STRUCTURE AND REPRODUCTION OF *PSUEDOGLOIOPHLŒA FASCICULARIS* (BOERGS.) COMB. NOV.

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INTRODUCTION

CONSIDERABLE work has been done on the Red algæ of India and Ceylon. In the last century, Harvey (1854, 1869) and Murray (1887) and in recent times Svedelius (1906, 1915, 1939, 1944, 1945, 1946, 1952, 1956), Boergesen (1931, 1932, 1933, 1934, 1937 *a* and *b*, 1938 *a* and *b*), etc., have contributed a great deal to our knowledge of the Red algæ of this region. But the details of structure and post-fertilisation stages are known only in a few. Papenfuss (1937) studied the structure and reproduction in *Vanvoorstia spectabilis*. Svedelius has worked out *Dermonema frappieri* (Mont. *et* Mill.) Boergs. (1939), *Dictyurus purpurascens* Bory (1946 *a*, 1946 *b*) and *Galaxaura* spp. (1944, 1945). Balakrishnan studied *Melobesia farinosa* Lamour. (1946), *Grateloupia lithophila* Boergs. (1949) and *Liagora erecta* Zeh (1955). Iyengar and Balakrishnan (1949, 1950) worked out *Polysiphonia platycarpa* Boergs. and Krishnamurthy (1953) *Compsopogon* sp. Boergesen in his various accounts also gives certain details of post-fertilisation stages in some of the species he has recorded.

A number of new species of Red algæ are known from India and its neighbourhood. There is a great need for a detailed study of the post-fertilisation stages in these forms.

Among the Indian Nemalionales there are very many interesting forms which are worthy of our attention. The interesting family Chætangiaceæ is divided into two subfamilies, Scinaieæ and Chætangieæ. The Chætangieæ have been studied in great detail by Svedelius (1939, 1942, 1944, 1945). and Martin (1936, 1939). Among the Scinaieæ *Scinaia furcellata* (Turn.) Bivona has been very thoroughly studied by Svedelius (1915). Till recently the genus *Pseudogloiophlœa* Levring (= *Gloiophlœa* Setchell, *non* Agardh)

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has not been studied in detail. *P. fascicularis* (Boergs.) comb. nov. (= *Gloiophlœa fascicularis* Boergesen, 1934, pp. 1–2) occurs very commonly at Okha, the type locality as also at Cape Comorin (leg., M. O. P. Iyengar). Hence, it was taken up for a detailed study of cystocarp development.†

MATERIAL AND METHOD

The alga was collected growing attached to rocks in the littorial region at Okha Port in Bombay State. It was preserved in 70% Formalin-alcohol.

The material was passed through alcohol and xylol series and was ultimately embedded in paraffin wax (56° C.). Microtome sections were prepared from these. Microtome sections were cut with 7 to 10 μ thickness using safety razor blades. These sections were stained with Hæmatoxylin and Fast green in the usual way.

The material was also studied in another way.

