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**NOTE**

# Studies on Oil-bodies in Some Liverworts from Sikkim, Eastern Himalaya, India

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ABSTRACT: Oil-bodies in 17 species of leafy liverworts from Sikkim in Eastern Himalaya, belonging to order Jungermanniales, are described for the first time in Indian bryoflora.

KEY WORDS: Eastern Himalaya, India, Liverworts, Oil-bodies, Sikkim.

## INTRODUCTION

The studies on oil-bodies in Indian liverworts have received considerable attention and so far 166 taxa spreading across 61 genera in 28 families of order Haplomitriales, Jungermanniales, Metzgeriales and Marchantiales have been investigated for this feature (Udar et al., 1970, 1978, 1982; Udar and Nath, 1971, 1976, 1977, 1978, 1979, 1981; D. Kumar and Udar, 1976; Udar and Shaheen, 1982; Udar and A.Kumar, 1981, 1982a, b, c, d, 1983; Udar and Awasthi, 1981, 1982a, b, 1983, 1984a, b; Udar and Dh. Kumar, 1983; Awasthi and Udar, 1984; Nath and Udar, 1984; A.Kumar and Udar, 1985; A.Kumar and Srivastava, 1986; Awasthi and Srivastava, 1988; Srivastava and Sharma, 1990; Sharma and Srivastava, 1993; Srivastava and Srivastava, 1994; Asthana et al., 1995; Awasthi et al., 2000; Srivastava and Srivastava, 2002; Asthana and Srivastava, 2003; D. Singh and Singh; 2006; Dey et al., 2008; D. Singh et al., 2008a, b; Singh and D. Singh, 2009; S.K. Singh and Singh, 2009; D. Singh et al., 2010; Dey and Singh, 2011; D. Singh, 2012; D. Singh and Singh, 2012). The present paper deals with the oil-bodies in yet another 17 species of jungermannioid liverworts from Sikkim in Eastern Himalaya, India. Of these, while oil-bodies in *Anastrepta orcadensis* (Hook.) Schiffn., *Anastrophyllum joergensenii* Schiffn., *A. minutum* (Schreb.) R.M. Schust. and *Mastigophora woodsii* (Hook.) Nees have been studied earlier in extra Indian materials (Hattori, 1953; Kitagawa, 1966; Schuster, 1969; Kis and Pócs 1997; Paton, 1999; Schill and Long, 2003), the remaining have been investigated for the first time for their oil-bodies.

## MATERIALS AND METHODS

The plants were collected from different localities of North and West Sikkim during the months of November 2009, July 2010 and May–June 2011 at altitudes ranging between 1350–4000 m above mean sea level. Photomicrographs of the oil-bodies were taken within 10–15 days of their collection under Biological Research Microscope (Olympus-CX 41) with the help of Olympus Camedia C-7070 digital camera. All specimens have been deposited in the Cryptogamic section of the Central National Herbarium of Botanical Survey of India, Howrah (CAL).

## RESULTS

**Lepidoziaceae**

1. ***Bazzania himalayana*** (Mitt.) Schiffn. Fig. 1A

Oil-bodies grayish, 4–6 per leaf cell, elongated, ellipsoidal to more or less clavate, 6–12 × 4–5 µm, smooth, sometimes digitately 2–3 (–4) segmented, with smooth segments.

Specimen examined: INDIA, Eastern Himalaya, South Sikkim, Maenam Wildlife Sanctuary, ca. 3300 m, 04.06.2011, *D. Singh* 51796.

2. ***Bazzania imbricata*** (Mitt.) S.Hatt. Fig. 1B

Oil-bodies grayish, 3–5 per leaf cell, ovoid-ellipsoidal, 7.0–10.0 × 5.0–7.0 µm, rarely spherical, 4.0–6.0µm in diameter, coarsely segmented, grape-cluster like.

Specimen examined: INDIA, Eastern Himalaya, North Sikkim, 12 km from Lachung towards Katau, ca. 3400 m, 24.05.2011, *D. Singh* 52139.

3. ***Bazzania sikkimensis*** (Steph.) Herzog Fig. 1C



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Oil-bodies grayish, 5–9 per leaf cell, usually ovoid-ellipsoidal, 6.0–11.0 × 4.0–5.0 µm, rarely spherical, 3.0–5.0µm in diameter, smooth, often digitately 2–3 segmented with smooth segments like those in *B. himalayana*.

