Reprinted from the Journal of the Indian Botanical Society,
Vol. XVIII, Nos. 4-6, 1940, pp. 195-200

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BY

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THE BANGALORE PRESS, MYSORE ROAD, BANGALORE CITY—1940

ON SEXUAL REPRODUCTION IN A *DICTYOSPHAERIUM**

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Received for publication on 7th January 1940

AN alga which appears to be a new species of *Dictyosphœrium* (*D. indicum* sp. nov.) occurs in large quantities as plankton in some small muddy rain-water pools near Madras. The cells of the alga, when young, are elliptic, spindle-shaped and somewhat flat on one side and slightly convex on the other (Text-figs. 1, 3). Each cell has a parietal plate-like chloroplast with a single pyrenoid embedded in it. The chloroplast in the young cell is placed at its centre close to its convex side (Text-fig. 3). The single nucleus is situated very near the pyrenoid. As the cells grow older, they become more and more swollen and assume finally a broadly elliptic shape (Text-figs. 1, 2, 5). These older cells contain generally two chloroplasts, one at either end of the cell, each with a single pyrenoid (Text-figs. 1, 2), the two chloroplasts being derived through the division of the single chloroplast of the younger cell. These enlarged older cells contain, however, only a single nucleus.

VEGETATIVE REPRODUCTION

Vegetative multiplication takes place by autospore formation. The contents of each cell divide into two or four protoplasts, each one of which surrounds itself with a wall. The mother-cell wall splits open into four quartets, the split commencing at the top of the cell and running downwards along its length. The daughter cells after the rupture of the mother cell remain attached by their one end to the tip of each lobe of the mother-wall. By such repeated autospore formations, colonies with a large number of cells are formed with the cells arranged near the periphery, the ruptured mother-walls of the previous generations forming a radiating system at the centre (Pl. I, Fig. 1, Text-figs. 1, 4). The entire colony is embedded in a wide gelatinous matrix (Text-fig. 1 *m*).

SEXUAL REPRODUCTION

The colonies of the alga are found mostly in a vegetative condition. Very occasionally, especially towards the end of the vegetative period, the colonies begin to show sexual reproduction. The colonies are dicecious, some producing biciliate antherozoids and

