

## **Liverworts of Bali, Indonesia, with new records to the island**

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**ABSTRACT.** A total of 72 species of liverworts have been found in Bali. Based on recent collections and former records of the species including 31 genera and 17 families, among them, 43 species are new to Bali.

**Keywords.** Bali, liverworts, new records

### **Introduction**

Bali is a major tourist destination in Indonesia. According to the Central Bureau of Statistics of the Republic of Indonesia, in 2015, 4,002,000 people visited Bali and in July 2016 alone 484,231 people visited. There is, therefore, great pressure to expand the infrastructure and facilities for tourists in Bali. This inevitably leads to the degradation or destruction of forest and other natural habitats and, consequently, the biological diversity found there becomes threatened.

Information on the bryophyte flora of Bali is rather rare. Hegewald & van Zanten (1986) reported 78 species of mosses and 17 species of liverworts from Bali. Touw (1992) noted 167 species of mosses for Bali. Additional literature including information on the liverworts of Bali include Eggers et al. (1998), Schäfer-Verwimp (2006, 2009), Haerida et al. (2010), Alam (2012), Heinrichs et al. (2012) and Girmansyah et al. (2013). Based on the results of their studies, only 26 species of liverworts have been recorded, therefore indicating that an inventory on liverwort diversity of Bali is needed. The study by Girmansyah et al. (2013) was a more general survey of Bali's plant and fungal diversity and they recorded about 1700 species of Spermatophytes, Pteridophytes, fungi (Basidiomycota and Glomeromycota), and bryophytes (mosses and liverworts). All of the species reported were based on specimens housed in Bogor Herbarium (BO), Naturalis in Leiden (L) and from the literature.

In 2013, 2015 and 2016 the author visited several localities in Bali to collect material of bryophytes and other cryptogams. The localities were in Candikuning (Bali Botanical Garden, Bedugul, Baturiti at c. 1250–1450 m asl, Mt Tapak at c. 1900 m and Mt Pohen at c. 2060 m), Bangli (Mt Abang at c. 1300–2250 m asl, Mt Batur and surrounding areas, including the lake, at c. 1085–1610 m asl, and Mt Penulisan west and east side at c. 1490–1610 m asl), and Karangasem (Mt Seraya, Bukit Tabuan area at c. 550–790 m asl, Pura Bhur, Bwah and Swah areas at c. 630–1050 m asl, and Pura

Lempuyang area at c. 800–1150 m asl). This resulted in c. 180 collections, among them c. 92 liverworts.

### Results and discussion

Based on the previous literature, such as Hegewald & van Zanten (1986), Eggers et al. (1998), Schäfer-Verwimp (2006, 2009), Haerida et al. (2010), Alam (2012), Heinrichs et al. (2012) and Girmansyah et al. (2013), and on the additional species found in this study, the total number of identified liverwort species recorded from Bali is now 72 species, of which 43 species are new records for Bali. Of these, 15 species are thalloid liverworts and 57 species are leafy liverworts. All new collections have been deposited in BO.

These 72 species are from 31 genera and 17 families (Aneuraceae, Aytoniaceae, Frullaniaceae, Herbertaceae, Jackiellaceae, Lejeuneaceae, Lophocoleaceae, Marchantiaceae, Metzgeriaceae, Pallaviciniaceae, Plagiochilaceae, Porellaceae, Radulaceae, Ricciaceae, Scapaniaceae, Targioniaceae and Wiesnerellaceae).

The specimens were identified using the *Guide to the Liverworts and Hornworts of Java* (Gradstein, 2011) and other literature such as Benedix (1953), Hattori (1973), Zhu & So (2001), Zhu & Gradstein (2005) and Siregar et al. (2013).

Candikuning has a higher number of liverworts species than Bangli and Karangasem. This is because the forests in this area are wetter, thereby suiting a greater bryophyte diversity (c. 77% of all species). Although Bangli has similar conditions to Candikuning in the undamaged forested areas, there is actually very little forest left undamaged, particularly around Mt Batur where the vegetation has been greatly impacted by volcanic eruptions. Most other areas around Mt Abang have been converted to agricultural land. Other species of liverwort were found in Bangli and in Karangasem. These areas are relatively dry and, therefore, fewer liverworts are present.

