

## Studies of Oil bodies and Oil Droplets of Some Hepatics (Jungermanniales) from New Caledonia

By

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**Abstract** The oil bodies and oil droplets are described for 23 species in 17 genera of Jungermanniales collected on New Caledonia. Among them the oil bodies of 12 species are described for the first time.

A number of papers dealing with hepatics of New Caledonia have been published. The known hepatic flora of this area shows very high percentage of endemic species (cf. Kitagawa, 1983). However, the oil bodies have been scarcely described for New Caledonian hepatics (Schuster, 1964, 1987; Kitagawa, 1986). The present paper deals with the morphological observations of the oil bodies and the oil droplets of New Caledonian hepatics collected by the second author from January to February, 1995.

Oil bodies are membrane-bound, terpene-containing organelles unique to the cells of hepatics; oil droplets are minute spherules of oil within the cell cytoplasm, not associated with a membrane (cf. Magill, 1990). Generally, oil bodies are larger than chloroplasts, and oil droplets are much smaller than chloroplasts. A large number of papers about oil bodies have been published. It is well-known that the shape and size of oil bodies are rather stable within a species, sometimes within a genus or family. Several types of oil bodies can be recognized particularly their number per cell, shape, size, and distribution. These differences are considered to be of great taxonomic value, although the taxonomic value of oil bodies varies from group to group (Müller, 1939; Hattori, 1951, 1953; Schuster & Hattori, 1954; Schuster 1966; Inoue 1967, Gradstein *et al.*, 1977).

Oil droplets (or oil drops) are poorly known. Jönsson & Olin (1898) studied lipids in Swedish mosses. Subsequently Lorch (1931) described the occurrence of

oil droplets in the cells of mosses, especially in spores. Recently Frahm (1994) discussed the taxonomic relevance of oil droplets in the family Dicranaceae (Musci).

### Materials and Methods

The materials studied were brought back from the field in a plastic bag and kept in incubator at  $15 \pm 3^\circ\text{C}$  under a light intensity of 2000–2500 lux obtained from white fluorescent tubes with 12 h diurnal light-dark cycle. Observations of oil bodies and oil droplets were made without chemical treatment and pertain to median cells of leaves, unless otherwise noted. Descriptions include the following characters: type, number per cell, shape, size, and color. The specimens examined are deposited in the herbarium of the National Science Museum, Tokyo (TNS) and duplicates in the herbarium of the Natural History Museum and Institute, Chiba (CBM).

### Results

The cells may include a greater number of oil bodies and oil droplets than those recognizable in the photographs because some oil bodies are out of the focal plane. Three types of oil bodies were recognized: (1) homogeneous type—oil bodies homogeneous (Pl. II: 4), (2) granulose type—oil bodies composed of minute granules (Pls. I: 2, IV: 4), and (3) botryoidal type—oil bodies segmented and composed of distinct granules (Pls. II: 2, III: 6). In some species, two types of oil bodies are observed in a cell (Table 1). The number of oil droplets is too many to count in many species, but few in others.

**1. *Adelanthus bisetulus* (Steph.) Grolle, J. Hattori Bot. Lab. 35: 359 (1972).**

(Pl. I: 3)

Oil bodies granulose type, 4–10 per cell, globose to oblong,  $5\text{--}7 \times 4\text{--}5 \mu\text{m}$ , composed of minute granules, colorless. Oil droplets homogeneous type, many per cell, spherical, less than  $1 \mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1380 m, on basal part of trunk, 13 Feb. 1995, Higuchi 27424.

**2. *Chandonanthus hirtellus* (Web.) Mitt. in J. D. Hook., Handb. New Zealand Fl. 2: 750 (1867).**

(Pl. I: 1, 2)

Oil bodies granulose type, 3–5 per median cell, 5–7 per basal cell, globose to oval,  $4\text{--}10 \times 4\text{--}5 \mu\text{m}$ , composed of exceedingly minute granules, colorless. Oil droplets not seen.

Specimen examined. Province Sud, Mt. Humboldt, 1420 m, on trunk, 14 Feb. 1995, Higuchi 27477.

Table 1. Types of oil bodies in 23 species of hepatics examined.

Species	Type of oil bodies	Locality	References
<i>Adelanthus bisetulus</i>	granulose	New Caledonia	present study
<i>Chandonanthus hirtellus</i>	granulose	Japan	Hattori (1951)*
	granulose	Japan	Kitagawa (1965)
	granulose	New Caledonia	present study
<i>Denotarisia linguifolia</i>	granulose	New Caledonia	Kitagawa (1986)
	granulose	New Caledonia	present study
<i>Goebeliella cornigera</i>	botryoidal	New Zealand	Schuster (1965)
	botryoidal	New Caledonia	present study
<i>Herbertus huelimannii</i>	homogeneous	New Caledonia	present study
<i>Herbertus setigerus</i>	homogeneous	New Caledonia	present study
<i>Jamesoniella flexicaulis</i>	granulose	Malaya	Inoue (1967)
	granulose	New Caledonia	Kitagawa (1986)
	granulose	New Caledonia	present study
<i>Kurzia</i> sp.	absent	New Caledonia	present study
<i>Mastigophora caledonica</i>	granulose, botryoidal	New Caledonia	Kitagawa (1986)
	granulose, botryoidal	New Caledonia	Schuster (1987)
	granulose, botryoidal	New Caledonia	present study
<i>Mastigophora diclados</i>	botryoidal	Japan	Hattori (1953)
	homogeneous	Japan	Inoue (1962)
	homogeneous, botryoidal	Malaya	Inoue (1967)
	botryoidal	New Caledonia	present study
<i>Odontoschisma naviculare</i>	granulose	New Caledonia	present study
<i>Otolejeunea schmidii</i>	botryoidal	New Caledonia	present study
<i>Perssoniella vitreocincta</i>	granulose	New Caledonia	Schuster (1964)
	granulose	New Caledonia	Kitagawa (1986)
	granulose	New Caledonia	present study
<i>Pleurozia articulata</i>	granulose	New Caledonia	present study
<i>Pleurozia caledonica</i>	granulose, botryoidal	New Caledonia	present study
<i>Pleurozia gigantea</i>	botryoidal	Malaya	Inoue (1967)
	botryoidal	New Caledonia	present study
<i>Porella viridissima</i>	homogeneous	New Caledonia	Kitagawa (1986)
	homogeneous	Fiji	Kitagawa (1986)
	homogeneous	New Caledonia	present study
<i>Schusterella chevalieri</i>	botryoidal	New Caledonia	present study
<i>Schusterella microscopica</i> fo. <i>microscopica</i>	granulose, botryoidal	New Caledonia	present study
<i>Schusterella microscopica</i> fo. <i>mamillata</i>	botryoidal	New Caledonia	present study
<i>Tetracymbaliella comptoni</i>	granulose	New Caledonia	Kitagawa (1986)
	granulose	New Caledonia	present study
<i>Tetracymbaliella decipiens</i>	homogeneous	New Caledonia	present study
<i>Trichocolea pluma</i>	homogeneous, granulose	Fiji	Kitagawa (1986)
	homogeneous, granulose	New Caledonia	present study
<i>Zoopsidella caledonica</i>	granulose	New Caledonia	present study

\* Previous reports are also included, but voucher specimens are not examined.