Specimen examined: INDIA, Eastern Himalaya, West Sikkim, Barsey *Rhododendron* Sanctuary (Barsey), ca. 2875 m, 16.07.2010, *D. Singh 48999*.

The Indian species of the genus can be categorized into three groups based on the characteristics of their oil-bodies. The first group comprises *B. himalayana* and *B. sikkimensis*, which have ellipsoid to more or less clavate oil-bodies with smooth surface, but often digitately 2–3 (–4) segmented. The other group, represented by *B. imbricata, B. sumbavensis* and *B. tridens*, exhibit ovoid-broadly ellipsoidal, finely-coarsely segmented grape-cluster like oil-bodies. Whereas, in *B. tricrenata* oil-bodies are spherical, subspherical to broadly ovoid and smooth. While majority of the Indian species have 3–9 oil-bodies in each leaf cell, *B. sumbavensis* and *B. tricrenata* show 7–15 and 2–4 oil-bodies per cell respectively (Sharma and Srivastava, 1993; D. Singh et al., 2008a).

**Calypogeiaceae**

4. ***Calypogeia aeruginosa*** Mitt. Fig. 1D

Oil-bodies bluish, 2–4 per leaf cell, ovoid-ellipsoidal, 8.0–11.0 × 3.5–5.0 µm, or spherical, 4.0–6.0 µm in diameter, finely segmented.

Specimen examined: INDIA, Eastern Himalaya, North Sikkim, 12 km from Lachung towards Katau, ca. 3400 m, 24.05.2011, *D. Singh* 52152.

All the Indian species of the genus investigated so far for this feature, viz. *C. aeruginosa*, *C. arguta, C. azurea, C. lunata* and *C. marginella*, show similar ovoid-ellipsoidal or spherical oil-bodies with characteristic blue colour or the bluish tinge (Sharma and Srivastava, 1993; D. Singh et al., 2008a).

**Scapaniaceae**

5. ***Anastrepta orcadensis*** (Hook.) Schiffn. Fig. 1E

Oil-bodies grayish, 4–8 per leaf cell, usually spherical, 3.0–5.0 µm in diameter, or sometimes ovoid-ellipsoidal, 4.0–6.0 × 3.0–4.0 µm, nearly smooth.

Specimen examined: INDIA, Eastern Himalaya, North Sikkim, 12 km from Lachung towards Katau, ca. 3400 m, 24.05.2011, *D. Singh* 52126.

Hattori (1953) and Kitagawa (1966) also reported 7–9 and 6–10 oil-bodies per leaf cell respectively with nearly smooth texture in this species from Japan.

6. ***Anastrophyllum joergensenii*** Schiffn. Fig. 1F

Oil-bodies grayish, 3 –4 per leaf cell, ovoid-ellipsoidal, 4.0–6.0 × 2.5–4.0 µm, coarsely segmented.

Specimen examined: INDIA, Eastern Himalaya, North Sikkim, 12 km from Lachung towards Katau, ca. 3400 m, 24.05.2011, *D. Singh* 52129.

Schill and Long (2003) reported up to 7, coarsely segmented oil-bodies per leaf cell in this species from Scotland.

7. ***Anastrophyllum minutum*** (Schreb.) R.M.Schust. Fig. 1G

Oil-bodies grayish, 6–10 per leaf cell, ovoid-ellipsoidal, 6.0–13.0 × 5.0–8.0 µm, or spherical, 5.0–9.0 µm in diameter, coarsely segmented.

Specimen examined: INDIA, Eastern Himalaya, North Sikkim, 12 km from Lachung towards Katau, ca. 3400 m, 24.05.2011, *D. Singh* 52146.

Schuster (1969) and Schill and Long (2003) reported 2–6 oil-bodies in this species from Scotland, whereas Kis and Pócs (1997) reported only 1–4 oil-bodies in the specimens from Africa.

8. ***Scapania ligulata*** Steph. Fig. 1H

Oil-bodies grayish, (2–) 3–4 per leaf cell, ovoid, 4–8 × 3–6 µm, or spherical, 3–5µm in diameter, coarsely segmented.

