

# Lejeuneaceae (Marchantiophyta) of Batang Gadis National Park, North Sumatra, Indonesia, with new records for Sumatra and Indonesia

NURMAINI GINTING<sup>1</sup>, NURSAHARA PASARIBU<sup>2,✉</sup>, ETTI SARTINA SIREGAR<sup>2</sup>, SYAMSUARDI<sup>3</sup>

<sup>1</sup>Doctoral Program of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara. Jl. Bioteknologi No. 1, Medan 20155, North Sumatra, Indonesia

<sup>2</sup>Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara. Jl. Bioteknologi No. 1, Medan 20155, North Sumatra, Indonesia. Tel./fax.: +62-61-8211050, ✉email: nursahara@usu.ac.id

<sup>3</sup>Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Andalas. Jl. Unand, Padang 25163, West Sumatra, Indonesia

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**Abstract.** *Ginting N, Pasaribu N, Siregar ES, Syamsuardi. 2026. Lejeuneaceae (Marchantiophyta) of Batang Gadis National Park, North Sumatra, Indonesia, with new records for Sumatra and Indonesia. Biodiversitas 27 (5): d270503. <https://doi.org/10.13057/biodiv/d270503>.* Lejeuneaceae (Marchantiophyta) represents one of the most diverse families of liverworts in tropical regions, yet its distribution and diversity in Sumatra remain poorly documented. This study provides the first documented checklist of Lejeuneaceae from Sopotinjak, Batang Gadis National Park (BGNP), North Sumatra, Indonesia, an ecologically important montane forest area located within the northern Sumatran biogeographic zone. Field surveys were conducted from July to November 2022, and both corticolous and epiphyllous specimens were collected across altitudes of 1,205-1,531 meter above sea level (masl). Morphological observations and species identification were carried out using standard bryological techniques under light microscopy and by comparison with regional taxonomic keys. A total of 31 species belonging to 12 genera and two subfamilies were recorded. *Drepanolejeunea* was the most species-rich genus, followed by *Lejeunea*, *Cololejeunea*, and *Lopholejeunea*. Five species are reported as new distributional records, including three new to Indonesia (*Cololejeunea surinamensis*, *Colura inuiti*, and *Diplasiolejeunea rudolphiana*) and two new to Sumatra (*Drepanolejeunea angustifolia* and *Cheilolejeunea falsinervis*). Most species were epiphyllous, reflecting the humid and shaded montane forest conditions of BGNP. These findings highlight BGNP as an important reservoir of Lejeuneaceae diversity in western Malesia and expand the known distribution of several taxa. The study also underscores the need for further systematic and quantitative surveys to better understand species richness, ecological patterns, and conservation significance of bryophyte communities in Sumatra.

**Keywords:** Batang Gadis National Park, bryophyte diversity, epiphyllous bryophytes, Lejeuneaceae, Sumatra

## INTRODUCTION

Liverworts (Marchantiophyta) are a major group of bryophytes distinguished by the presence of cellular oil bodies, trigones, and synchronous spore maturation, features absent in mosses and hornworts (He et al. 2013; Glime 2021). Their morphological and reproductive plasticity enables them to colonize diverse substrates across most terrestrial ecosystems (Hallingbäck and Hodgetts 2000). In humid forests, liverworts play important ecological roles as components of ground and canopy vegetation, providing microhabitats for microorganisms and invertebrates (Gerson 1982) and serving as sensitive indicators of moisture and air quality (Tuba et al. 2011). Among liverworts, the family Lejeuneaceae is the largest and most taxonomically complex, comprising approximately 1,800-1,950 recognized species in 73-87 genera worldwide (Zhu et al. 2018; WFO 2025). Members of this family exhibit remarkable morphological diversity and ecological specialization, particularly in epiphytic and epiphyllous habitats (Yu et al. 2025). Despite recent advances in molecular phylogenetics, several Lejeuneaceae lineages remain poorly resolved due to limited molecular data and incomplete anatomical

documentation, including the fine structure of oil bodies and ocelli (Zhu and Shu 2018; Zhu et al. 2019).

Regionally, Lejeuneaceae dominate liverwort floras throughout tropical and subtropical Asia, accounting for up to 40% of total liverwort diversity in certain areas (Lee et al. 2022). In Malaysia, the family comprises 312 species in 30 genera, with *Cololejeunea*, *Bazzania*, and *Frullania* as the most speciose genera. In Peninsular Malaysia, Lejeuneaceae is the largest component of the liverwort flora, with 54 species (67%) recorded from Mount Tebu Forest Reserve (Sarimi et al. 2025), and 31 species (89%) of the epiphyllous liverwort assemblage from Panti Forest Reserve (Pesiú et al. 2025). These studies consistently demonstrate that Lejeuneaceae is the ecologically dominant liverwort family in humid tropical lowland and montane forests of Southeast Asia. Lejeuneaceae also shows exceptional richness in the Himalayan biodiversity hotspot, comprising 20 genera and 131 taxa in the eastern Himalaya, India (Singh 2024). Similar dominance patterns occur in Java, Indonesia, where Lejeuneaceae is a major component of montane forest bryophyte communities, as observed in the Ireng-Ireng Forest of Bromo Tengger Semeru National Park (Putri et al. 2024). The floristic patterns documented to date position Southeast Asia as a

leading region for Lejeuneaceae diversity in tropical ecosystems.