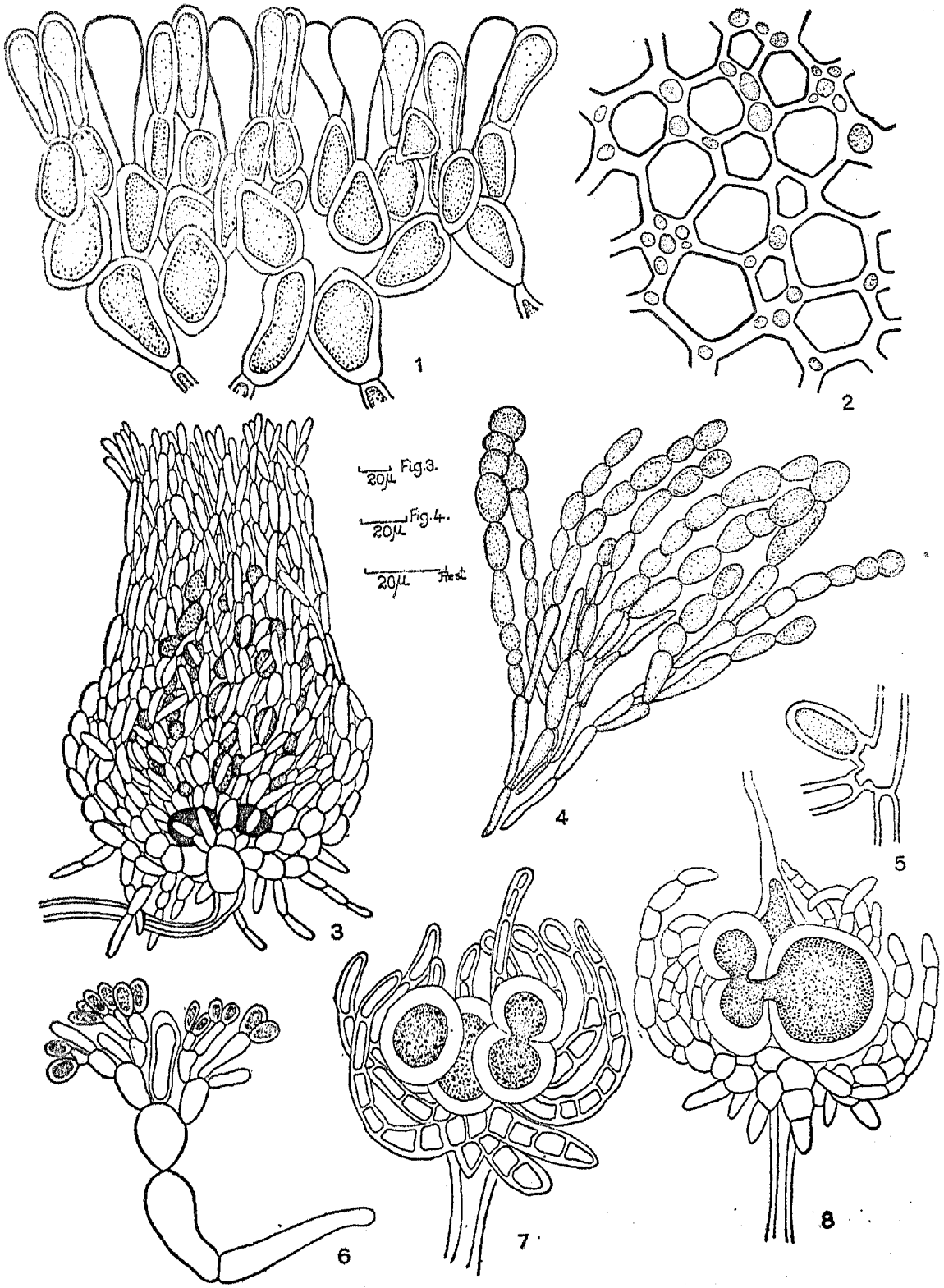
Small portion of the material was treated in 5% acetic acid for 12 hours for purpose of maceration. The macerated pieces of the thallus were placed on the slide and chopped to very fine portions with a blade. It was then stained with Cotton blue and mounted in lactophenol or in 4% Formalin. The cover-slip was gently pressed in order to spread the material evenly on the slide. Acid fuchsin was also used as an alternative stain. The latter stain was found useful in studying the post-fertilisation stages.

DESCRIPTION

The plant is erect and reaches a height of 12 to 15 cm. The thallus is terete, cartilaginous and unconstricted. The thickness of the plant is about 2 cm. and this size is remarkably kept very evenly throughout from the base to apex of the thallus (Plate VIII, Figs. 2, 4). It is branched dichotomously up to 8 to 10 times (Plate VIII, Fig. 2) with a distance of about 1·5 to 2 cm., more rarely only 1 cm. or up to 3 cm., between each successive dichotomy. The plant is attached by a very small discoid hold-fast (Plate VIII, Fig. 2).