Specimen examined: INDIA, Eastern Himalaya, West Sikkim, Barsey *Rhododendron* Sanctuary (4 km from Anden towards Okhrey), ca. 2260 m, 13.07.2010, *D. Singh* 48911.

The oil-bodies in the Indian species of the genus are usually similar in shape, but show little variation in number per cell from 2–3 in *S. contorta* and *S. ornithopodioides* to 3–7 in *S. griffithii* (Srivastava and Srivastava, 1994; D. Singh et al., 2008a, b).

**Plagiochilaceae**

9. ***Plagiochila denticulata*** Mitt. Fig. 1I

Oil-bodies grayish, 4–6 per leaf cell, fusiform-ellipsoidal, 8.0–18.0 × 4.0–5.0 µm, usually curved, finely segmented.

Specimen examined: INDIA, Eastern Himalaya, West Sikkim, Barsey *Rhododendron* Sanctuary (Fedi), ca. 2900 m, 08.06.2011, *D. Singh* 51827.

The characteristically curved, larger oil-bodies in this species make it easily distinguishable from other Indian species of the genus, which usually show ovoid-ellipsoidal or spherical oil-bodies (Udar et al., 1970; Udar and Nath, 1976; Udar and Shaheen, 1982; D. Singh and Singh; 2006; D. Singh et al., 2008a).

10. ***Plagiochila detecta*** M.L.So & Grolle Fig. 2A



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Oil-bodies grayish, 5–10 per leaf cell, ovoid-ellipsoidal, 4.0–6.0 × 2.5–3.5μm, or sometimes spherical, 2.5–3.5μm in diameter, coarsely segmented.

Specimen examined: INDIA, Eastern Himalaya, West Sikkim, Barsey *Rhododendron* Sanctuary (2 km from Barsey towards Hee), ca. 2600 m, 16.07.2010, *D. Singh* 49043C.

11. ***Plagiochila flexuosa*** Mitt. Fig. 2B

Oil-bodies yellowish, 4–8 per leaf cell, usually ovoid-ellipsoidal, 9–14 × 5–8 μm, or sometimes spherical, 4–8 μm in diameter, smooth.

Specimen examined: INDIA, Eastern Himalaya, West Sikkim, Barsey *Rhododendron* Sanctuary (Fedi), ca. 2900 m, 08.06.2011, D. *Singh* 51823.

In the presence of yellowish and smooth oil-bodies of this species, it is easily recognizable amongst other Indian species of the genus which have grayish, finely-coarsely segmented oil-bodies (Udar et al., 1970; Udar and Nath, 1976; Udar and Shaheen, 1982; D. Singh and Singh; 2006; D. Singh et al., 2008a).

**Mastigophoraceae**

12. ***Mastigophora woodsii*** (Hook.) Nees Fig. 2C

Oil-bodies grayish, 3–8 per leaf cell, ovoid-ellipsoidal, 5.0–9.0 × 2.5–5.0 μm, or spherical, 3.0–4.5 μm in diameter, very finely segmented.

Specimen examined: INDIA, Eastern Himalaya, North Sikkim, 12 km from Lachung towards Katau, ca. 3400 m, 24.05.2011, *D. Singh* 52156.

Paton (1999) also reported up to 8, finely segmented oil-bodies in this species from British Isles.

**Lejeuneaceae**

13. ***Cheilolejeunea subopaca*** (Mitt.) Mizut. Fig. 2D

Oil-bodies grayish, one per leaf cell, ellipsoidal, 12–20 × 8–11 μm, coarsely segmented.

Specimen examined: INDIA, Eastern Himalaya, North Sikkim, Dobang valley, ca. 2984 m, 21.05.2011, *D. Singh* 52009.

Unlike *C. birmensis*, *C. laeviscula* and *C. trapezia* with 1–2 oil-bodies per cell; *C. serpentina* with 1–4 oil-bodies and *C. trifaria* with 2–3 oil-bodies (Asthana et al., 1995; D. Singh et al., 2008a; D. Singh, 2012), *C. subopaca* possesses a single oil-body only in each cell.

14. ***Cololejeunea dozyana*** (Sande Lac.) Schiffn. Fig. 2E

Oil-bodies grayish, 4–6 per leaf cell, usually spherical, 3–5 μm in diameter, or sometimes ellipsoidal-fusiform, 5.0–8.0 × 3.0–4.5 μm, finely segmented.