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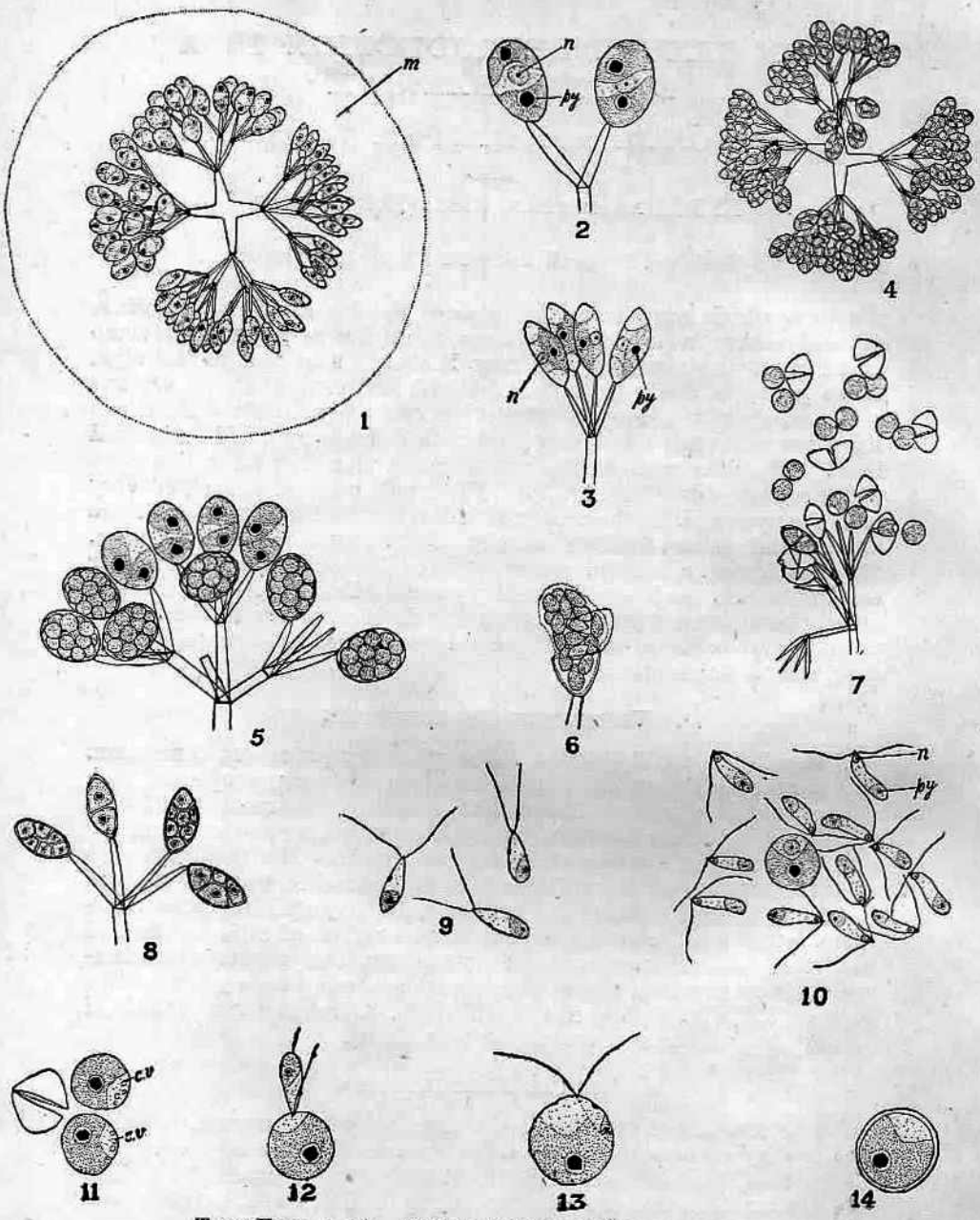

TEXT-FIGS. 1–14. *Dictyosphœrium indicum* sp. nov.

Fig. 1. Vegetative colony with the mucilaginous envelope (× 307).
Fig. 2. Two fully mature cells showing two chloroplasts and a single

others non-motile eggs. Both the male and the female colonies, however, are quite similar to one another in external appearance, until the formation of the gametes.

Male colonies.—In the male colonies almost all the cells divide to form antherozoids (Pl. I, Fig. 2 ; Text-fig. 4). The larger ellipsoidal cells generally form 16 or 32 antherozoids (Text-fig. 5), while the smaller and younger cells form generally eight antherozoids (Text-fig. 8). The antherozoids when fully formed, are discharged outside in a mass (Text-fig. 6) enclosed in a delicate protoplasmic membrane, the discharge taking place by a transverse rupture of the mother-cell wall (Pl. I, Fig. 3 ; Text-fig. 6). Soon after their discharge the investing membrane dissolves away very rapidly and the antherozoids become free and swim away. They are elongate with a somewhat rounded posterior end and a narrow anterior portion, with a tiny beak at the end (Text-figs. 9, 10). They are 8·4–10·0 μ long and 3·34 μ broad and possess two cilia, which are nearly $1\frac{1}{2}$ times as long as the length of the body. They have each a small parietal chloroplast at the posterior region and a somewhat streak-like eyespot towards the anterior end (Text-fig. 9). A small pyrenoid is seen embedded in the chloroplast.