The colour of the dried plant (herbarium specimen) is light red in the upper, younger parts, but it is darker in the older portions. The alga sticks fast to paper. In living condition (see also Boergesen, 1934 *a*) the plant has a rosy-red colour. The axial strand is visible neither in the dried specimen nor in the preserved material. The thallus surface, when seen from above,

† Since the completion of the present study, the writers saw Svedelius' (1956) account of the post-fertilisation stages in *Pseudogloiophlœa capensis* (Setchell) Levring.



TEXT-FIGS. 1–8. *Pseudogloiophlœa fascicularis* (Boergs.) comb. nov.—Fig. 1. Radial section of the cortex showing the vesicles formed in between the coloured cells. Fig. 2. Surface view of the thallus showing utricles surrounded by coloned cells. Fig. 3. Mature cystocarp. Fig. 4. A few gonimoblast filaments with terminal carpospores. Fig. 5. One-celled carpogonial branch initial. Fig. 6. Cortical branch showing antheridia. Figs. 7, 8. One of the hypogynous cells much bigger than the other three and showing prominent protoplasmic connections.

shows pentagonal or hexagonal colourless cells (Text-Fig. 2), 16 to 18 μ in diameter, surrounded by roundish coloured cells which are 8 to 10 μ in diameter. The apex of the thallus is somewhat conical in shape.

Internally the thallus can be clearly distinguished into a central medulla and a cortex (Plate VIII, Fig. 3). The cortex is 90 μ thick. The outer part is 60 μ thick and composed of more or less closely placed anticlinal filaments with moniliform rows of coloured cells enclosing utricles in various stages of development and size from 26 μ long and 12 μ broad to small ones (Text-Fig. 1). The inner cells of these anticlinal filaments are large and rounded and the outer cells are gradually smaller (Text-Fig. 1). The inner cortex is not much developed and is composed of thin interwoven filaments. On its inner side numerous thin filaments are found, running as a rule in the direction of the central axis which in the adult thallus is about 90 μ thick. The cortical tissue near the growing point scarcely shows any marked difference between apical and other cells in the branch system. Soon the outermost cells of the filaments proceeding down from these unite to form a continuous cortical tissue which soon differentiates into an outer region with big cells, poor in chromatophores and an inner part with smaller cells rich in chromatophores. It is very rarely that all these outside cells immediately become vesicular as in the case in *Scinaia furcellata*. But between them various short branches with 2 or 3 cells grow out from the chromatophore containing cortical cells (Text-Figs. 1, 2).

A study of the early development of the cortical tissue, however, shows that to an extent this alga agrees with *Scinaia furcellata* in this alga cortex development. At first the outermost cells are transformed into vesicles, but the cells below these vesicles give off branchlets which grow in between the vesicles and ultimately form the anticlinal rows described by Agardh. The branching of the peripheral filaments is markedly cymose. The terminal cell becomes an utricle and does not divide further (Text-Fig. 1). Later, branchlets grow up outwards around the vesicle and may, in turn, become vesicles. The vesicles are gradually compressed and become transparent on account of their lack of colour.

REPRODUCTION

Spermatangial Branches.—The plant is monœcious. The spermatangia are formed in superficial sori scattered irregularly in rows in the thallus. The spermatangia are borne terminally on lateral branches arising from the central axis. The spermatangial branches are slender and generally clustered. They project beyond the other cortical cells. Each terminal cell bears two

