

THE GENUS ZYGOGONIUM.

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Taking *Zyogonium ericetorum* (Kütz.) de Bary as the type species of the genus there are three outstanding characteristics that clearly separate these forms from the species of *Zygnema*. In the first place the chromatophores are a pair of rounded plate-like, or irregular polsterform bodies, each with a central more or less prominent pyrenoid. When grown under conditions of poor nutrition the chromatophores may be poorly defined, and when gorged with starch grains and oil droplets the outline may become almost completely obscured. These facts account for the many conflicting descriptions of the chromatophores in the literature discussed by West and Starkey, 1915, and by Skuja, 1932. Certainly in the many collections I have seen from various parts of the world, the chromatophores were never stellate or globose with radial projections as in *Zygnema*. Most authors following Palla are agreed that the chromatophores afford one of the fundamental bases of separating the genera of the *Zygnemales*.

In the second place, a sporangium wall is formed which cuts off the gametangia before the formation of the spore wall. De Bary, 1858, and Hodgetts, 1918, have described the conjugation of this species as proceeding by formation of secondary gametangia which subsequently fuse and form the zygote. It is quite probable that such fusions do take place. However, a not improbable interpretation of their figures and observations is that these are arrested and encysted stages in conjugation, comparable to those sometimes found in other *Zygnemales* subjected to sudden changes in water content and temperature. Furthermore, *Z. ericetorum* has an unusual tendency to form aplanospores, akinetes, azygospores, or "cysts," as has been remarked by West, Fritsch, and many others. It seems probable that W. & G. S. West (1894) gave the first correct account of the conjugation of *Z. ericetorum* when growing under favorable conditions in their description of "*Zygnema pachydermum*." In material collected near Longwood, Florida, in a drainage ditch I found not only the encysted stages described

by de Bary and by Hodgetts, but also conjugation without the formation of secondary gametangia, as shown on the accompanying figures.

The third characteristic of *Zygogonium* is that there is a cytoplasmic residue left in the gametangia, just as in the genus *Mougeotia*. This is very marked in *Z. ericetorum*, and also takes place when aplanospores are formed from vegetative cells. In *Zygnema* such residues have not been observed either in conjugation or in aplanospore formation.

Skuja (1932) has shown that *Pleurodiscus* Lagerheim is merely an extreme form of *Z. ericetorum* in which the two chromatophores are disc or saucer-shaped. West has examined the original specimens of *Zygogonium didymium* Rabenh. (Alg. Exsic. No. 182) and found them to be identical with *Z. ericetorum*.

As the genus *Zygogonium* is here defined there is no basis for separating *Pyxispora* W. & G. S. West (1897). This genus was largely postulated on the basis of a prominent equatorial suture in the sporangium wall. The Florida material of *Z. ericetorum* also shows a median suture on some of the sporangia and the spores are set free by the splitting of the sporangium wall along this line.

The plant rather inadequately described by Schmidle in 1897 as "*Zygnema Heydrichii*" should evidently be classified in this genus. This collection showed only lateral conjugation with the zygote formed in the greatly enlarged tube, which is cut off from the gametangia by cross walls and thus forms a distinct sporangium. Schmidle's figures suggest that this sporangium also splits by a median suture.

Recently Iyengar has described a species from India that is distinguished by the peculiar and regularly lateral position of the aplanospores.

Finally two species described as *Zygnemas* which have been found producing only aplanospores seem to be better classified in this genus.

Following are the diagnoses of the genus and six species.

ZYGOGONIUM (Kütz.) de Bary.

Filamentous algae with cylindrical cells containing two axillary disc-, or polsterform chromatophores with rounded, or irregular, margins, each with a central pyrenoid; connected by a cytoplasmic isthmus to which the nucleus is attached laterally. Filaments usually unbranched,

but sometimes with lateral branches of several, or many, cells. Cell walls thin, or lamellate and greatly thickened, often yellowish or brownish in color, cell sap sometimes purple.