The size of oil bodies of New Caledonian plants was larger than that of Japanese ones ( $4-4.5 \times 2.5-3 \mu\text{m}$ ) reported by Hattori (1951) and Kitagawa (1965).

**3. *Denotarisia linguifolia* (De Not.) Grolle, Feddes Report. 82: 6 (1971).**

(Pl. I: 4-6)

Oil bodies granulose type, 10-25 per cell, globose,  $5-9 \mu\text{m}$  dia., composed of minute granules, colorless. Oil droplets homogeneous type, many per cell, spherical, to  $2 \mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1420 m, on trunk, 14 Feb. 1995, *Higuchi* 27466.

The oil droplets of this species are the largest among taxa examined in this study (Pl. I: 6). Kitagawa (1986) reported fewer oil bodies in New Caledonian plants of this species, that is, 2-8 (mostly 4-6) per cell.

**4. *Goebeliella cornigera* (Mitt.) Steph., Hedwigia 51: 62 (1911). (Pl. II: 1, 2)**

Oil bodies botryoidal type, 2(-3) per median cell, oval to oblong,  $5-10 \times 5-6 \mu\text{m}$ , 3(-5) per basal cell, oval to elliptical,  $10-15 \times 5-7 \mu\text{m}$ , composed of distinct granules, colorless. Oil droplets homogeneous type, many per cell, spherical, less than  $1 \mu\text{m}$  dia., colorless.

Specimens examined. Province Sud, Rivière Bleue, 150 m, on trunk, 11 Feb. 1995, *Higuchi* 27299; Mt. Humboldt, 1420 m, on trunk, 14 Feb. 1995, *Higuchi* 27500.

**5. *Herbertus huelimannii* Miller, J. Hattori Bot. Lab. 30: 248 (1968).**

(Pl. II: 3, 4)

Oil bodies homogeneous type, 10-20 per cell of vitta, 3-15 per submarginal cell, globose to oval,  $3-15 \times 4-7 \mu\text{m}$ , scarcely turbid, colorless. Oil droplets homogeneous type, many per cell, spherical, less than  $1 \mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1618 m (summit), on basal part of trunk, 13 Feb. 1995, *Higuchi* 27429.

The oil bodies almost fully occupy cells of the vitta. Generally the marginal cells and smaller apical cells have fewer oil bodies, while the larger basal cells may have two to three time as many or more (Schuster, 1966). We could observe the former case in *Herbertus huelimannii*, *H. setigerus*, and *Perssoniella vitreocincta*, and the latter in *Pleurozia gigantea*.

**6. *Herbertus setigerus* (Steph.) Miller, J. Hattori Bot. Lab. 28: 326 (1965).**

(Pl. II: 5)

Oil bodies homogeneous type, 10-20 per cell of vitta, 5-15 per submarginal cell, globose to oblong,  $3-15 \times 4-7 \mu\text{m}$ , colorless. Oil droplets homogeneous type, many per cell, spherical, less than  $1 \mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1618 m (summit), on boulder, 13 Feb.

1995, *Higuchi* 27423.

Oil bodies of this species almost occupy the cells. The number of oil droplets per cell in this species is more than that of *H. huelimannii*.

**7. *Jamesoniella flexicaulis* (Nees) Schiffn., Denkschr. K. Akad. Wiss. Math.-Nat. Kl. Wein 67: 196 (1898). (Pl. II: 6)**

Oil bodies granulose type, 8–12 per cell, globose to oblong,  $5\text{--}12 \times 4\text{--}8 \mu\text{m}$ , composed of exceedingly minute granules, colorless. Oil droplets homogeneous type, many per cell, spherical, less than  $1 \mu\text{m}$  dia., colorless.

Specimen examined. Province Nord, Mt. Menazi (southwest of Kouaoua), near mine, 1035 m, on trunk, 17 Feb. 1995, *Higuchi* 27627.

**8. *Kurzia* sp. (Pl. III: 1)**

Oil bodies and oil droplets not seen.

Specimens examined. Province Sud, Mt. Humboldt, 1420 m, on decaying log, 14 Feb. 1995, *Higuchi* 27479, 27480.

This is very similar to Bornean *K. abietinella* in having nearly the same size of stems, shape of discs, cell arrangement in the leaf lobes, and thickness of cell walls. However, it differs markedly from *K. abietinella* by the incurved leaf lobes. *Kurzia* belongs to the family Lepidoziaceae. In Jungermanniales, almost all species lacking oil bodies belong to the Lepidoziaceae and Cephaloziaceae (Schuster, 1966).

**9. *Mastigophora caledonica* Steph., Rev. Bryol. 35: 31 (1908). (Pl. III: 3, 4)**

Oil bodies granulose or botryoidal type, 5–12 per cell at leaf-disc, 4–8 per cell at leaf lobe, globose to oblong,  $10\text{--}20 \times 8\text{--}10 \mu\text{m}$ , composed of minute to large granules, colorless. Oil droplets homogeneous type, many per cell, spherical, less than  $1 \mu\text{m}$  dia., colorless.

Specimens examined. Province Sud, Rivière Bleue, 150 m, on trunk, 11 Feb. 1995, *Higuchi* 27272, 27278.

The oil body granules vary in size from exceedingly minute (less than  $1 \mu\text{m}$ ) to  $2 \mu\text{m}$  in diameter.