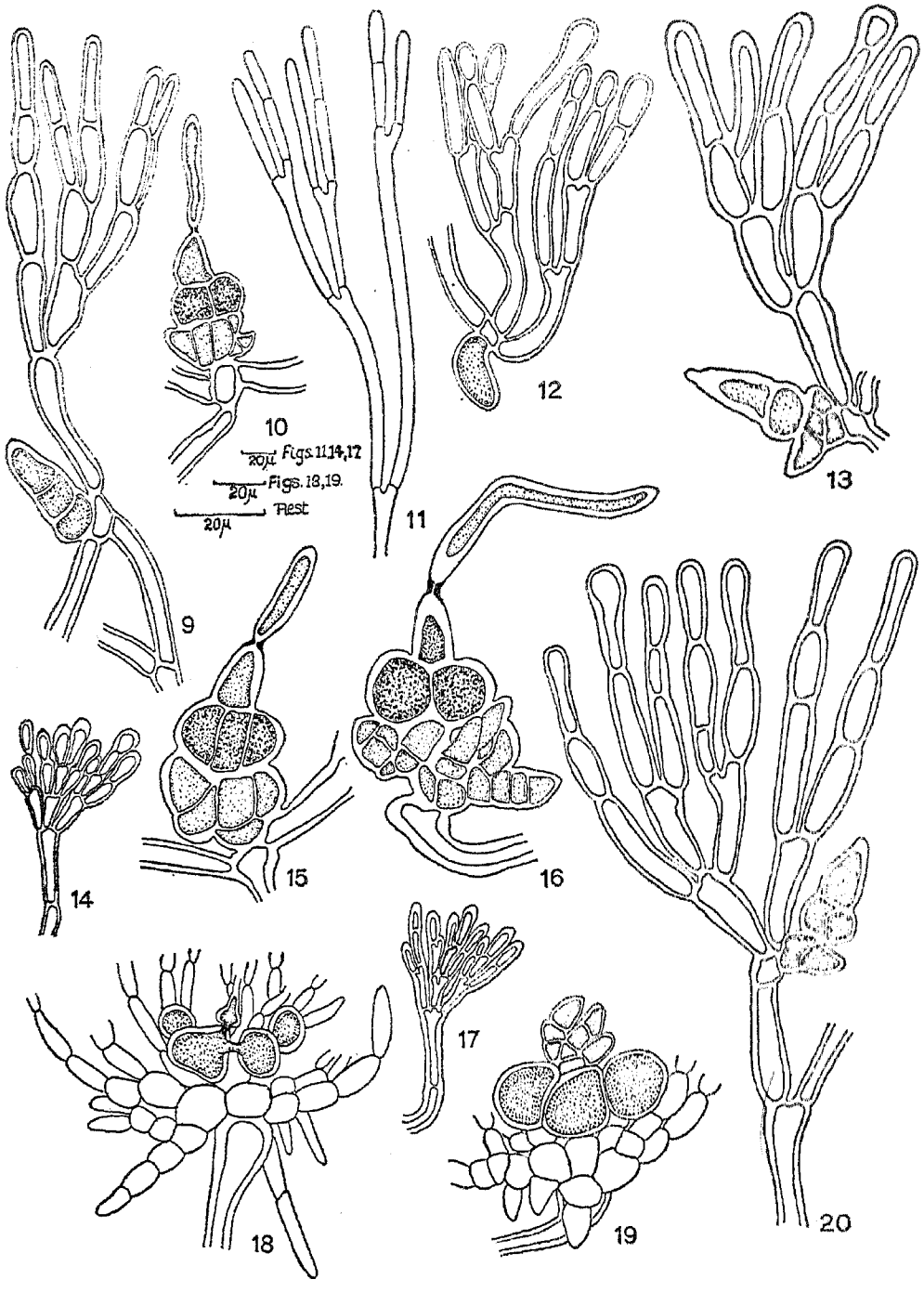
spermatangia or a spermatangium terminally (Text-Fig. 6). The spermatangia are oval or elongate. They are 3 μ long and 5 μ broad. Several spermatangial branches are given out from a single peripheral cell of the spermatangial branch. The spermatangia are definitely stalked, the stalk being one or two celled generally.

Carpogonial Branches.—Carpogonial cells are formed close to the growing apex and upon the lateral branches of the central axis. They are generally formed on the fourth forking from the periphery of the cortical filaments and are lateral or axillary in position (Text-Figs. 9, 12).