In contrast, Sumatra remains one of the least explored regions for liverworts in Indonesia. Earlier explorations in North Sumatra and nearby localities revealed Lejeuneaceae as the most species-rich family, for example, 22 leafy liverwort species recorded from 12 genera and six families in Simancik (Pasaribu et al. 2018). This was followed by the study of Siregar et al. (2017), who documented 29 species across 10 genera from Sicike-cike Natural Park, including eight new records for Sumatra. Further surveys supported these findings: Siregar and Pasaribu (2020) reported 31 species of Lejeuneaceae from Taman Eden 100 Natural Park, while Siregar et al. (2020) identified 37 species from Mount Lubuk Raya, adding several new island records. More recently, Susilo et al. (2022) recorded 83 liverwort species from Mount Sibuatan, of which 26 species belonged to Lejeuneaceae, confirming the predominance of the family within the montane bryophyte flora of North Sumatra. The park encompasses a wide elevational range from lowland to montane forest and serves as a key conservation area supporting diverse biota, including the Asian tapir (Kuswanda et al. 2022, 2024), hornbills (Purwaningsih and Nasution 2024), the Sumatran tiger (Wibisono et al. 2009), the corpse flowers (Rambe et al. 2023), and other wildlife communities (Rambe et al. 2021). The humid tropical forests of Batang Gadis National Park (BGNP), North Sumatra, characterized by diverse vegetation and complex topography, are likely to provide suitable microhabitats for epiphytic and epiphyllous liverworts, particularly members of the Lejeuneaceae. However, despite biodiversity studies on vertebrates and vascular plants in BGNP, no published floristic study has specifically addressed the Lejeuneaceae, leaving the bryophyte diversity of this protected area largely undocumented.

This study then aims to document the diversity and taxonomic composition of Lejeuneaceae in Sopotinjak, BGNP, and to report new distributional records for Sumatra and Indonesia in support of the Global Strategy for Plant Conservation. We hypothesize that the humid montane forest conditions of BGNP support high Lejeuneaceae diversity, including previously undocumented taxa. Specifically, this study addresses the following questions: (i) what is the species composition and richness of Lejeuneaceae in the study area, and (ii) does the

assemblage include taxa that represent new records for Sumatra and Indonesia?

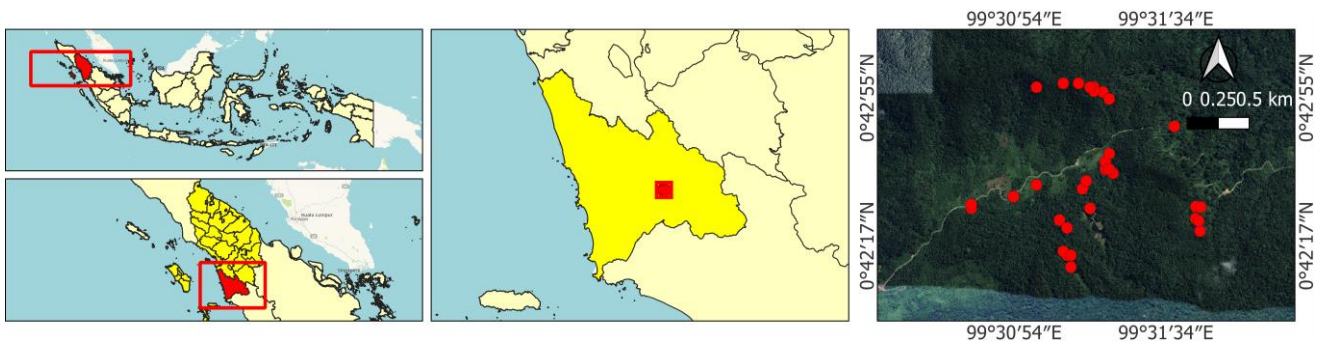
## MATERIALS AND METHODS

### Study area

This study was conducted in Resort 7 Sopotinjak, part of Batang Gadis National Park (BGNP), located in Mandailing Natal District, North Sumatra, Indonesia (00°42'14"N, 99°13'09"E; Figure 1). The Sopotinjak sector covers a mixed landscape of lower to upper montane forest at elevations of approximately 1,200-1,550 meters above sea level (masl), encompassing protected and conservation forest zones. The area forms part of the Bukit Barisan mountain range, characterized by steep slopes, high rainfall (>3,000 mm yr<sup>-1</sup>), and humid microclimates that support dense canopy vegetation and abundant epiphytic flora. Administratively, it lies between Desa Bulu Soma (west), Panyabungan Selatan (east), Panyabungan Utara (north), and the Lembah Sorik Marapi area (south).

### Sampling design and field collection

A non-quantitative, exploratory floristic survey was conducted to document Lejeuneaceae diversity in the Sopotinjak sector of Batang Gadis National Park, North Sumatra. Sampling was carried out opportunistically along approximately 6 km of forest trails, encompassing four main routes (D, T, DK, and RA) and covering both shaded and semi-open habitats. The survey routes were selected to capture major topographic and microhabitat variation within the sampled area of Resort 7 Sopotinjak, thereby providing broad floristic coverage for documenting Lejeuneaceae taxa present along the surveyed trails. Bryophyte specimens were collected with both gametophytic and sporophytic generations represented whenever possible. For each specimen, habitat data (e.g., forest type, canopy condition), substrate type (e.g., bark, leaf, rock, soil), and environmental parameters (e.g., light intensity, humidity, and elevation) were recorded in situ using standard field instruments. Specimens were carefully detached using fine-tipped forceps and scalpels, placed in paper packets, and air-dried under shade. Each specimen was assigned a field collection number, and a total of approximately 180 voucher specimens were collected and processed during the two field expeditions.