Reproduction by akinetes, aplanospores and by zygotes. Akinetes formed by pronounced thickening of cell walls. Aplanospores formed by the contraction of a part of the cell contents and the formation of a new globose or ovoid spore wall within the vegetative cell wall, leaving a more or less conspicuous mass of cytoplasmic residue outside the spore wall. Zygotes produced by the scalariform, or lateral conjugation of isogamous gametes, which are formed from only a part of the cell contents. Encysted gametes have been interpreted as secondary gametangia, but are not necessarily formed in aquatic habitats. Zygotes enclosed in a definite sporangium, which dehisces by an equatorial suture. Spore wall smooth or scrobiculate.

1. *Zygonium ericetorum* Kützing, 1843.

(Plate I, Figs. 1-12; Plate II, Figs. 33-35.)

Phycologia generalis, p. 446; A. de Bary, Untersuchungen über die Familie der Conjugaten. 1885; West and Starkey, Cytology and Life History of *Zygnema ericetorum*, New Phytologist, 14: 194. 1915; Hodgetts, Conj. of *Zygonium ericetorum*, New Phytologist, 17: 238, 1918; Skuja, Le genre *Pleurodiscus*, Rev. algolog. 6: 137. Includes *Z. didymum* Rab., *Z. agardhii* Rab. and *Pleurodiscus purpureus* (Wolle) Lagerheim and *Zygnema pachydermum* W. & G. S. West.

A highly variable terrestrial or submerged form with unbranched or branched filaments. Vegetative cells vary from 12-33 μ in diameter and from 10 to 100 μ in length. Chromatophores two, axillary, disc- or polsterform or indefinite, each with a central pyrenoid, zygospores develop in a definite sporangium, formed by the conjugating tube and cut off from the adjoining gametangia. Zygospores thick walled, smooth, ovoid or ellipsoid, 15-26 μ \times 20-36 μ . Aplanospores globose or ovoid, occupying only a part of the cell, 15-20 μ \times 15-40 μ , wall smooth.

In terrestrial forms the cell sap is frequently purple, the cells somewhat smaller, and the walls thick, lamellate, colored yellow or brown. Widely distributed in bogs, acid pools, and on wet acid soils. Reported from all of the continents. In America known to occur throughout the coastal plain from New Brunswick to Mississippi and in Ohio, Michigan and Southern Ontario.

2. *Zygonium mirabile* (W. & G. S. West) Comb. nov.

(Plate II, Figs. 18-20.)

Pyxispora mirabilis W. & G. S. West, Welwitsch's African Freshwater Algae, Jour. Bot. 35: 1897; *Zygnema mirabile* (W. & G. S. W.) Czurda, 1932.

Vegetative cells 12-13.5 μ \times 18-50 μ with two rather indistinct chromatophores, each with a central pyrenoid. Only a part of the contents of the vegetative cells enters into the formation of the

gametes. Zygospores formed in the enlarged conjugating tubes, which are walled off from the original cells. Sporangium ovoid with prominent equatorial suture. Spores filling the sporangium smooth walled, but possibly not mature in the one known collection, $13.5\text{--}17\mu \times 19\text{--}32\mu$.

Collected by Welwitsch, Huilla, Portuguese West Africa, April, 1860.

3. *Zygonium heydrichii* (Schmidle) Comb. nov.

(Plate II, Figs. 21-25.)

Zygnema heydrichii Schmidle, Zur Entwicklung einiger Zygnema und Calothrix. Flora 83: 167. Pl. V, Figs. 5-7, 10-11. 1897.

Vegetative cells $20\mu \times 25\text{--}66\mu$, with two chromatophores, not stellate, in each cell. Conjugation lateral by tubes arising from adjoining cells, forming a sporangium cut off from the original cells. Spores globose, ovoid or heart-shaped, $24\text{--}28\mu \times 32\mu$, median wall yellow, scrobiculate.

Collected by Lauterbach at Sidney, Australia.

4. *Zygonium capense* (Hodgetts) Comb. nov.

(Plate II, Figs. 26-28.)

Hodgetts, W. J. Some Freshwater Algae from Stellenbosch, Cape of Good Hope. Trans. Roy. Soc. South Africa, 13: 66. 1925. (*Zygnema capense*.)