**10. *Mastigophora diclados* (Brid. in Web.) Nees in Gott. et al., Syn. Hepat.: 241 (1845). (Pl. III: 5, 6)**

Oil bodies botryoidal type, 10–20 per cell at leaf-disc, 5–12 per cell at leaf lobe, oval to oblong,  $5\text{--}15 \times 5\text{--}8 \mu\text{m}$ , composed of distinct granules, colorless. Oil droplets homogeneous type, many per cell, spherical, less than  $1 \mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1260 m, on humus, 15 Feb. 1995, *Higuchi* 27581.

The number of granules per oil body is variable, and their size varies from

less than  $1\mu\text{m}$  to  $10\mu\text{m}$ . Inoue (1962) described the type of oil bodies as homogeneous based on Japanese plants. Subsequently Inoue (1967) reported that this species has homogeneous and botryoidal oil bodies based on Malayan plants, and noted that the homogeneous type is recognized in only fresh materials. Furuki observed that both types are present in the same plant (Ryukyu Isls., S. Japan, Furuki 11939 in CBM).

**11. *Odontoschisma naviculare* (Steph.) Grolle in Grolle et Piippo, Acta Bot. Fennica 125: 71 (1984). (Pl. III: 2)**

Oil bodies granulose type, 4–7 per cell, globose to oblong,  $5\text{--}15 \times 5\text{--}8\mu\text{m}$ , composed of minute granules, colorless. Oil droplets homogeneous type, many per cell, spherical, less than  $1\mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1280m, on decaying log, 15 Feb. 1995, *Higuchi* 27573.

**12. *Otolejeunea schmidii* (Tixier) Grolle, Haussknechtia 2: 54 (1986).**

(Pl. IV: 1)

Oil bodies botryoidal type, 30–50 per cell at leaf lobe, oval to oblong,  $5\text{--}7 \times 2\text{--}3\mu\text{m}$ , composed of distinct granules, colorless. Oil droplets homogeneous type, few per cell, spherical, less than  $1\mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Rivière Bleue, 150m, on living leaves, 11 Feb. 1995, *Higuchi* 27255.

**13. *Perssoniella vitreocincta* Herz., Ark. f. Bot. Ser. 2, 2(4): 265 (1952).**

(Pl. IV: 2)

Oil bodies granulose or botryoidal type, 10–20 per cell, 2–10 per marginal cell, oval to oblong, sometimes fusiform with one or both ends pointed,  $7\text{--}13 \times 5\text{--}8\mu\text{m}$ , composed of indistinct to distinct granules, colorless. Oil droplets homogeneous type, many per cell, spherical, less than  $1\mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1380m, on trunk, 13 Feb. 1995, *Higuchi* 27330.

**14. *Pleurozia articulata* (Lindb.) Lindb. et Lackstroem, Hepat. Scand. Exs. Fasc. 1, no. 5 (1874). (Pl. IV: 3, 4)**

Oil bodies granulose type, 5–10(–12) per cell, globose to oval,  $4\text{--}7 \times 4\text{--}5\mu\text{m}$ , composed of minute granules, colorless. Oil droplets homogeneous type, few per cell, spherical, less than  $1\mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, on trunk, 1440m, 13 Feb. 1995, *Higuchi* 27440.

**15. *Pleurozia caledonica*** (Gott. et Jack) Steph. in Paris, Rev. Bryol. 33: 29 (1906). (Pl. IV: 5, 6)

Oil bodies granulose or botryoidal type, 5–15 per cell, spherical, 4–6  $\mu\text{m}$  dia., composed of minute to distinct granules, colorless. Oil droplets homogeneous type, many per cell, spherical, to 1  $\mu\text{m}$  dia., colorless.

Specimens examined. Province Sud, Rivière Bleue, 150 m, on trunk, 11 Feb. 1995, *Higuchi* 27276; on decaying log, *Higuchi* 27286; 155 m, on trunk, 18 Feb. 1995, *Higuchi* 27650 (accompanied by *Schusterella microscopica* fo. *mamillata*), 27658; Province Sud, Mt. Humboldt, 1380 m, on trunk, 13 Feb. 1995, *Higuchi* 27331.

**16. *Pleurozia gigantea*** (Web.) Lindb. in Lindb. et Lackstroem, Hepat. Scand. Exs. Fasc. 1, no. 5 (1874). (Pl. V: 1, 2)

Oil bodies botryoidal type, 8–15 per cell, 12–20 per basal cell, globose to oval, 4–10  $\times$  4–6  $\mu\text{m}$ , composed of distinct granules, colorless. Oil droplets homogeneous type, many per cell, spherical, less than 1  $\mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1380 m, on trunk, 13 Feb. 1995, *Higuchi* 27338.

**17. *Porella viridissima*** (Mitt.) Grolle in Groeel et Schultze-Motel, J. Hattori Bot. Lab. 36: 83 (1972). (Pl. V: 3)

Oil bodies homogeneous type, 20–35 per cell, irregular globose, like the shape of a rice grain, 5–10  $\times$  3–5  $\mu\text{m}$ , colorless. Oil droplets not seen.

Specimen examined. Province Sud, Mt. Humboldt, 1618 m (summit), on boulder, 13 Feb. 1995, *Higuchi* 27411.

**18. *Schusterella chevalieri*** (Schust.) Hatt., Sharp et Mizut., J. Jpn. Bot. 20: 331 (1972). (Pl. V: 4)

Oil bodies botryoidal type, 2–3 per cell, globose, 3–4  $\mu\text{m}$  dia., 2–3 per basal cell, oval, 4–6  $\times$  3–4  $\mu\text{m}$ , absent in marginal cells, composed of distinct granules, colorless. Oil droplets homogeneous type, many per cell, spherical, to 1  $\mu\text{m}$  dia., colorless.

Specimen examined. Province Nord, Mt. Menazi (southwest of Kouaoua), near mine, 1035 m, on branch, 17 Feb. 1995, *Higuchi* 27623.

**19a. *Schusterella microscopica*** (Pears.) Hatt., Sharp et Mizut. fo. ***microscopica***, J. Jpn. Bot. 20: 331 (1972). (Pl. V: 5)

Oil bodies granulose or botryoidal type, 2 per cell, globose, 3–4  $\mu\text{m}$  dia., 2 per basal cell, oval, 3–5  $\times$  2–4  $\mu\text{m}$ , absent in submarginal and marginal cells, composed of minute to distinct granules, colorless. Oil droplets homogeneous type, many in median cells, spherical, less than 1  $\mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1230 m, on trunk, 15 Feb. 1995, *Higuchi* 27598.