The higher number of species found in the Candikuning areas is due to the optimal climate for bryophytes, specifically liverworts. Bali Botanical Garden and surrounding areas have an annual precipitation of 2,950 mm/y, an average temperature of c. 20.06°C, and an average of humidity of c. 80.82%. Mt Abang and surrounding areas in Bangli have an annual precipitation of c. 2,200 mm/y, an average temperature of c. 24.9°C, and an average humidity of c. 88%. The driest area, Mt Seraya in Karangasem, has an annual precipitation of c. 1,945 mm/y, an average temperature of c. 23°C, and an average humidity of c. 79%.

### Species list

All specimens cited are in BO unless otherwise stated. An asterisk (\*) indicates a new record for Bali. Nomenclature follows Söderström et al. (2010, 2016) and Gradstein (2011). IH + number refers to a collection by the author. Records which are based only on information from the literature are referenced.

**ANEURACEAE**

- \**Aneura maxima* (Schiffn.) Steph. – by little pond near spring, shaded at Mt Seraya c. 700 m, *IH* 2132.
- \**Aneura pinguis* (L.) Dumort. – on soil, semi-shaded site on Mt Abang, c. 1200 m, *IH* 2133.

**AYTONIACEAE**

- \**Asterella vulcanica* (Schiffn.) Pand et al. ex Kachroo & Bapna – on rock and on soil, semi-shaded sites on Mt Penulisan Barat and Mt Seraya, trail to Pura Lempuyang, c. 850–c. 1400 m, *IH* 2116, 2117, 2120.
- \**Reboulia hemisphaerica* (L.) Raddi – on soil, semi-shaded to shaded sites in Bali Botanical Garden, on Mt Penulisan Barat and on Mt Seraya, trail to Pura Lempuyang, c. 900–1400 m, *IH* 2028, 2114, 2118.

**FRULLANIACEAE**

- Frullania ericoides* (Nees) Mont. – Record from Hegewald & van Zanten (1986).
- \**Frullania gaudichaudii* (Nees & Mont.) Nees & Mont. – on fallen trunk, open site in Bali Botanical Garden, *IH* 2037.
- \**Frullania gracilis* (Reinw., Blume & Nees) Dumort. – on fallen trunk, open site in Bali Botanical Garden, *IH* 2038.
- \**Frullania junghuhniana* Gottsche – on fallen trunk, open site in Bali Botanical Garden, *IH* 2052.
- \**Frullania meyeniana* Lindenb. – on tree trunk and on fallen trunk, open sites in Bali Botanical Garden, *IH* 2051, 2053.
- \**Frullania moniliata* (Reinw., Blume & Nees) Mont. – on tree trunk and on fallen trunk, shaded to open sites in Bali Botanical Garden, on Bukit Tapak and on Bukit Pohen, *IH* 2013, 2015, 2032, 2043, 2058, 2086, 2098.
- \**Frullania ornithocephala* (Reinw., Blume & Nees) Nees – on fallen branch, open site on Bukit Pohen, *IH* 2062.
- Frullania riojaneirensis* (Raddi) Spruce – on rotten log, open site on Bukit Tapak, *IH* 2096.
- Frullania ternatensis* Gottsche – Record from Hegewald & van Zanten (1986).
- Frullania tricarinata* Sande Lac. – Record from Hegewald & van Zanten (1986).

**HERBERTACEAE**

- Herbertus ramosus* (Steph.) H.A.Mill. – Record from Hegewald & van Zanten (1986).

**JACKIELLACEAE**

- \**Jackiella javanica* Schiffn. – on fallen branch, shaded site on Mt Seraya, *IH* 2130.

**LEJEUNEACEAE**

- Acanthocoleus javanicus* (Steph.) Kruijt – Record from Heinrichs et al. (2012).
- Acrolejeunea aulacophora* (Mont.) Steph. – Record from Hegewald & van Zanten (1986).