Specimen examined: INDIA, Eastern Himalaya, South Sikkim, Maenam Wildlife Sanctuary, ca. 3300 m, 01.06.2011, *D. Singh* 52173B.

Oil-bodies in the Indian species of this genus are of two types, viz. smooth, usually spherical or rarely ellipsoidal-fusiform, as in the case of *C. bhutanica, C. furcilobulata, C. udarii* (Asthana and Srivastava, 2003; Dey and Singh, 2011), and finely segmented , usually ellipsoidal-fusiform or spherical as in *C. latilobula, C. longifolia, C. kashyapii, C. planissima* and *C. minutissima* (Asthana and Srivastava, 2003; D. Singh et al., 2008a). However, *C. dozyana* is interesting in this regard as it combines the features of both the groups in the presence of usually spherical yet finely segmented oil-bodies. Most of the species have 3–22 oil-bodies per cell, except *C. minutissima* and *C. bhutanica*, which show 2–3 and 4–6 oil-bodies per cell respectively.

15. ***Drepanolejeunea longii*** Grolle & R.L.Zhu Figs. 2F & G

Oil-bodies grayish, 3–5 per leaf cell in the middle of leaf lobe, spherical, 4–6 μm in diameter; up to 6 in basal leaf cells, spherical 4–6 μm in diameter or ellipsoidal, 5–8 × 4–5μm, coarsely segmented.

Specimen examined: INDIA, Eastern Himalaya, South Sikkim, Maenam Wildlife Sanctuary, ca. 3200 m, 31.05.2011, *D. Singh* 51718A.

So far, only *D. erecta* and *D. yunnanensis* were studied in India for their oil-bodies (Udar and Awasthi, 1984; D. Singh et al., 2008a), and both are more or less similar to *D. longii* in this feature.

16. ***Lejeunea cocoes*** Mitt. Fig. 2H

Oil-bodies grayish, (1–) 2–3 per leaf cell, ovoid-ellipsoidal, 4.0–8.0 × 3.0–4.5 μm, or spherical, 3–4 μm in diameter, coarsely segmented.

Specimen examined: INDIA, Eastern Himalaya, South Sikkim, Maenam Wildlife Sanctuary, ca. 3200 m, 01.06.2011, *D. Singh 51729.*

17. ***Lejeunea eifrigii*** Mizut. Fig. 2I

Oil-bodies grayish, (1–) 2–3 per leaf cell, spherical, 4–5 μm in diameter, or ovoid-ellipsoidal, rarely fusiform, 5–8 × 3–5 μm, coarsely segmented.

Specimen examined: INDIA, Eastern Himalaya, North Sikkim, Chungthang (along the Lachung Chhu), ca. 2050 m, 23.11.2009, *D. Singh* 46680.

Except *L. kashyapii* and *L. obscura*, which show 18–35 and 40–55, smooth oil-bodies per cell respectively, the other Indian species of the genus have segmented oil-bodies which vary in number from 2–3



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per cell in *L. cocoes, L. eifrigii* and *L. punctiformis* to 2–4 in *L. wallichiana*, 2–6 in *L. indica*, 4–6 in *L. flava*, 3–8 in *L. tuberculosa* and 3–12 in *L. nepalensis* (Udar and Awasthi, 1981; Udar and Shaheen, 1982; D. Singh and Singh, 2006; Dey et al., 2008; D. Singh et al., 2008a).

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# 印度錫金（東喜馬拉雅山脈）地區之蘚類油滴體研究

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摘要：本文研究17種在錫金（東西馬拉雅山脈）的葉蘚目物種之油滴體，為印度苔蘚植物誌之首次描述。