Female colonies.—The contents of the cells of the female colony divide only once and form two eggs each (Pl. I, Figs. 4, 6 ; Text-figs. 7, 11). These eggs are discharged outside the cell through a transverse median rupture of the cell-wall (Text-figs. 7, 11) and remain inside the surrounding mucilage of the colony, not far from the ruptured mother-wall (Pl. I, Figs. 4, 5, 6 ; Text-figs. 7, 11). These egg-cells are rounded and do not possess a cell-wall. They contain each a single nucleus and a parietal plate-like chloroplast with a single pyrenoid in it (Text-figs. 10, 11). They are non-motile and do not possess any cilia or eyespot. They possess, however, 2–6 contractile vacuoles situated near the anterior hyaline region (Text-fig. 11, *c.v.*).

Fertilisation.—The antherozoids after their discharge from the male colonies, swim towards the female colonies and surround the

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nucleus (× 1070). Fig. 3. Four young cells each showing a single chloroplast and a single nucleus (× 1070). Fig. 4. A male colony showing the division of its cells to form antherozoids (× 307). Fig. 5. Portion of a male colony showing fully formed antheridial cells (× 707). Fig. 6. Discharge of the antherozoids from an antheridial cell ; note the delicate protoplasmic vesicle enclosing the antherozoid mass. (× 707). FIG. 7.—Portion of a female colony showing the pairs of discharged eggs from their mother cells (× 483). Fig. 8. Portion of a male colony showing the division of the younger cells to form antherozoids (× 707). Fig. 9. Antherozoids (drawn from material fumed with osmic vapour) (× 1070). Fig. 10. Antherozoids swarming round an egg (drawn from material stained in iodine) (× 1070). FIG. 11. Two eggs just discharged from their mother cell ; note the contractile vacuoles (*c.v.*) at their anterior ends (× 1070). Fig. 12. Antherozoid about to fuse with an egg. (× 1200). Fig. 13. Antherozoid just fused with an egg ; the two cilia of the antherozoid are seen still attached to the zygote. (× 1330). Fig. 14. A fully formed zygote with the wall surrounding it. (× 1330).

(*m.* mucilage ; *py.* pyrenoid ; *n.* nucleus , *c.v.* contractile vacuole.)

eggs in large numbers (Pl. I, Fig. 5 ; Text-fig. 10). By their active movement, the antherozoids often set the egg moving round and round, reminding one of the eggs of *Fucus*. Finally one of the antherozoids succeeds in getting attached to the egg near its anterior hyaline region and soon fuses with it (Pl. I, Fig. 7; Text-figs. 12, 13). During fusion, the antherozoid applies itself along its length to one side of the egg and gradually fuses with it (Text-fig. 13). After fusion, the two cilia of the antherozoid remain attached to the zygote, which then keeps moving round and round for a short time with the help of the two cilia of the male gamete (Text-fig. 13). Finally the cilia are lost and the zygote comes to rest and surrounds itself with a wall (Text-fig. 14). The eyespot of the male gamete remains clearly visible in the zygote for some time. The further fate of the zygote was not followed.

From the foregoing description it may be seen that the process of sexual reproduction in the alga is of a high type in being oogamous. The alga shows a further advance in being diœcious. Though numerous living sexual colonies were observed repeatedly on several days, no case was observed in which both the antheridia and the oogonia were formed in the same colony.