**Figure 1.** Location of Resort 7 Sopotinjak, part of Batang Gadis National Park, Mandailing Natal District, North Sumatra, Indonesia, showing the sampling sites of Lejeuneaceae collections

### Specimen identification and curation

Dried specimens were curated and identified at the Herbarium Medanense (MEDA), Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, North Sumatra, Indonesia. Morphological examinations were performed using an Olympus CX43 compound microscope at magnifications ranging from 40× to 400×. Diagnostic features studied included branching pattern, leaf-lobe and lobule morphology (shape, margin, apex, and trigones), as well as the size and form of underleaves. Generative organs, when present, were examined to assist in species determination. All specimens were compared with descriptions and identification keys from major taxonomic references (Mizutani 1961; Zhu and So 2001; Gradstein 2011).

## RESULTS AND DISCUSSION

A total of 31 species of Lejeuneaceae were recorded from the study area, representing two subfamilies and 12 genera. Lejeuneoideae comprised eight genera: *Cheilolejeunea*, *Cololejeunea*, *Colura*, *Diplasiolejeunea*, *Drepanolejeunea*, *Lejeunea*, *Leptolejeunea*, and *Metalejeunea*. *Ptychanthoideae* comprised four genera: *Caudalejeunea*, *Lopholejeunea*, *Ptychanthus*, and *Thysananthus*. Based on field observations, the genus *Drepanolejeunea* was found to be the most species-rich, represented by six species, followed by *Lejeunea* (4 spp.), *Cololejeunea* (4 spp.), *Lopholejeunea* (4 spp.), *Cheilolejeunea* (3 spp.), *Leptolejeunea* (2 spp.), *Colura* (2 spp.), and *Thysananthus* (2 spp.). In contrast, the genera *Caudalejeunea*, *Metalejeunea*, *Ptychanthus*, and *Diplasiolejeunea* were each represented by a single species in the study area. Members of this family were found growing as epiphytes on a variety of substrates, including living leaves, tree bark, and decaying wood (Tables 1 and S1). Most species in the study area occurred as epiphylls, growing on living leaves (61.3%, 19 species), as observed in the genera *Drepanolejeunea*, *Cololejeunea*, *Cheilolejeunea*, *Leptolejeunea*, *Colura*, *Metalejeunea*, *Diplasiolejeunea*, and *Caudalejeunea*, followed by tree bark with 18 species (58.1%) and decaying wood with nine species (29.0%). Since several species occurred on more than one substrate, these percentages are not mutually exclusive. In the present study, Lejeuneaceae species were recorded at elevations ranging from 1,200 to 1,500 m a.s.l., and were distributed across all four sampling trails, namely Danau Kiri (D), Tower (T), Danau Kanan (DK), and Rest Area (RA), as detailed in Tables 1 and S1. Across survey sites, site D had the highest number of recorded species, with 15 species (48.4%), followed by T with 11 species (35.5%), DK with nine species (29.0%), and RA with eight species (25.8%).

To facilitate identification, a dichotomous key to the species of Lejeuneaceae occurring in BGNP is provided hereafter, based on diagnostic morphological characters observed in the examined specimens.

***Thysananthus retusus*** (Reinwardt, Blume & Nees) B. Thiers & Gradstein *Memoirs of The New York Botanical Garden* 52: 67. 1989. (Mem. New York Bot. Gard.), Thiers, B. M. & S. R. Gradstein. 1989. Lejeuneaceae (Hepaticae) of Australia. I. Subfamily Ptychanthoideae. Mem. New York Bot. Gard. 52: 1-81.

Diagnosis: Underleaves distinctly spatulate, with shortly toothed and shallowly notched apices. Dorsal and ventral lobe margins dentate. Lobule apex acute.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 10 Nov 2022; N. Ginting 993, 1002, 1013, 1025, 1136 (MEDA).

Distribution. Philippines, Thailand, Indonesia (Sumatra, Java, Papua), Solomon Islands, Australia.

***Thysananthus spathulistipus*** (Reinw, Blume & Nees) Lindenb. Gottsche, C. M., J. B. W. Lindenb. & C.G.D. Nees von Esenbeck. 1844. Syn. Hepat. 834 pp. Meissner, Hamburg. *Jungermannia spathulistipa* Reinw., Blume & Nees. Reinwardt, C. G. C., C. L. von Blume & C.G.D. Nees von Esenbeck. 1824. Hepaticae Iavanicae. Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 12(1): 181-238.

Diagnosis: Underleaves spatulate. Lobes and underleaves obtuse. Dorsal and ventral lobe margins entire.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 2 Jul 2022; N. Ginting 87 (MEDA); 9 Nov 2022; N. Ginting 851 (MEDA); 10 Nov 2022; N. Ginting 973, 986, 1136 (MEDA).

Distribution. Java, Sumatra, Peninsular Malaysia, Borneo, Bali, Sumbawa, Sulawesi, Maluku, West Irian, Papua New Guinea, Australia, Solomon Islands, Thailand, India, Sri Lanka, Tropical Africa.