**19b. *Schusterella microscopica* fo. *mamillata* Hatt., Sharp et Mizut., J. Jpn. Bot. 20: 331 (1972). (Pl. V: 6)**

Oil bodies botryoidal type, 1–3 per cell, spherical, 1–3  $\mu\text{m}$  dia., 1–3 per basal cell, oval, 3–5  $\times$  1–3  $\mu\text{m}$ , absent in submarginal and marginal cells, composed of distinct granules, colorless. Oil droplets homogeneous type, many in median cells, spherical, to 1  $\mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Rivière Bleue, 155 m, on trunk, 18 Feb. 1995, *Higuchi* 27650 (mixed with *Pleurozia caledonica*).

**20. *Tetracymbaliella comptoni* (Pears.) Grolle, Rev. Bryol. Lichénol. 32 (1–4): 164 (1963). (Pl. VI: 1)**

Oil bodies granulose type, 2–3 per cell, oblong to elliptical, sausage-like, 15–25  $\times$  7–10  $\mu\text{m}$ , composed of minute granules, colorless. Oil droplets homogeneous type, many per cell, spherical, less than 1  $\mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1400 m, on basal part of trunk, 13 Feb. 1995, *Higuchi* 27447.

**21. *Tetracymbaliella decipiens* (Gott. in Gott. et al.) Grolle, Nova Hedwigia 3: 49 (1961). (Pl. VI: 3, 4)**

Oil bodies homogeneous type, 2–3 per cell, elliptical or sausage-like, 12–18  $\times$  5–10  $\mu\text{m}$ , composed of indistinct granules, colorless. Oil droplets homogeneous type, many per cell, spherical, less than 1  $\mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1430 m, on humus, 14 Feb. 1995, *Higuchi* 27359.

**22. *Trichocolea pluma* (Reinw. et al.) Mont. in Gaudichaud, Voy. autuour de monde Bonite, Bot. 2, Crypt. Cell. (1): 238 (1846). (Pl. VI: 5, 6)**

Oil bodies homogeneous or granulose type, 10–30 per cell at leaf-disc and cilia, gradually decreasing in number from disc to tip of cilia, absent in 1–2 cells of tip, globose to oval, 4–15  $\times$  4–6  $\mu\text{m}$ , composed of minute granules with a refractive spot, colorless. Oil droplets homogeneous type, many in cells of leaf-disc, gradually decreasing in number from disc to tip of cilia, spherical, less than 1  $\mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1618 m (summit), on humus, 13 Feb. 1995, *Higuchi* 27412.

This species is closely allied to *Trichocolea tomentella* (Ehrh.) Dum. For example, Piippo (1984) treated *Trichocolea pluma* as a synonym of *T. tomentella*, s. lat. Oil bodies of *Trichocolea tomentella* have been described as finely botryoidal type with a single eye-spot by Müller (1939) and Hattori (1951). Their descriptions are nearly the same as the above description. There are no differences in that the oil bodies of the species aid in distinguishing one another.



23. **Zoopsidella caledonica** (Steph.) Schust., Taxon 18: 57 (1969). (Pl. VI: 2)  
Oil bodies granulose type, 2 per cell, fusiform to elliptical, sausage-like,  $10\text{--}15 \times 3\text{--}5 \mu\text{m}$ , composed of minute granules, colorless. Oil droplets homogeneous type, few per cell, spherical, less than  $1 \mu\text{m}$  dia., colorless.

Specimen examined. Province Sud, Mt. Humboldt, 1380 m, on trunk, 13 Feb. 1995, Higuchi 27363.

### Discussion

The oil droplets have never been recognized in hepatics. Hattori & Inoue (1958) reported the drop-like oil in *Takakia lepidozoides* Hatt. et Inoue described as a hepatic. However it is now generally accepted it is a moss. Arnell (1956) noted that *Riccardia latifrons* Lindb. has 7–10 large oil bodies per cell and several small ones in cells of the thallus, although Müller (1954) described the absence of oil bodies in this species. Mendelak (1974) and Furuki (1991) reported minute, numerous and homogeneous drop-like oil bodies in *Riccardia latifrons*. While, in a study of sporelings of some species of *Riccardia*, Furuki (1990) pointed out that drop-like oil bodies and oil bodies are present in the same cells in some *Riccardia* species. This suggests that the small oil bodies in Arnell (1956) and the drop-like oil bodies in Mendelak (1974) and Furuki (1991) as well as those in Furuki (1990) are oil droplets. Thus, in hepatics, oil droplets may have been overlooked and are less conspicuous than oil bodies.

The oil droplets were recognized in the cells of most of species examined in this study, except *Chandnanthus hirtellus*, *Kurzia* sp., and *Porella viridissima*. Oil droplets were almost uniformly similar in all the taxa examined, that is, they are spherical, homogeneous and colorless. The number of oil droplets is variable among taxa. Oil droplets are too many to count in many taxa (e.g. Pl. VI: 4), but rather few in the following species: *Otolejeunea schmidii*, *Pleurozia articulata*, and *Zoopsidella caledonica*. The size of oil droplets is almost less than  $1 \mu\text{m}$  diameter, which is smaller than that of mosses (usually larger than  $1 \mu\text{m}$  diameter; cf. Frahm, 1994). In his study of Dicranaceae, Frahm (1994) noted that presence or absence is useful taxonomically. The taxonomic significance of oil droplets in hepatics is uncertain because of the small number of collections examined. However, it may be much less than oil bodies, since there is no morphological differentiation in the oil droplets of some hepatics examined.