A small cell is cut off in the branch at the forking point or at the junction of two cells. This cell does not elongate prominently (Text-Figs. 5, 12). It is 2 μ long and 3 μ broad. In this connection it may be mentioned that Svedelius (1956, p. 17, Text-Figs. 10 A and B) has shown the carpogonial branch having a well-pronounced stalk cell. In *Pseudogloiophlœa fascicularis* Boergs., the writer has not seen such a prominent stalk cell. The carpogonial branch has a small cell at its base (see Text-Figs. 9, 12, 13).

At the forking a carpogonial branch initial 7–9 μ long and 5–6 μ broad is formed which is deflected. It is somewhat oval in shape. It has dense protoplasmic contents and is easily distinguished from the other cells of the branch. Soon it divides into two producing a two-celled carpogonial branch 14·16·5 μ long and 5–6 μ broad. Then finally the upper cell cuts off one more cell to its bottom. Thus, a three-celled carpogonial branch is formed and it is 17–19 μ long and 5–7 μ broad (Text-Fig. 9). The terminal cell ultimately becomes the carpogonium. It is 8–9 μ long and 5–6 μ broad. The lowermost cell is the pericarpic cell. It is 7 μ long and 5–6 μ broad. All the three cells of the carpogonial filament are densely filled with protoplasm. The carpogonial branch is formed even before the vesicles are formed. The terminal cell of a carpogonial branch develops into a carpogonium with a long trichogyne at its upper end (Text-Figs. 15, 16). The trichogyne is formed terminally and has an accumulation of dense protoplasm. There is generally a constriction at the junction of the carpogonium and the trichogyne. A very narrow passage is present at this constriction connecting the trichogyne and the carpogonium. In microscopic preparations this protoplasmic connection is generally lost thus disconnecting the contents of the carpogonium and the trichogyne (Text-Figs. 15, 16). The trichogyne becomes somewhat broader towards the tip from this constriction. Its apex is bluntly rounded.

The middle cell or the hypogynous cell divides vertically and produces four cruciately arranged 'auxiliary' cells. These auxiliary cells are formed



TEXT-FIGS. 9–20. *Pseudogloiophlœa fascicularis* (Boergs.) comb. nov. Fig. 9. Three-celled carpogonial branch before the formation of the trichogyne. Figs. 10, 15, 16. Fully formed carpogonial branches together with early stages of the formation of the hypogynous cells and sterile branches. Note in Fig. 10 the division of the second cell of the carpogonial branch, *i.e.*, hypogynous cell initial. Figs. 11, 14, 17. Young cortical filaments showing stages in the development of branches and the formation of utricles. Fig. 12. One-celled carpogonial branch initial. Note the undifferentiated cortical branches. Figs. 13, 20. Initiation of sterile pericarpic branches before the formation of trichogyne. Fig. 18. Showing the fusion of the carpogonium with one of the hypogynous cells. Fig. 19. Young gonimoblast filaments.

before fertilisation and even before trichogyne formation (Text-Figs. 15, 16 and 20). These four auxiliary cells do not fuse to form a single large fusion cell, but they remain distinct. They gradually become very large in size and 14-15 μ in diameter. Generally they are all similar. Yet in some cases, one of these four auxiliary cells appears bigger than the other three (Text-Figs. 7, 8, 18). Protoplasmic connections between the four hypogynous cells are very much enlarged. The wall of the hypogynous cells, however, shows extreme bulging and is about 4-5 μ away. The exact mode of cutting of these cells by the hypogynous cell could not be followed. However from the preparations it seems that the cell below the carpogonium cuts off two cells one on either side and one of these cells later gives rise to the fourth (Plate VIII, Fig. 1; Text-Figs. 7, 8). Owing to the pressure caused by the growth of the sterile filaments all round these cells probably get closely adpressed and become cruciately arranged. The fourth has been very often observed to be prominently connected with one of the lateral cells (Text-Figs. 7, 8). This needs to be verified again with the help of other species.