***Ptychanthus striatus*** (Lehm. & Lindenb.) Nees. Nees von Esenbeck, C.G.D. 1838. Naturgesch. Eur. Leberm. 3: 594 pp. August Rucker, Breslau. *Ptychanthus bidentatus* Herzog, Ann. Bryol. 4: 85. 1931.

Diagnosis: Lobes fan-shaped, with acute apices and finely dentate margins. Underleaves rounded. Lobule apex obtuse. Plants robust, with imbricate leaves spreading obliquely to the stem.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 20 Oct 2022; N. Ginting 455 (MEDA); 9 Nov 2022; N. Ginting 795 (MEDA).

Distribution. Tropical Africa, Sri Lanka, India, China, Japan, Taiwan, the Philippines, and Thailand.

**Table 1.** Taxonomic composition, substrate occurrence, altitudinal range, and survey-site frequency of *Lejeuneaceae* species recorded in the study area

Subfamily	Genus	Species	L	DW	TB	Substrate (n)	Alt. (min)	Alt. (max)	Survey sites	Site frequency
Lejeuneoideae	<i>Cheilolejeunea</i>	<i>Cheilolejeunea falsinervis</i> (Sande Lac.) R.M. Schust. & Kachroo	0	0	1	1	1,337	1,337	DK	1
		<i>Cheilolejeunea ceylanica</i> (Gottsche) R.M.Schust. & Kachroo	1	1	1	3	1,257	1,307	D, RA	2
		<i>Cheilolejeunea longiloba</i> (Steph. ex G. Hoffm.) Kachroo & R.M. Schust. ex J.J. Engel & B.C. Tan	1	0	1	2	1,286	1,390	D	1
	<i>Cololejeunea</i>	<i>Cololejeunea appressa</i> (A.Evans) Benedix	1	0	0	1	1,344	1,344	DK	1
		<i>Cololejeunea denticulata</i> (Horik.) S.Hatt.	1	0	0	1	1,280	1,286	D	1
		<i>Cololejeunea falcata</i> (Horik.) Benedix	1	0	0	1	1,329	1,364	DK	1
		<i>Cololejeunea surinamensis</i> Tixier	1	0	0	1	1,337	1,337	DK	1
	<i>Colura</i>	<i>Colura acroloba</i> (Prantl) Jovet-Ast	1	0	0	1	1,279	1,279	D	1
		<i>Colura inuii</i> Horik.	1	0	0	1	1,390	1,390	D	1
	<i>Diplasiolejeunea</i>	<i>Diplasiolejeunea rudolphiana</i> Steph.	1	0	0	1	1,491	1,491	T	1
	<i>Drepanolejeunea</i>	<i>Drepanolejeunea angustifolia</i> (Mitt.) Grolle	0	0	1	1	1,531	1,531	T	1
		<i>Drepanolejeunea levicornua</i> Steph.	1	0	0	1	1,278	1,487	T, DK	2
		<i>Drepanolejeunea pentadactyla</i> (Mont.) Steph.	1	0	0	1	1,278	1,525	T, DK, RA	3
		<i>Drepanolejeunea ternatensis</i> (Gottsche) Schiffn.	1	0	1	2	1,290	1,526	D, T	2
		<i>Drepanolejeunea tricornua</i> Herzog	1	0	0	1	1,491	1,491	T	1
		<i>Drepanolejeunea thwaitesiana</i> (Mitt.) Steph.	1	0	0	1	1,257	1,257	RA	1
		<i>Lejeunea</i>	<i>Lejeunea eifrigii</i> Mizut.	0	1	1	2	1,299	1,329	D, DK
	<i>Lejeunea</i>	<i>Lejeunea obscura</i> Mitt.	0	1	1	2	1,282	1,299	RA	1
		<i>Lejeunea sordida</i> (Nees) Mont.	0	0	1	1	1,205	1,205	RA	1
		<i>Lejeunea tuberculosa</i> Steph.	1	1	1	3	1,205	1,282	RA	1
<i>Leptolejeunea</i>		<i>Leptolejeunea epiphylla</i> (Mitt.) Steph.	1	0	0	1	1,282	1,282	RA	1
		<i>Leptolejeunea maculata</i> (Mitt.) Schiffn.	1	0	1	2	1,351	1,361	D	1
<i>Metalejeunea</i>		<i>Metalejeunea cucullata</i> (Reinw., Blume & Nees) Grolle	1	0	1	2	1,337	1,525	D, T, DK	3
Ptychanthoideae		<i>Caudalejeunea</i>	<i>Caudalejeunea recurvistipula</i> (Gottsche) Schiffn.	1	0	0	1	1,295	1,295	D
	<i>Lopholejeunea</i>		<i>Lopholejeunea wiltensii</i> Steph.	0	0	1	1	1,279	1,279	D
<i>Lopholejeunea</i>	<i>Lopholejeunea recurvata</i> Mizut.	0	1	1	2	1,390	1,521	D, T	2	
	<i>Lopholejeunea applanata</i> (Reinw., Blume & Nees) Schiffn.	0	0	1	1	1,525	1,525	T	1	
	<i>Lopholejeunea subfusca</i> (Nees) Schiffn.	0	1	1	2	1,286	1,312	D	1	
	<i>Ptychanthus</i>	<i>Ptychanthus striatus</i> (Lehm. & Lindenb.) Nees	0	1	1	2	1,379	1,525	T, DK	2
	<i>Thysananthus</i>	<i>Thysananthus retusus</i> (Reinw., Blume & Nees) B.M.Thiers & Gradst.	0	1	1	2	1,288	1,511	D, T, RA	3
		<i>Thysananthus spathulistipus</i> (Reinw., Blume & Nees) Lindenb.	0	1	1	2	1,290	1,350	D	1