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### Explanation of Plates

- Plate I. Oil bodies, oil droplets and chloroplasts in cells at leaf-disc (1, 2) and -middle (3-6). Scales all 10  $\mu\text{m}$ . 1, 2. *Chandonanthus hirtelus* (Web.) Mitt. (Higuchi 27477). 3. *Adelanthus bisetulus* (Steph.) Grolle (Higuchi 27424). 4-6. *Denotarisia linguifolia* (De Not.) Grolle (Higuchi 27466). 6. Another focus of Fig. 5. Arrows show oil droplets.
- Plate II. Oil bodies, oil droplets and chloroplasts in cells at leaf-middle (1, 6), -vitta (3-5) and -base (2). Scales all 10  $\mu\text{m}$ . 1, 2. *Goebeliella cornigera* (Mitt.) Steph. (Higuchi 27299). 3, 4. *Herbertus huelimannii* Miller (Higuchi 27429). 5. *Herbertus setigerus* (Steph.) Miller (Higuchi 27423). 6. *Jamesoniella flexicaulis* (Nees) Schiffn. (Higuchi 27627).
- Plate III. Oil bodies, oil droplets and chloroplasts in cells at leaf-lobe (1), -middle (2) and -disc (3-6). Scales all 10  $\mu\text{m}$ . 1. *Kurzia* sp. (Higuchi 27480). 2. *Odontoschima naviculare* (Grolle) Grolle (Higuchi 27573). 3, 4. *Mastigophora caledonica* Steph. (Higuchi 27272). 5, 6. *Mastigophora disclados* (Brid.) Nees (Higuchi 27581).
- Plate IV. Oil bodies, oil droplets and chloroplasts in cells at leaf-middle. Scales all 10  $\mu\text{m}$ . 1. *Otolejeunea schmidii* (Tixier) Grolle (Higuchi 27255). 2. *Perssoniella vitreocinctata* Herz. (Higuchi 27330). 3, 4. *Pleurozia articulata* (Lindb.) Lindb. (Higuchi 27440). 5, 6. *Pleurozia caledonica* (Gott. et Jack.) Steph. (5 from Higuchi 27276, 6 from Higuchi 27658).
- Plate V. Oil bodies, oil droplets and chloroplasts in cells at leaf-middle. Scales all 10  $\mu\text{m}$ . 1, 2. *Pleurozia gigantea* (Web.) Lindb. (Higuchi 27338). 3. *Porella viridissima* (Mitt.) Grolle (Higuchi 27411). 4. *Schusterella chevalieri* (Schust.) Hatt., Sharp et Mizut. (Higuchi 27623). 5. *Schusterella microscopica* (Peart.) Hatt., Sharp et Mizut. fo. *microscopica* (Higuchi 27598). 6. *Schusterella microscopica* fo. *mamillata* Hatt., Sharp et Mizut. (Higuchi 27650).
- Plate VI. Oil bodies, oil droplets and chloroplasts in cells at leaf-middle (1-4) and -disc (5, 6). Scales all 10  $\mu\text{m}$ . 1. *Tetracymbaliella comptoni* (Pears.) Grolle (Higuchi 27447). 2. *Zoopsidella caledonica* (Steph.) Schust. (Higuchi 27363). 3, 4. *Tetracymbaliella decipiens* (Gott.) Grolle (Higuchi 27359). 4. Two oil bodies and many oil droplets. Arrows show oil droplets. 5, 6. *Trichocolea pluma* (Reinw. et al.) Mont. (Higuchi 27412).

