoids is especially profuse at the points of origin of the branches of unlimited growth where they form a cortical covering around the axis and the bases of the branches.

Minor points of difference lie in the character of the plant mass with its long projecting mucilaginous threads and in the occasional barrel-shaped cells of the long axes. The rhizoids at the base of the main axis are branched and sometimes appear to represent modifications of the branches of limited growth. The rhizoids borne elsewhere appear always to be more or less complete modifications of the branches of limited growth. The cells of the main axes and their long branches are larger than those in the American form, while the branches of limited growth (excluding the terminal hairs) are not so long. The habitat of the Indian alga is quite different since it occurs practically at sea-level.

The general character of the plant-body in both forms is quite like that of a *Draparnaldia* in which likewise the basal portion of the main axis is attenuated and bears rhizoids (cf. Berthold(1), Taf. 3, Fig. 4). The chloroplasts in the cells of the branches of unlimited growth in the Indian alga are like those of *D. platyzonata* Hazen (cf. Hazen(2), Pl. 41), although in other species of *Draparnaldia* they are equatorial and girdle-shaped. The production of rhizoids at the points of formation of branches of unlimited growth has been described by Berthold (Berthold(1), Taf. 3, Fig. 2) in *D. glomerata* (Vauch.) Agardh., where, however, they are not produced in anything like the same profusion and do not form a cortical covering.

The American and the Indian algae thus show a great measure of general resemblance with *Draparnaldia*, and the only significant differences are the alternation of long internodal and short nodal cells in the main axis and its branches of unlimited growth and the restriction of the branches of limited growth to the nodal cells. Moreover, the growth of the thallus in these forms, as at present observed, is more markedly intercalary than in *Draparnaldia* (cf. Berthold(1), p. 204), though the absence of apical growth of the type described by Berthold for the latter genus cannot be positively dismissed, since there has been no opportunity of examining growing material of the Indian form. The account of the American species also leaves open the possibility of the growth not being entirely intercalary. A minor point of difference from *Draparnaldia* lies in the shape of the basal cells of the branches of limited growth and in

their mode of branching. These differences, which appear to be shared both by the American and the Indian algae, are probably sufficient to warrant the retention of the genus *Draparnaldiopsis*.

The Indian form described here is clearly a new species of the genus whose diagnostic characters are slightly modified in order to include both the American and the Indian species which may be named *Draparnaldiopsis indica*.

Draparnaldiopsis Smith and Klyver, diagn. emend.

Thallus macroscopic, filamentous, differentiated into long and short branches, the former composed of alternating long internodal and short nodal cells; branches of both kinds formed only on the short cells and arising from their median region to the number of 1–4. Cells of the short branches much smaller than those of the long ones, the basal cells cuneiform and bearing up to six branches at their apices where basal cells branch in the same way. Branches of the short laterals terminating in long hairs. Chloroplasts single, girdle-shaped and reticulate or laminate with from one to several pyrenoids. Rhizoids confined to the base of the plant or, in one species, arising abundantly on nodal cells, especially those bearing long branches as more or less complete modifications of the short branches, sometimes forming a dense cortical covering around the main axis and the bases of the branches. Thallus invested with a copious hyaline gelatinous envelope, attached to the substratum by the basal rhizoids. Reproduction unknown.

(1) *D. alpinis* Smith and Klyver.
Trans. Amer. Microsc. Soc. **48**, 1929, p. 200.

(2) *D. indica* sp.nov.

Cells of branches of unlimited growth cylindrical or barrel-shaped; basal cells of laterals of limited growth bearing two to six branches. Lateral branches solitary, opposite or in whorls of four, those at a node all of limited or all of unlimited growth or some of the one and some of the other; chloroplasts (except in cells of hairs and rhizoids) parietal and reticulate, occupying the whole length of the cell. Rhizoids copiously developed at the base of the plant as well as on the nodes of the branches of unlimited growth, especially when these produce similar branches. Rhizoids with numerous branches.

Internodal cells 28–63 μ (average about 35 μ) long and 20–60 μ (average about 30 μ) broad; nodal cells 8–31 μ (average about 16 μ)

long and 16–60 μ (average about 33 μ) broad; cells of short laterals 4·2–8·4 μ broad; width of the thallus including the hairs on the short laterals 800–1800 μ (average about 1 mm.), without the hairs 160–500 μ (average about 250 μ).

In a pond in Benares, India, August, 1931.

The author wishes, in conclusion, to express his great indebtedness to Prof. F. E. Fritsch, F.R.S., for his guidance and criticism.

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EXPLANATION OF PLATE VIII

Draparnaldiopsis indica sp.nov.

Fig. 1. General habit. (×73.)

Fig. 2. Main axis totally concealed by a cortical covering of rhizoids around the place of origin of a long lateral. (×160.)

Fig. 3. Basal portion of main axis, totally concealed by a covering of rhizoids. (×90.)

Fig. 4. Portion of axis with partial transformation of a short lateral into a branched rhizoid. (×300.)

Note. After sending this communication to press a paper by Meyer (*Rev. Alg.* **2**, 241 *et seq.*, 1925) came to my notice dealing with a number of new species of *Draparnaldia*. In one of these (*D. baicalensis*) Meyer describes the formation of a dense cortical covering around the axis due to a profuse growth of rhizoids similar to that described in this paper.

Fig. 1

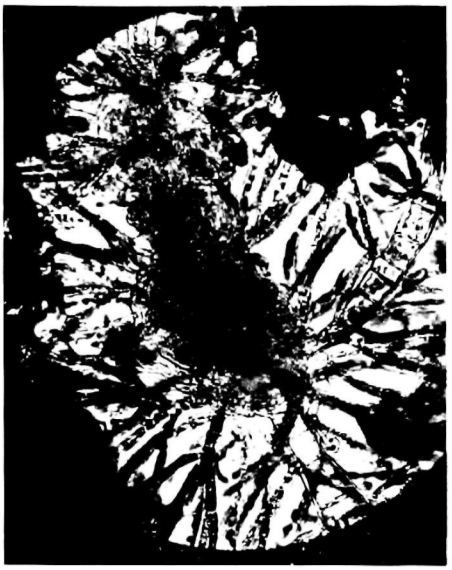

Fig. 2

Fig. 3

Fig. 4