Note: L: Leaf, DW: Decaying Wood, TB: Tree Bark. Values of 1 and 0 indicate presence and absence, respectively. D, T, DK, and RA indicate survey-site codes for Danau Kiri, Tower, Danau Kanan, and Rest Area, respectively. Site frequency refers to the number of survey sites where each species was recorded. Alt.: Altitude that is presented as the minimum (min) and maximum (max) elevation in meters above sea level

**Taxonomic treatment**  
**Key to the species of Lejeuneaceae**

1a. Underleaf apex bifid .....	<b>Lejeuneoideae</b>	2
1b. Underleaf apex entire .....	<b>Ptychanthoideae</b>	24
2a. Underleaves present .....		3
2b. Underleaves absent .....		21
3a. Lobes bearing a sac .....		4
3b. Lobes lacking a sac .....		5
4a. Sac tubular, ca. 1/5 longer than the lobe.....	<b>Colura acroloba</b>	
4b. Sac oblong-ovate, ca. 1/3 longer than the lobe .....	<b>Colura inuii</b> *)	
5a. Lobes nearly parallel to the stem .....	<b>Metalejeunea cucullata</b>	
5b. Leaves arranged obliquely or perpendicular to the stem .....		6
6a. Underleaves V-shaped or horn-like .....		7
6b. Underleaves ovate .....		15
7a. Lobes with ocelli .....		8
7b. Lobes without ocelli .....		9
8a. Ocelli confined to the apical portion of the lobe .....	<b>Drepanolejeunea pentadactyla</b>	
8b. Ocelli scattered throughout the lobe .....	<b>Drepanolejeunea tricornua</b>	
9a. Lobe apex acute to acuminate .....		10
9b. Lobe apex obtuse .....		11
10a. Lobule surface papillose .....	<b>Drepanolejeunea ternatensis</b>	
10b. Lobule surface smooth .....	<b>Drepanolejeunea angustifolia</b> **)	
11a. Lobe margin entire .....		12
11b. Lobe margin dentate .....		13
12a. Lobes rectangular, ocelli $\leq 20$ cells .....	<b>Leptolejeunea epiphylla</b>	
12b. Lobes ovate, ocelli $\geq 20$ cells .....	<b>Diplasiolejeunea rudolphiana</b> *)	
13a. Trigones rounded .....	<b>Leptolejeunea maculata</b>	
13b. Trigones triangular .....		14
14a. Lobule ovate, apex acute.....	<b>Drepanolejeunea thwaitesiana</b>	
14b. Lobule ovate, apex obtuse .....	<b>Drepanolejeunea levicornua</b>	
15a. Lobules margin toothed .....		16
15b. Lobules margin entire .....		18
16a. Lobes with a vitta .....	<b>Cheilolejeunea falsinervis</b> **)	
16b. Lobes without a vitta .....		17
17a. Lobule margin curved, forming a hooked tooth .....	<b>Cheilolejeunea ceylanica</b>	
17b. Lobule margin straight, forming an upright tooth .....	<b>Cheilolejeunea longiloba</b>	
18a. Lobes apex acute .....	<b>Lejeunea eifrigii</b>	
18b. Lobes apex obtuse .....		19
19a. Lobule triangular .....	<b>Lejeunea obscura</b>	
19b. Lobule ovate .....		20
20a. Lobes large, 0.5–0.9 mm long and 0.5–0.7 mm wide; underleaves bifid to $\frac{1}{3}$ – $\frac{1}{4}$ of their length .....	<b>Lejeunea sordida</b>	
20b. Lobes small, 0.32–0.45 mm long and 0.2–0.3 mm wide; underleaves bifid to ca. $\frac{1}{2}$ of their length.....	<b>Lejeunea tuberculosa</b>	
21a. Lateral leaves with a vitta .....		22
21b. Lateral leaves lacking a vitta .....		23
22a. Vitta 1 row wide .....	<b>Cololejeunea appressa</b>	
22b. Vitta 3 rows wide .....	<b>Cololejeunea falcata</b>	
23a. Lobule triangular.....	<b>Cololejeunea surinamensis</b> *)	
23b. Lobule oblong-ovate.....	<b>Cololejeunea denticulata</b>	
24a. Underleaf apex entire .....		25
24b. Underleaf apex dentate .....		28
25a. Lobule triangular, apex dentate .....	<b>Lopholejeunea wiltensii</b>	
25b. Lobule ovate, apex entire apex .....		26
26a. Lobes elongate, apex acute to acuminate; underleaves reniform .....	<b>Lopholejeunea applanata</b>	
26b. Lobes ovate, apex rounded; underleaves orbicular .....		27
27a. Underleaves $\geq 0.5$ mm long.....	<b>Lopholejeunea recurvata</b>	
27b. Underleaves $\leq 0.5$ mm long .....	<b>Lopholejeunea subfusca</b>	
28a. Underleaves reniform.....	<b>Caudalejeunea recurvistipula</b>	
28b. Underleaves spatulate.....		29
29a. Dorsal and ventral lobe margins entire .....	<b>Thysananthus spathulistipus</b>	
29b. Dorsal and ventral lobe margins dentate .....		30
30a. Lobule apex acute .....	<b>Thysananthus retusus</b>	
30b. Lobule apex obtuse .....	<b>Ptychanthus striatus</b>	

Note: \*) New record for Indonesia, \*\*) New record for Sumatra

*Drepanolejeunea angustifolia* (Mitt.) Grolle. Grolle, R. 1965. *Miscellanea hepaticologica* (41-50). *J. Jap. Bot.* 40 (7): 206-219. *Drepanolejeunea tenuis* (Nees) J.B. Jack & Steph., *Hedwigia* 31 (1): 12. 1892.