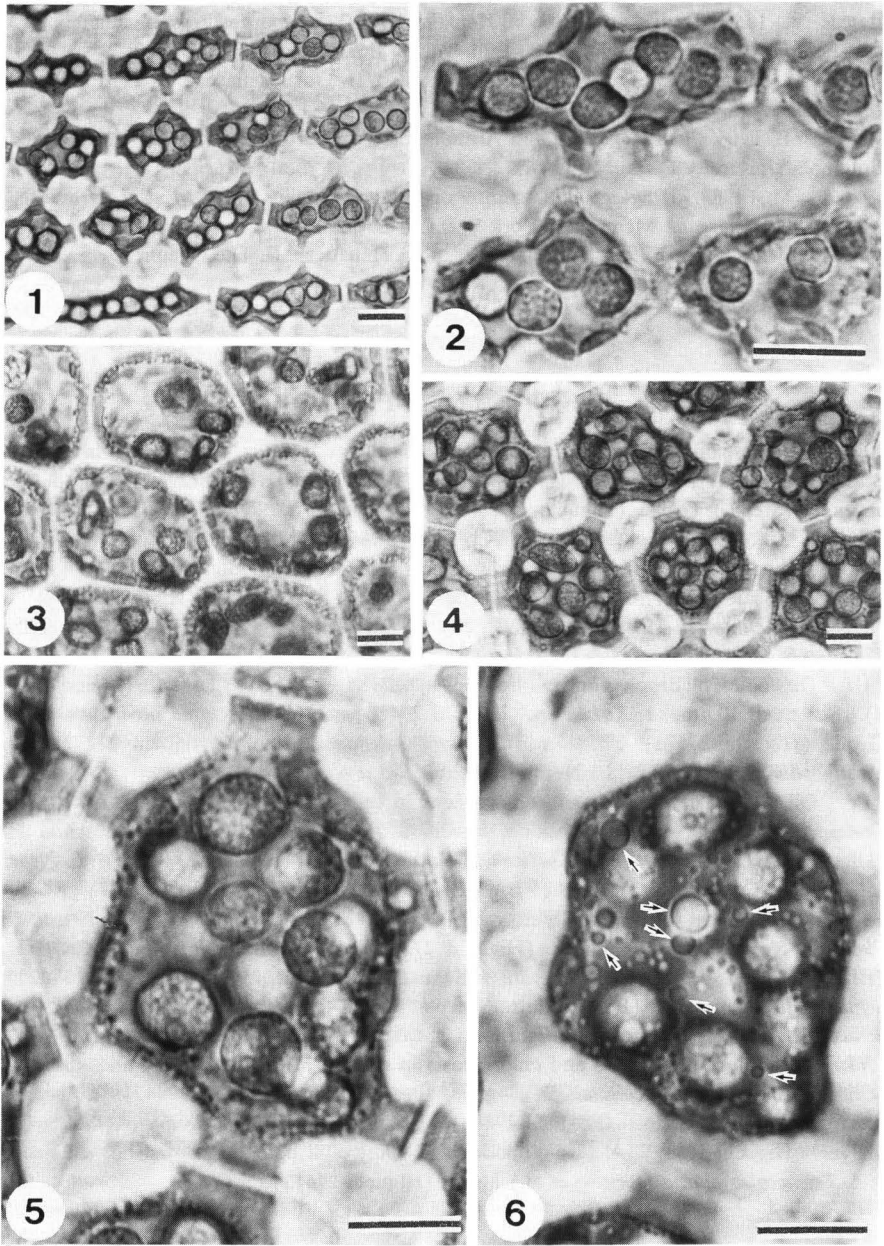


Plate I

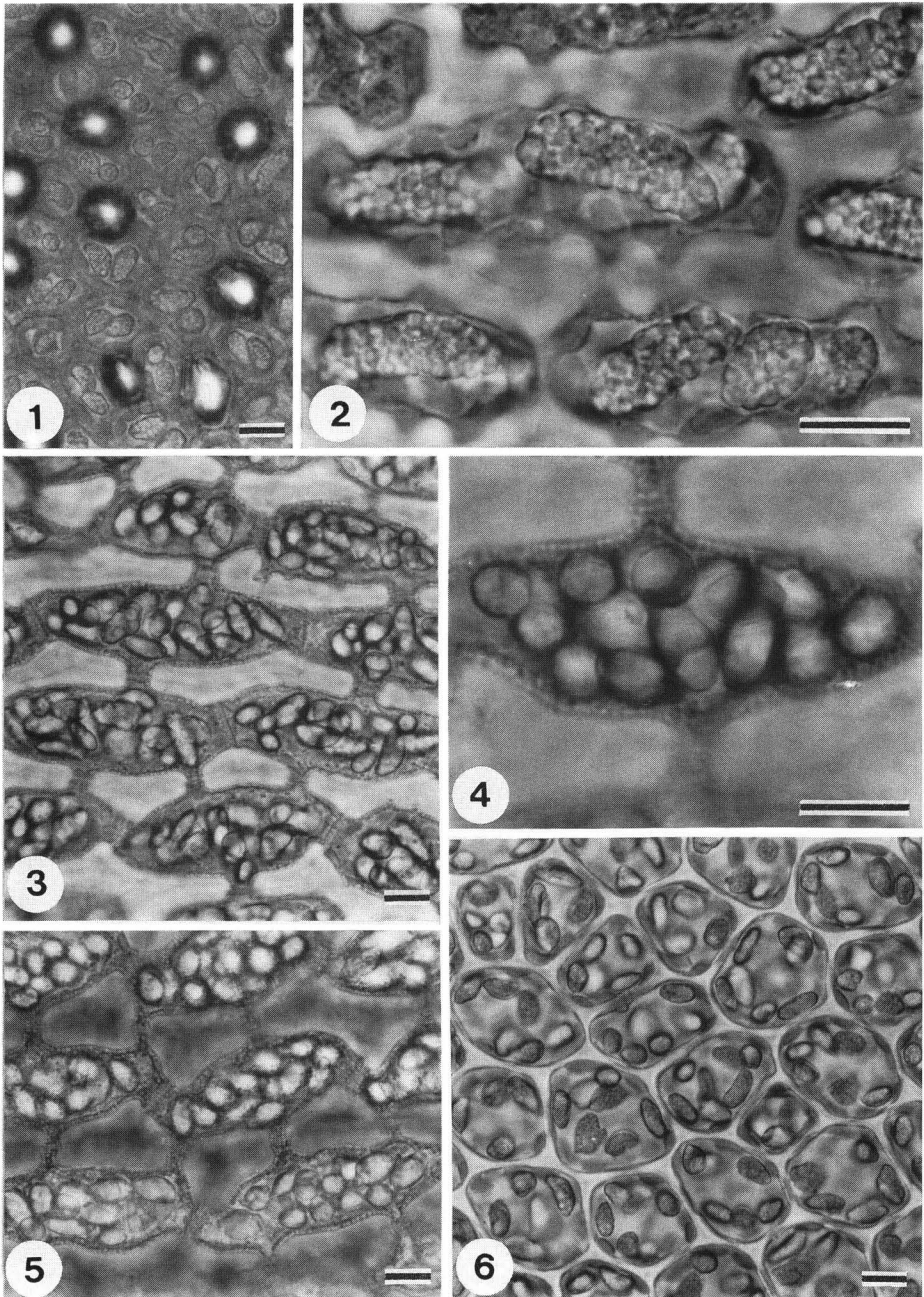


Plate II

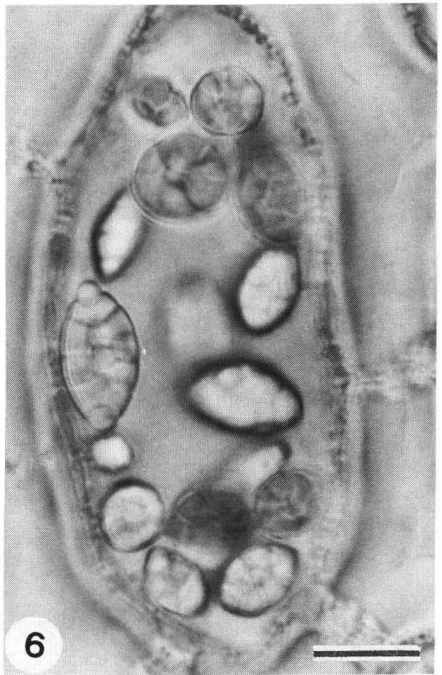
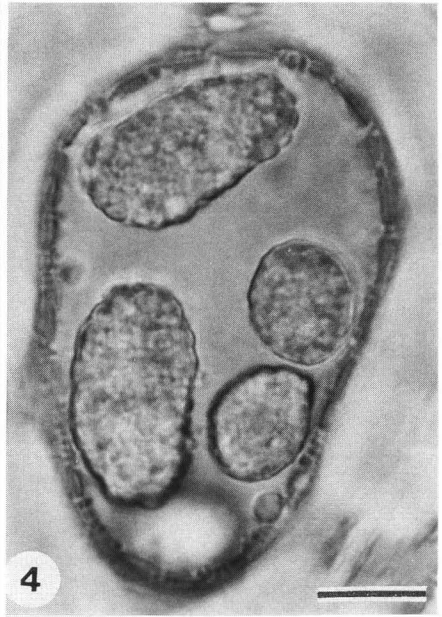
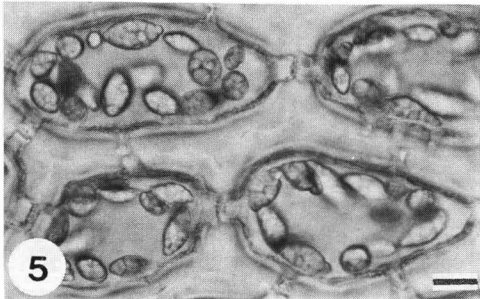
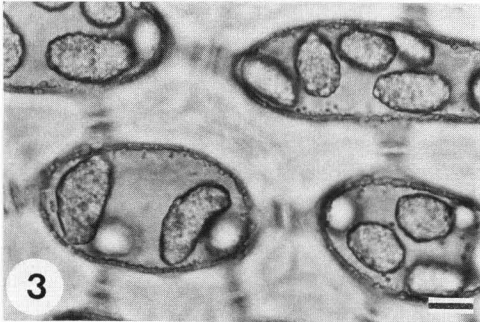
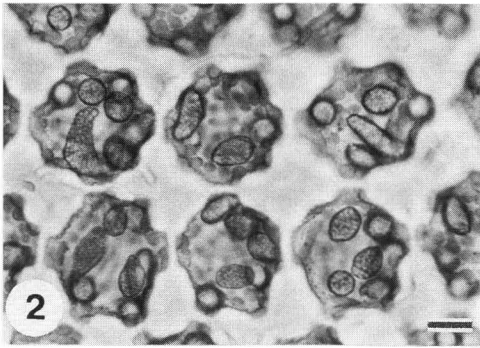
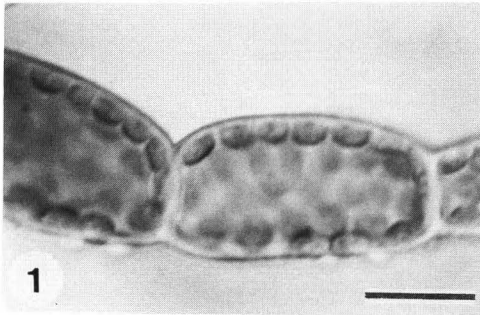