- Acrolejeunea fertilis* (Reinw., Blume & Nees) Schiffn. – Record from Heinrichs et al. (2012).
- \**Cheilejeunea trapezia* (Nees) R.M.Schust. & Kachroo – on leaves, shaded site in Bali Botanical Garden, *IH 2080*.
- \**Cololejeunea angustiflora* (Steph.) Mizut. – on leaves, semi-shaded site on Bukit Tapak, *IH 2040*.
- \**Cololejeunea appressa* (A.Evans) Benedix – on leaves, shaded site on Bukit Tapak, *IH 2024*.
- \**Cololejeunea cf. lanciloba* – on leaves, shaded site on Bukit Tapak, *IH 2092*.
- \**Cololejeunea macounii* (Spruce ex Underw.) A.Evans – on leaves, semi-shaded to shaded sites in Bali Botanical Garden and on Bukit Tapak, *IH 2041, 2074*.
- \**Cololejeunea cf. serrulata* – on leaves, semi-shaded site on Bukit Tapak, *IH 2018*.
- \**Cololejeunea goebelii* (Gottsche ex K.I.Goebel) Schiffn. – on leaves, shaded site on Bukit Tapak, *IH 2082, 2083, 2084*.
- \**Cololejeunea gottschei* (Steph.) Mizut. – on leaves, semi-shaded site on Bukit Tapak, *IH 2090*.
- \**Cololejeunea subfloccosa* Mizut. – on leaves, shaded site on Bukit Tapak, *IH 2023*.
- \**Cololejeunea triapiculata* (Herzog) Tixier – on leaves, semi-shaded site on Bukit Tapak, *IH 2019*.
- Colura leratii* (Steph.) Steph. – Record from Eggers et al. (1998).
- Diplasiolejeunea cavifolia* Steph. – Record from Schäfer-Verwimp (2006).
- \**Drepanolejeunea pentadactyla* (Mont.) Steph. – on leaves, shaded sites on Bukit Tapak and in Bali Botanical Garden, *IH 2078, IH s.n.*
- \**Lejeunea apiculata* Sande Lac. – on leaves, shaded site in Bali Botanical Garden, *IH 2079*.
- Lejeunea mimula* Hürl. – Record from Heinrichs et al. (2012).
- \**Leptolejeunea epiphylla* (Mitt.) Steph. – on leaves, semi-shaded to shaded sites on Mt Seraya and on Bukit Tapak 825 m, *IH s.n., IH 2128*.
- Leptolejeunea foliicola* Steph. – Records from Eggers et al. (1998) and Bechteler et al. (2017).
- Leptolejeunea massartiana* Schiffn. ex Herzog – Record from Eggers et al. (1998).
- \**Leptolejeunea subacuta* Steph. – on leaves, semi-shaded to shade sites on Bukit Tapak and on Mt Seraya, *IH 2093, 2129*.
- Lopholejeunea eulopha* (Taylor) Schiffn. – Record from Haerida et al. (2010).
- Lopholejeunea horticola* Schiffn. – Record from Haerida et al. (2010).
- \**Lopholejeunea nigricans* (Lindenb.) Steph. – on soil, semi-shaded on Mt Seraya 1500 m, *IH 2120*.
- Lopholejeunea recurvata* Mizut. – Record from Haerida et al. (2010).
- Lopholejeunea subfusca* (Nees) Schiffn. – Records from Haerida et al. (2010) and recent collections from Bali on fallen twigs, open site on Bukit Pohen, *IH 2044*.
- \**Lopholejeunea zollingeri* (Steph.) Schiffn. – on rotten log, open site on Bukit Pohen, *IH 2031*.
- Ptychanthus striatus* (Lehm. & Lindenb.) Nees – on tree trunk, semi-shaded site on Bukit Pohen, *IH 2085*.

*Thysananthus spathulistipus* (Reinw., Blume & Nees) Lindenb. – Records from Heinrich et al. (2012) and recent collections from Bali, on tree trunk and on fallen branch, semi-shaded site on Bukit Pohen, *IH* 2049, 2073.