Discussion

The only method of reproduction known so far in *Dictyosphœrium* is by autospore formation. Massee (1891) and Zopf (1893) recorded the presence of biciliate swarmers in *D. Ehrenbergianum*, but their observations have not been confirmed so far and consequently the correctness of their record has been doubted by algologists [Printz, (1927), Smith (1933)]. Fritsch (1935) and Oltmanns (1922), however, say that the occurrence of swarmers is not improbable. But no case of sexual reproduction has been recorded so far in the genus. The present record of the occurrence of a highly advanced type of reproduction by means of motile biciliate antherozoids fusing with non-motile eggs is quite surprising in the genus. Until quite recently, no case of oogamous reproduction was known in the Chlorococcales. Korschikoff (1937) very recently, however, observed the occurrence of oogamous reproduction in the two genera *Golenkinia* and *Micractinium* belonging to this group. He found that in these two genera fertilisation took place by the fusion of biciliate antherozoids with non-motile eggs. The process of sexual reproduction in the present alga is very similar to that of the above-mentioned genera, except in a few details. In the present alga, two eggs are formed from each oogonium, whereas only one egg is formed in each oogonium in the two above-mentioned genera. Further, in the present alga, the eggs are discharged outside the oogonium before fertilisation, whereas in *Golenkinia* and *Micractinium* they are fertilised while still enclosed inside the oogonium. Finally, the antherozoids of *Micractinium pusillum* and *Golenkinia longispina* possess a wall which is not discarded until just before fertilisation, whereas, in the present alga, they are naked throughout from the

time they are set free. In this latter feature the present form agrees somewhat with *Golenkinia solitaria* Korschikoff, where the antherozoids are naked throughout. Finally, it may be mentioned that, when the sexual reproduction of such a high type as oogamy occurs in this genus, there appears to be no reason for doubting the occurrence of biciliated zoospores in *Dictyosphærium Ehrenbergianum* as originally recorded by Massee (1891) and Zopf (1893).

The alga differs from the previously recorded species in the more or less plano-convex spindle-shaped nature of its younger cells and the enlarged elliptic shape of its older ones. Further it is distinguished from the other species by the occurrence of oogamous reproduction. It appears therefore to be a new species which may be named *D. indicum* sp. nov.

Description

Dictyosphærium indicum sp. nov.

Colonies spherical to broadly ovoid or slightly irregular and consisting of 4, 16, 64 or more cells; cells elliptic, spindle-shaped and somewhat plano-convex when young and broadly elliptic when mature; younger cells 11·7–15·0 μ long and 5·0–8·4 μ broad, older cells 11·7–15·0 μ long and 8·4–10·0 μ broad; chloroplast single in young cells, two in older ones; parietal, plate-like, with a single pyrenoid; vegetative multiplication by the formation of 2–4 autospores in each cell; sexual reproduction by the fusion of a motile biciliate antherozoid with a non-motile egg; antherozoids spindle- to pear-shaped, 3·3 μ broad and 8·4–10·0 μ long; egg cells round, 8·4–10 μ in diameter; zygotes round and smooth-walled, 10·0–11·7 μ in diameter.

Habitat.—Planktonic in a muddy rain-water pool near Madras.

Summary

An account is given in the paper of the life-history of a new species of *Dictyosphærium* (*D. indicum*) from Madras. Sexual reproduction of an oogamous type was observed in the alga and has been described in detail. This appears to be the first record of sexual reproduction in the genus.

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EXPLANATION OF PLATE VIII

FIG. 1. Photomicrograph of a mature vegetative colony. × 412·5.

FIG. 2. A male colony, showing the division of the cell contents to form antherozoids. × 412·5.

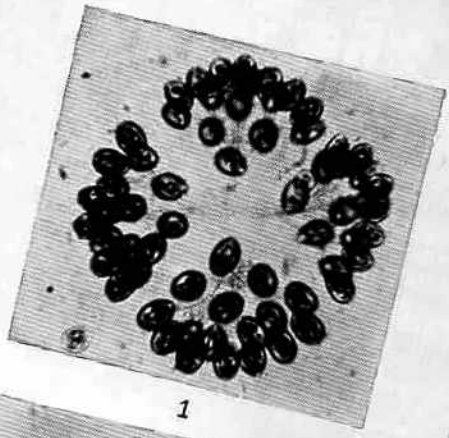
FIG. 3. A male colony showing the escape of the antherozoids ; antherozoids have already escaped from most of the cells of the colony. × 412·5.

FIG. 4. A female colony with pairs of eggs just discharged from their mother-cells, but still lying close to them inside the mucilage of the mother colony. × 412·5.