Diagnosis: Lobes narrow, elongate, with acute apices; lobule surface smooth. Apical margin composed of three cells in a single row. Dorsal margin with about five small teeth, each composed of a single cell (Figure 2).

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 9 Nov 2022; N. Ginting 756 (MEDA).

Distribution. Bhutan, China, Japan, Malaysia, Nepal, Papua New Guinea, India, and Indonesia (new record for Sumatra)

*Drepanolejeunea levicornua* Steph., *Sp. Hepat.* (Stephani) 5: 347. 1913.

Diagnosis: Lobes with obtuse apices; dorsal and ventral margins dentate. Lobules ovate, with obtuse apices.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 2 Jul 2022; N. Ginting 60, 80 (MEDA); 9 Nov 2022; N. Ginting 866 (MEDA).

Distribution. China, Indonesia (Borneo, Java, Seram, Sulawesi, Sumatra), Malaysia, and Papua New Guinea.

*Drepanolejeunea pentadactyla* (Mont.) Steph. Stephani, F. 1917. *Sp. Hepat.* (Stephani) 5: 1-1044. Georg & Cie, Geneva. *Drepanolejeunea camboueana* Steph., *Sp. Hepat.* (Stephani) 5: 321. 1913.

Diagnosis: Lobes bearing five long, finger-like marginal teeth, giving the lobe a digitiform appearance. Ocelli confined to the apical portion of the lobe.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 2 Jul 2022; N. Ginting 79 (MEDA); 20 Oct 2022; N. Ginting 613 (MEDA); 9 Nov 2022; N. Ginting 696, 791, 842 (MEDA).

Distribution. India, China, Taiwan, Cambodia, Hawaii, Malaysia, Indonesia (Sumatra, Seram, West Irian), Philippines,

Thailand, Vietnam, Madagascar, New Caledonia, Samoa, Tahiti, and Australia.

*Drepanolejeunea ternatensis* (Gottsche) Schiffn., *Hepat.* (Engl.-Prantl): 126. 1893. *Drepanolejeunea papillosa* S.W. Arnell, *Bot. Not.* 1953: 170. 1953.

Diagnosis: Lobes with acute to acuminate apices. Lobule surface papillose.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 9 Nov 2022; N. Ginting 777 (MEDA); 10 Nov 2022; N. Ginting 1015 (MEDA).

Distribution. Sri Lanka, China, Japan, the Philippines, Malaysia, Indonesia (Sumatra, Java, Maluku), Papua New Guinea, Samoa, and Australia.

*Drepanolejeunea tricornua* Herzog, *Ann. Bryol.* 9: 124. 1937.

Diagnosis: Lobes ovate, with short, rounded marginal teeth. Ocelli scattered throughout the lobe.

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 9 Nov 2022; N. Ginting 856 (MEDA).

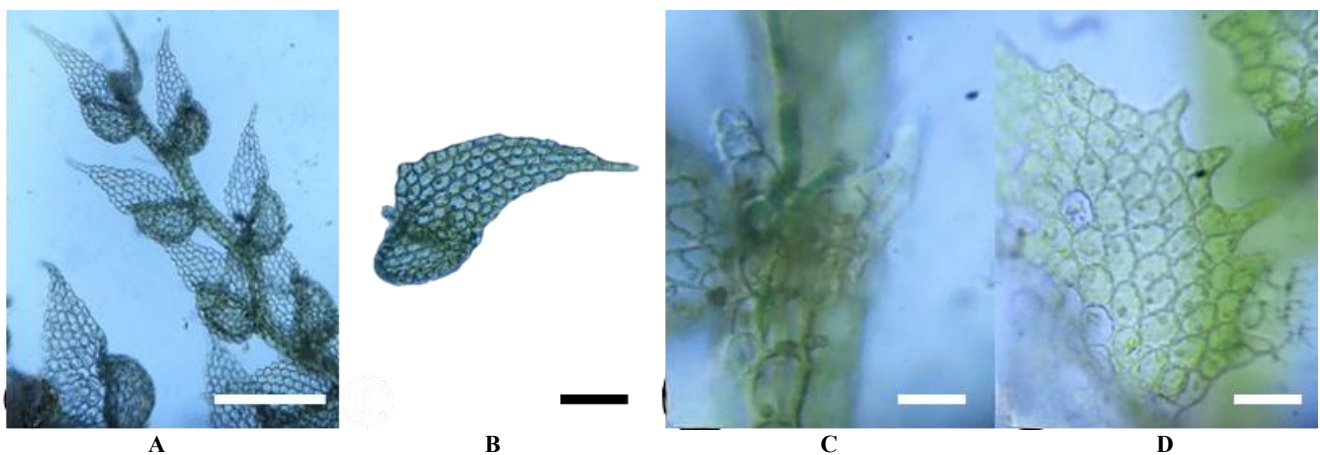
Distribution. Malaysia, Papua New Guinea, and Indonesia (Sumatra).