### LOPHOCOLEACEAE

\**Heteroscyphus argutus* (Nees) Schiffn. – on root, shaded site on Bukit Tapak, *IH* 2095.

\**Heteroscyphus aselliformis* (Reinw., Blume & Nees) Schiffn. – on rotten log, semi-shaded site on Bukit Pohen, *IH* 2029.

*Heteroscyphus coalitus* (Hook.) Schiffn. – on soil, on root and on rock, semi-shaded to shaded sites in Bali Botanical Garden, on Bukit Tapak and on Mt Seraya, *IH* 2045, 2094, 2126.

### MARCHANTIACEAE

*Dumortiera hirsuta* (Sw.) Nees – on soil, semi-shaded to shaded sites in Bali Botanical Garden, on Mt Abang and on Mt Seraya, c. 850–c.1700 m, *IH* 2046, 2107, 2113, 2121.

\**Marchantia acaulis* Steph. – on soil, semi-shaded on Mt Abang, c. 1700, *IH* 2131.

*Marchantia emarginata* Reinw., Blume & Nees – on soil and on ‘pura’ wall, semi-shaded to open sites in Bali Botanical Garden, on Mt Penulisan and on Mt Seraya, *IH* 2030, 2108, 2122.

\**Marchantia geminata* Reinw., Blume & Nees – on soil, open site on Mt Penulisan, *IH* 2100.

\**Marchantia treubii* Schiffn. – on soil, semi-shaded to open sites on Mt Penulisan, c. 1800 m, *IH* 2101, 2111.

### METZGERIACEAE

\**Metzgeria ciliata* Raddi – on soil, shaded site in Bali Botanical Garden, growing together with *Wiesnerella denudata*, *IH* 2047.

\**Metzgeria lindbergii* Schiffn. – on tree trunk and on twigs, shaded sites in Bali Botanical Garden and on Bukit Tapak, *IH* 2072, 2077.

### PALLAVICINIACEAE

\**Pallavicinia lyellii* (Hook.) Gray – on soil, open site on Mt Seraya, *IH* 2125.

### PLAGIOCHILACEAE

*Chiastocaulon oppositum* (Reinw., Blume & Nees) S.D.F.Patzak et al. – Record from Hegewald & van Zanten (1986).

*Plagiochila javanica* (Sw.) Nees & Mont. – Record from Hegewald & van Zanten (1986).

*Plagiochila salacensis* Gottsche – Record from Hegewald & van Zanten (1986).

*Plagiochila teysmannii* Sande Lac. – Record from Hegewald & van Zanten (1986).

**PORELLACEAE**

*Porella acutifolia* (Lehm. & Lindenb.) Trevis. – Record from Hegewald & van Zanten (1986).

**RADULACEAE**

\**Radula acuminata* Steph. – on leaves, shaded site on Bukit Tapak, *IH* 2088.

\**Radula campanigera* Mont. – on tree trunk, semi-shaded site on Bukit Tapak, *IH* 2026.

\**Radula complanata* (L.) Dumort. – on tree trunk, shaded site on Bukit Pohen, *IH* 2033.

\**Radula javanica* Gottsche – on climber, on leaves and on tree trunk, shaded to open sites on Bukit Tapak, *IH* 2016, 2089, 2099.

*Radula multiflora* Gottsche ex Schiffn. – Record from Hegewald & van Zanten (1986).

\**Radula ventricosa* Steph. – on tree trunk, semi-shaded on Bukit Tapak, *IH* 2025.

**RICCIACEAE**

\* *Riccia junghuhniana* Nees & Lindenb. – on soil, open site in Bali Botanical Garden, *IH* 2017.

**SCAPANIACEAE**

*Scapania javanica* Gottsche – Record from Schäfer-Verwimp (2009).

**TARGIONIACEAE**

\* cf. *Targionia hypophylla* – on soil, semi-shaded on Mt Seraya, *IH* 2119.

**WIESNERELLACEAE**

\**Wiesnerella denudata* (Mitt.) Steph. – on rock, shaded site near Batur Lake, *IH* 2104.

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