關鍵詞：東喜馬拉雅山脈、印度、蘚類、油滴體、錫金。



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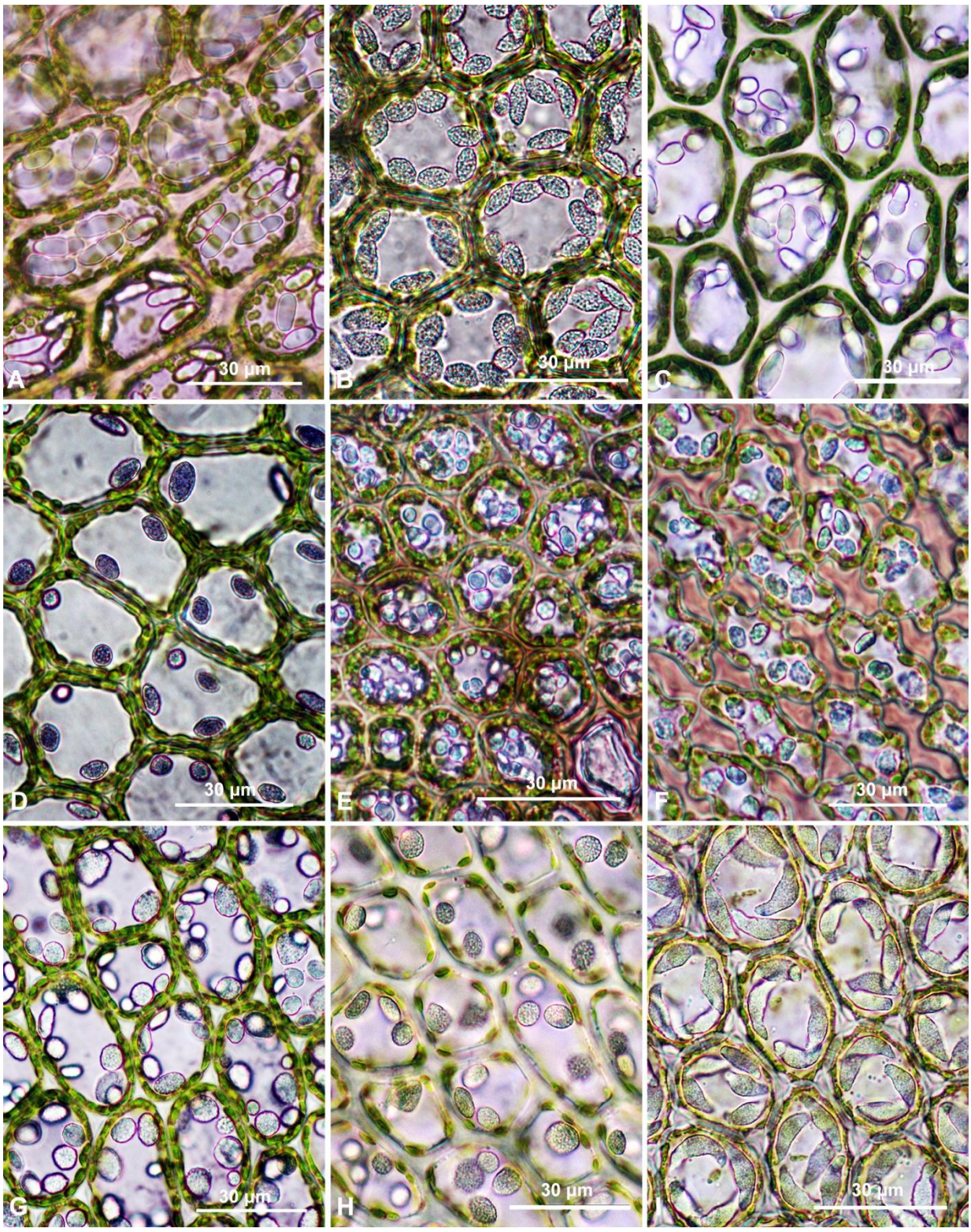



**Fig.1. Photomicrographs of oil bodies. A: *Bazzania himalayana* (Mitt.) Schiffn. B: *Bazzania imbricata* (Mitt.) S.Hatt. C: *Bazzania sikkimensis* (Steph.) Herzog. D: *Calypogeia aeruginosa* Mitt. E: *Anastrepta orcadensis* (Hook.) Schiffn. F: *Anastrophyllum joergensenii* Schiffn. G: *Anastrophyllum minutum* (Schreb.) R.M.Schust. H: *Scapania ligulata* Steph. I: *Plagiochila denticulata* Mitt.**