*Drepanolejeunea thwaitesiana* (Mitt.) Steph. *Sp. Hepat.* (Stephani) 5: 350. 1913. *Ceratolejeunea thwaitesiana* (Mitt.) Steph. *Sp. Hepat.* (Stephani) 5: 445. 1913.

Diagnosis: Lobes asymmetric, fan-shaped, with shortly dentate dorsal and ventral margins. Trigones triangular. Lobules ovate, with acute apices.

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 2 Jul 2022; N. Ginting 107 (MEDA)

Distribution. Cambodia, China, India, Indonesia (Borneo, Java, Seram, Sumatra), Sri Lanka, Thailand, Peninsular Malaysia, and Papua New Guinea.



**Figure 2.** *Drepanolejeunea angustifolia*. A. Branch habit (ventral view), B. Leaf with lobule, C. Underleaf, D. Leaf apex cells. Scale bars: A: 500 µm, B: 100 µm. C-D: 20 µm

*Lejeunea eifrigii* Mizut., J. Hattori Bot. Lab. 33: 244. 1970. *Taxilejeunea acutiloba* Eifrig, Ann. Bryol. 9: 94. 1937.

Diagnosis: Lobes ovate, with acute apices. Lobules inflated. Underleaves nearly orbicular, with bifid and acutely pointed apices.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 20 Oct 2022; N. Ginting 657 (MEDA); 10 Nov 2022; N. Ginting 928 (MEDA).

Distribution. Japan and Indonesia (Java, Sulawesi, Sumatra).

*Lejeunea obscura* Mitt., J. Proc. Linn. Soc., Bot. 5: 112. 1861., *Taxilejeunea obscura* (Mitt.) Eifrig, Ann. Bryol. 9: 93. 1936 [1937].

Diagnosis: Lobes with obtuse apices. Lobules minute, triangular, about  $\frac{1}{5}$ – $\frac{1}{2}$  the size of the lobe. Underleaves rounded, bifid at the apex, with acute divisions.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 2 Jul 2022; N. Ginting 03, 73 (MEDA).

Distribution. Sri Lanka, India, Nepal, China, and Indonesia (Java, Sumatra).

*Lejeunea sordida* (Nees) Mont., Ann. Sci. Nat., Bot., sér. 2, 14: 335. 1840., *Hygrolejeunea amboinensis* Schiffn. ex P. Syd., Just's Bot. Jahresber. 19 (1): 246. 1894.

Diagnosis: Lobes large, 0.5–0.9 mm long and 0.5–0.7 mm wide, with curved dorsal and ventral bases. Lobules small, about  $\frac{1}{4}$  the length of the lobe. Underleaves bifid to  $\frac{1}{4}$ – $\frac{1}{2}$  of their length, with blunt apices.

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 3 Jul 2022; N. Ginting 119 (MEDA).

Distribution. Philippines, Cambodia, Sri Lanka, Malaysia, and Indonesia (Sumatra, Java, Sulawesi).

*Lejeunea tuberculosa* Steph., Sp. Hepat. (Stephani) 5: 790. 1915., *Eulejeunea camerunensis* Steph., Sp. Hepat. (Stephani) 6: 417. 1923., *Eulejeunea microclada* Pearson, Ann. Cryptog. Exot. 4 (2): 66. 1931.

Diagnosis: Lobes small, 0.32–0.45 mm long and 0.2–0.3 mm wide, with rounded apices. Underleaves bifid to ca.  $\frac{1}{2}$  of their length. Lobules with entire, slightly curved margins and two short apical teeth.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 2 Jul 2022; N. Ginting 21 (MEDA); 3 Jul 2022; N. Ginting 111, 122 (MEDA).

Distribution. Africa, India, Nepal, Bhutan, China, the Philippines, and Indonesia (Sumatra, Java).

*Cololejeunea appressa* (A. Evans) Benedix, Feddes Repert. Spec. Nov. Regni Veg. Beih. 134: 31. 1953., *Leptocolea appressa* A. Evans, Bull. Torrey Bot. Club 39: 606. 1912.

Diagnosis: Lateral leaves with a vitta 1 row wide, composed of 3–4 cells arranged in a single row. Lobules short, with a 1-celled, bidentate apex.

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 20 Oct 2022; N. Ginting 1344 (MEDA).

Distribution. Indonesia (Java, Sumatra), Andaman Islands, and Jamaica.

*Cololejeunea denticulata* (Horik.) S. Hatt., Bull. Tokyo Sci. Mus. 11: 99. 1944., *Leptocolea denticulata* (Horik.) P.C. Chen & P.C. Wu, Acta Phytotax. Sin. 9: 262. 1964.

Diagnosis: Lobes obovate, with entire margins and flat bases. Lobules elongate to rounded,  $\frac{1}{2}$ – $\frac{1}{4}$  the length of the lobe, with flat bases, entire margins, rounded apices, and without a vitta.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 10 Nov 2022; N. Ginting 898, 1144 (MEDA).

Distribution. Java (Mount Gede Pangrango), Japan, Taiwan, and Sumatra (Mount Sibuatan, Batang Gadis National Park).

*Cololejeunea falcata* (Horik.) Benedix, Feddes Repert. Spec. Nov. Regni Veg. Beih. 134: 29. 1953., *Cololejeunea falcatooides* Benedix, Feddes Repert. Spec. Nov. Regni Veg. Beih. 134: 30. 1953.