FIG. 5. Antherozoids actively swarming round the discharged eggs ; at the right hand top, a number of antherozoids can be seen swarming round a single egg. × 412·5.

FIG. 6. Two pairs of eggs just discharged from their mother cells and lying close to the ruptured mother-walls. ×675 .

FIG. 7. An antherozoid fusing with an egg ; two other free antherozoids are seen closeby. × 675.



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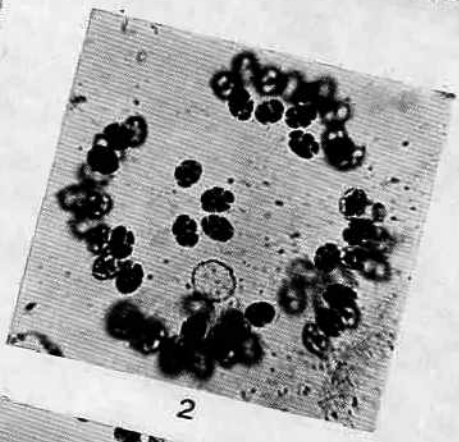

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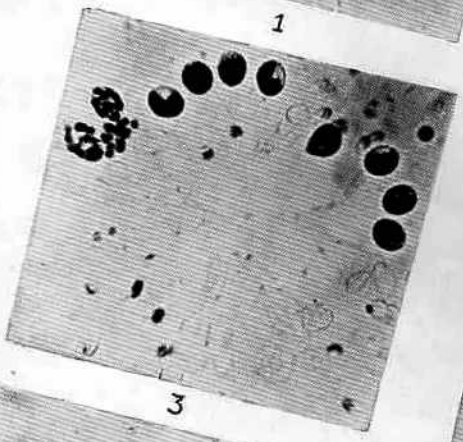

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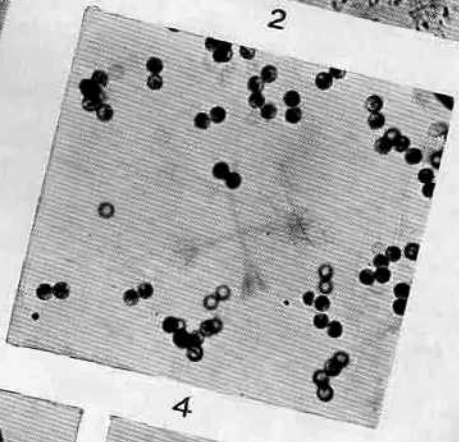

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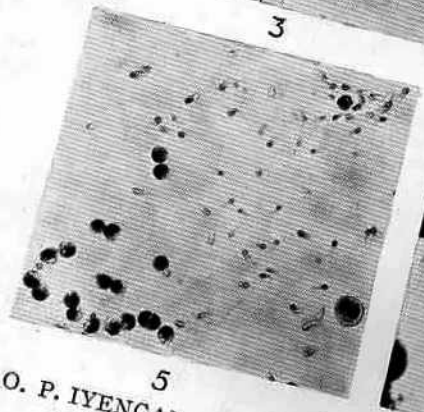

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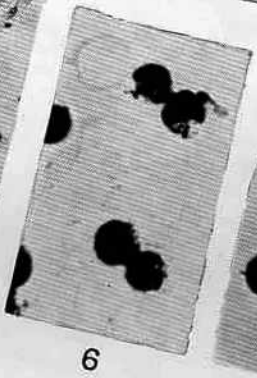

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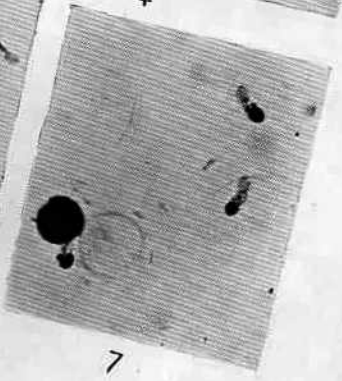

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