The lowermost cell of the carpogonial branch produces the sterile filaments which ultimately form the urn-shaped pericarp. Even before the initiation of the trichogyne, this cell starts dividing and gives rise to cells which develop into upwardly curved sterile filaments. These filaments are at first separate, but later grow adpressed so closely that ultimately a sort of pseudoparenchymatous envelope is formed surrounding the sporogenous tissue. This pyriform cavity formed by the sterile filaments or the pericarp opens out through a narrow opening, the carpostome. The lowermost cells of these sterile branches become prominently enlarged. From these enlarged cells of the pericarp branch send out rhizoid-like filaments which grow inwardly parallel to the cortical branches. These filaments are as long as 5-6-celled. The initial pericarp is nearly fully formed even before the formation of the sporogenous tissue.

Post-Fertilisation Stages.—The writer has not observed fertilisation. After fertilisation the trichogyne gets disorganised though very often its remnants are seen. A very clear connection is established between the fertilized carpogonium and one of the hypogynous cells and generally that is the one immediately below it. At the same time the four hypogynous cells also show enlarged protoplasmic connections between them (Figs. 7, 8, 18).

Whether the sporogenous tissue develops through the empty carpogonium or not is not clear, but it is generally produced only from one of the

hypogynous cells (Text-Fig. 19). At first the gonimoblast initial is a single-celled structure, but soon it starts to divide and produce filaments with oval cells which are rich in contents. The sporogenous tissue is in the form of a globular mass of dense filaments, which are surrounded by pericarpic wall. The sporogenous tissue remains distinct throughout from the pericarp. Only one gonimoblast initial generally develops from the hypogynous cells. This cell branches profusely forming a compact mass of cystocarpic branches which bear terminally the carpospores. The gonimoblast filaments are much broader at their extremities. A number of carpospores are formed in succession on the same filament. The carpospores are oval to somewhat elongate. They are 9–19 μ long and 5–15 μ broad.

The mature cystocarps are almost spherical with a rather long carpostome (Text-Fig. 3). The cystocarps are about 323–25 μ long and about 195–255 μ broad together with the neck. The neck alone is about 100 μ long and 90 μ broad. Boergesen (1934) gives the cystocarp as 225 μ long and 160 μ broad together with the neck, the neck alone being 70 μ long.

Post-fertilisation stages described above in *Pseudogloiophlœa fascicularis* Boergs. comb. nov. resemble in essential details those of *Pseudogloiophlœa capensis* (Setch.) Levr., so well described by Svedelius (1956). Svedelius did not observe a trichogyne in his specimen (Svedelius, 1956, p. 19). A distinct trichogyne very much similar to that of *Scinaia furcellata* is seen in the present alga.

The cruciately arranged hypogynous cells are not cruciately formed. But two cells are cut off on either side by the hypogynous cell immediately below to carpogonium and one of these cuts off the fourth hypogynous cell. In other words a two-celled branch on one side and a single cell on the other is formed by the hypogynous cell below the carpogonium.

The post-fertilisation stages in *Pseudogloiophlœa fascicularis* Boergs. comb. nov. in general very closely resemble those of *Scinaia furcellata* described by Svedelius (1915).

SUMMARY

The structure of the thallus, formation of the spermatangia and the carpogonial branches together with post-fertilisation stages in *Pseudogloiophlœa fascicularis* (Boergs.) comb. nov., are described in detail.

In the general features of reproduction the alga agrees with *Pseudogloiophlœa capensis* (Setch.) Lev. described by Svedelius. The post-fertilisa

tion stages of *Pseudogloiophlæa fascicularis* (Boergs.) comb. nov. appear to be similar to those of *Scinaia furcellata* as described by Svedelius.

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EXPLANATION OF PLATE VIII

FIGS. 1–4. *Pseudogloiophlæa fascicularis* (Boergs.) comb. nov.

FIG. 1. Carpogonial branch showing the disposition of the four hypogynous cells.

FIGS. 2, 4. Habit. Fig. 2. Showing the attachment.

FIG. 3. Median vertical section of the apex showing the medulla and the cortex.