Plate III

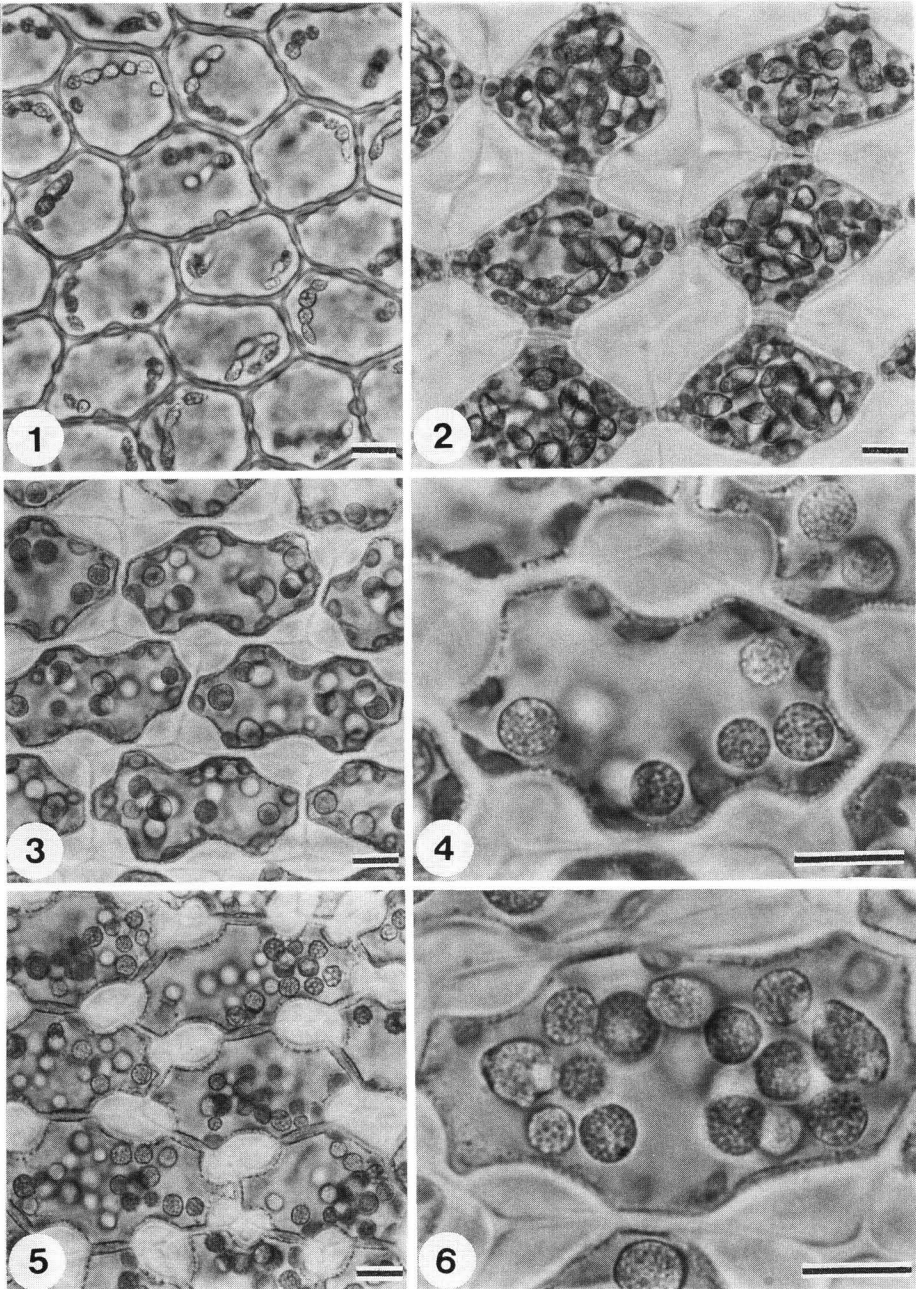


Plate IV

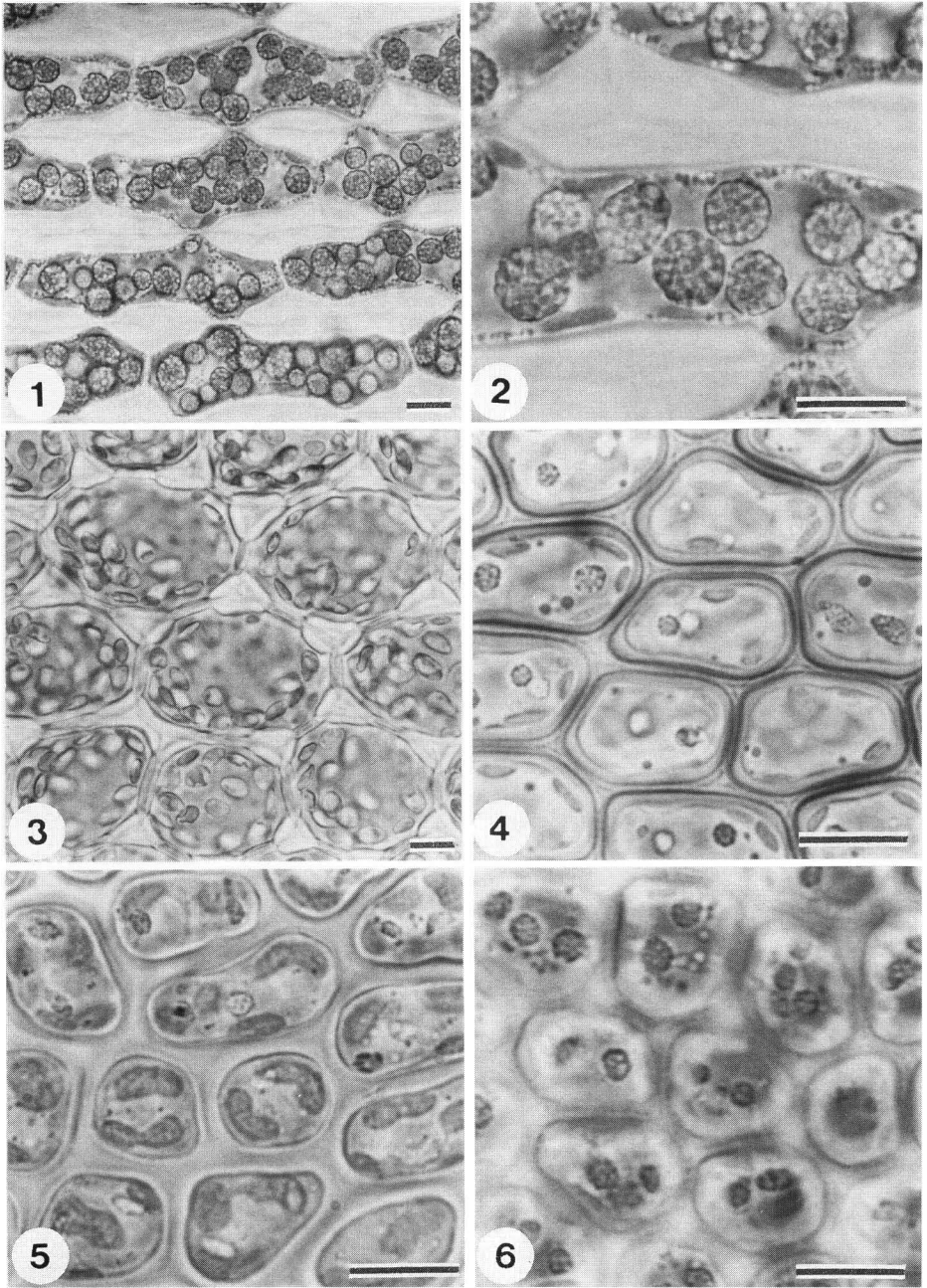