Vegetative cells $16\text{--}20\mu$, 1.3-3 diameters long, conjugation unknown, aplanospores globose formed at the ends of the cells, $19\text{--}26\mu$ in diameter, median wall brown, scrobiculate.

Evidently closely related to *Z. heydrichii*. The tendency to form aplanospores at the ends of vegetative cells is also characteristic of many collections of *Z. ericetorum*.

On damp earth, Stellenbosch, South Africa.

5. *Zygonium hansgirgi* (Schmidle) Comb. nov.

(Plate II, Figs. 29-32.)

Schmidle, W. Ueber einige von Prof. Hansgirg in Ostindien gesammelte Suesswasser-algen. Hedwigia 39: 160. 1900. (*Zygnema hansgirgi*.)

Filament short, vegetative cells irregular $8\text{--}12\mu$, 3-5 diameters long, conjugation unknown; aplanospores variable, ovoid, about the same diameter as the cells; median wall brown, with small angular protuberances (verrucose).

Igatpuri, India, 1895.

6. *Zyogonium talguppense* Iyengar, 1932.

(Plate II, Figs. 36-37.)

Iyengar, O.-P. Studies on Indian Zygenemales, Rev. Algologique 6: 263-274. 1932.

Filaments forming a thick felt on soil, increasing in width upwards, often branching below, lower cells of the filament $12-16\mu \times 30-60\mu$, the upper $17-20\mu \times 30-90\mu$. Aplanospores ("azygospores") developed in a lateral swelling and cut off from the parent-cell by a curved wall, ellipsoid to subglobose $12-26\mu \times 13-34\mu$, median wall smooth; zygospires unknown.

On moist soil in a plantation of Areca palms, Talguppa, Mysore, India.

EXPLANATION OF PLATES.

PLATE I.

(Figs. 1-12. *Zyogonium ericetorum* from a drainage ditch at Longwood, Florida.)

- Fig. 1. Zygospires of various forms: (a) sporangium wall showing equatorial suture; (b) ruptured sporangium from which the spore has escaped.
 Fig. 2. Conjugation without formation of secondary gametangia, also aplanospores adjoined by cytoplasmic residue.
 Fig. 3. Zygospires and conjugating gametes (a) and encysted gametes at (b).
 Fig. 4. Zygospires (a) and at (b) aplanospore that has germinated and formed a secondary aplanospore inside the original vegetative cell.
 Fig. 5. Encysted gametes which may perhaps conjugate later.
 Fig. 6. Germinating aplanospores.
 Fig. 7. Filament showing rhizoidal branches.
 Fig. 8. Zygospires, parthenospore and several aplanospores.
 Fig. 9. Cells showing lamellate wall and distinct H-pieces formed between the cells.
 Fig. 10. Thick-walled short cells.
 Fig. 11. Conjugation of gametes with prominent pectic ring at (a), and at (b) sporangium wall formed on one side and not on the other.
 Fig. 12. Zygospire.

PLATE II.

- Figs. 13-15. *Zyogonium ericetorum* (formerly described as *Pleurodiscus purpureus* Lagerheim) after Skuja, 1932.
 Fig. 16. *Z. ericetorum*, aplanospores after West & Starkey, 1915.
 Fig. 17. *Z. ericetorum*, actively growing cell after Czurda, 1931.
 Figs. 18-20. *Zyogonium mirabile* showing sporangia and spores after G. S. West.
 Figs. 21-25. *Zyogonium heydrichii* showing lateral conjugation after Schmidle.
 Figs. 26-28. *Zyogonium capense* showing aplanospores, after Hodgetts, 1925.
 Figs. 29-32. *Zyogonium hansgirgi* showing aplanospores, after Schmidle, 1900.
 Figs. 33-35. *Zyogonium ericetorum* from Kwong Tung, China, (McClure Collection). Showing zygospires, aplanospores, and parthenospores. At (34a) partial fusion of three encysted gametes. These specimens were growing on moist soil, and the stages in conjugation are very similar to Hodgett's figures.
 Figs. 36-37. *Zyogonium talguppense* from Mysore Province, India, showing aplanospores, after Iyengar.