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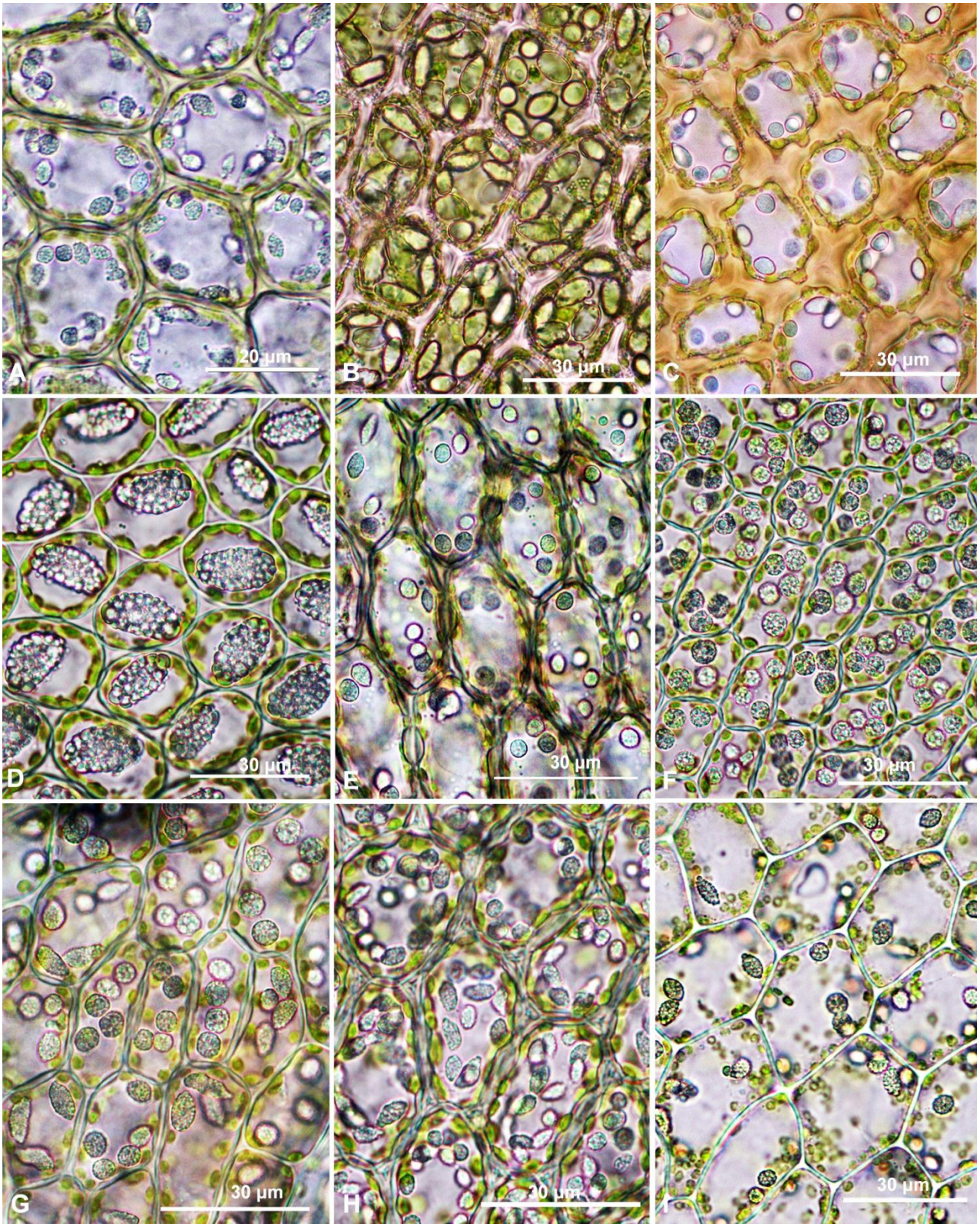



**Fig. 2. Photomicrographs of oil bodies. A: *Plagiochila detecta* M.L.So & Grolle. B: *Plagiochila flexuosa* Mitt. C: *Mastigophora woodsii* (Hook.) Nees. D: *Cheilolejeunea subopaca* (Mitt.) Mizut. E: *Cololejeunea dozyana* (Sande Lac.) Schiffn. F: *Drepanolejeunea longii* Grolle & R.L.Zhu (from middle). G: The same from base. H: *Lejeunea cocoes* Mitt. I: *Lejeunea eifrigii* Mizut.**



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