Plate V



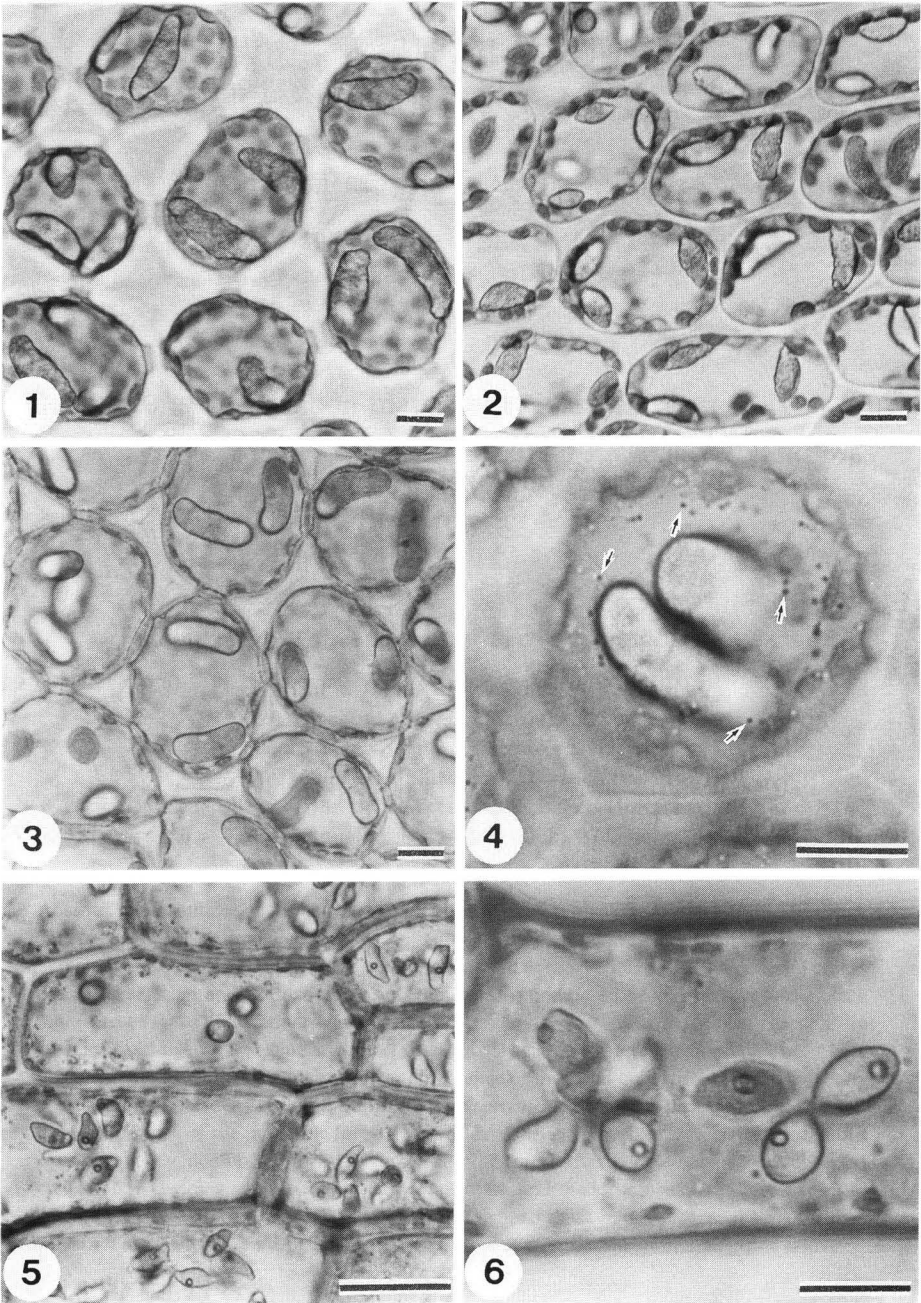


Plate VI