Diagnosis: Lobes ovate, with rounded apices and entire margins, bearing a vitta 3 rows wide, each row consisting of 8–10 cells. Lobules ovate, with bidentate apices.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 20 Oct 2022; N. Ginting 445, 664 (MEDA).

Distribution. Madagascar, Brazil, Sri Lanka, China, Japan, Taiwan, the Philippines, Thailand, Cambodia, Vietnam, Malaysia, Indonesia (Sumatra, Borneo), and New Zealand.

*Cololejeunea surinamensis* Tixier, Bradea 3: 42. 1980.

Diagnosis: Lateral leaves without a vitta. Lobes rounded, with shortly toothed margins. Lobules triangular, very small, almost indistinct to the naked eye (Figure 3).

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 20 Oct 2022; N. Ginting 418 (MEDA).

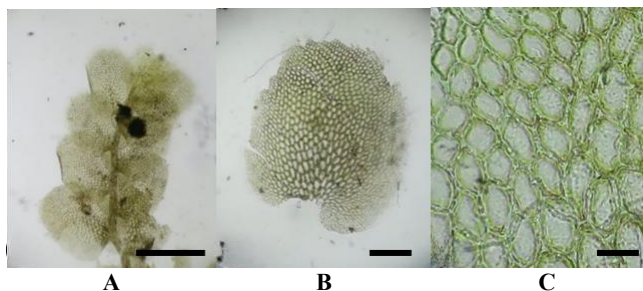
Distribution. Brazil, Suriname, and Indonesia (new record).

*Cheilolejeunea falsinervis* (Sande Lac.) R.M. Schust. & Kachroo, J. Linn. Soc., Bot. 56(368): 509. 1961., *Lejeunea falsinervis* Sande Lac., Ned. Kruidk. Arch. 3(4): 421. 1855.

Diagnosis: Lobes with a distinct vitta extending from the lobe base to the apex, composed of 17–22 elongated cells. Lobes ovate, with acute apices. Lobules ovate, about two-thirds the length of the lobe, bidentate at the apex (Figure 4).

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 20 Oct 2022; N. Ginting 420 (MEDA).

Distribution. Japan, China, Indonesia (Sulawesi, new record for Sumatra), Australia, and South America



**Figure 3.** *Cololejeunea surinamensis*. A. Branch habit (ventral view), B. Leaf, C. Median leaf cells. Scale bars: A = 500 µm, B = 100 µm, C = 20 µm

***Cheilolejeunea ceylanica*** (Gottsche) R.M.Schust. & Kachroo, J. Linn. Soc., Bot. 56(368): 509. 1961., *Lejeunea ceylanica* Gottsche, Syn. Hepat.: 359. 1845.

Diagnosis: Lobes and lobules elongate-ovate. Lobules about  $\frac{2}{3}$  the length of the lobe; lobule margin curved, forming a hooked tooth.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous and epiphyllous; 2 Jul 2022; N. Ginting 107 (MEDA); 10 Nov 2022; N. Ginting 1005, 1095, 1104 (MEDA).

Distribution. China, Japan, Malaysia, and Indonesia (Sulawesi, Sumatra, Java, Lesser Sunda Islands).

***Cheilolejeunea longiloba*** (Steph. ex G. Hoffm.) Kachroo & R.M. Schust. ex J.J. Engel & B.C. Tan, J. Hattori Bot. Lab. 60: 294. 1986. *Pycnolejeunea longiloba* Steph. ex G. Hoffm., Ann. Bryol. 8: 114. 1935.

Diagnosis: Closely resembles *C. ceylanica*. Lobules rectangular-elongate, about  $\frac{2}{3}$  the length of the lobe. Lobule margin straight, forming an upright tooth, and a bidentate apex.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous and epiphyllous; 10 Nov 2022; N. Ginting 1063, s.n., 1204 (MEDA).

Distribution. Sri Lanka, India, China, the Philippines, Thailand, Vietnam, Cambodia, Malaysia, Indonesia (Sumatra, Java, Borneo), Papua New Guinea, and Australia.

***Leptolejeunea epiphylla*** (Mitt.) Steph., Sp. Hepat. (Stephani) 5: 362. 1913., *Lejeunea epiphylla* Mitt., J. Proc. Linn. Soc., Bot. 5: 118. 1861.

Diagnosis: Lobes rectangular-elongate, with scattered ocelli not exceeding 20 cells, usually 6–10 per lobe. Lobules triangular, about  $\frac{1}{6}$ – $\frac{1}{7}$  the length of the lobe.

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 2 Jul 2022; N. Ginting 25 (MEDA).

Distribution. Indonesia (Sumatra), Malaysia, Thailand, and Cambodia.

***Leptolejeunea maculata*** (Mitt.) Schiffn., Consp. Hepat. Arch. Ind.: 275. 1898., *Lejeunea maculata* Mitt., J. Proc. Linn. Soc., Bot. 5: 118. 1861.

Diagnosis: Lobes ovate, with acute apices; dorsal and ventral margins dentate. Trigones rounded. Lobules  $\frac{1}{3}$ – $\frac{1}{2}$  the length of the lobe, with flat bases, entire margins, and apices bearing two short teeth.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 10 Nov 2022; N. Ginting 962, 1022 (MEDA).

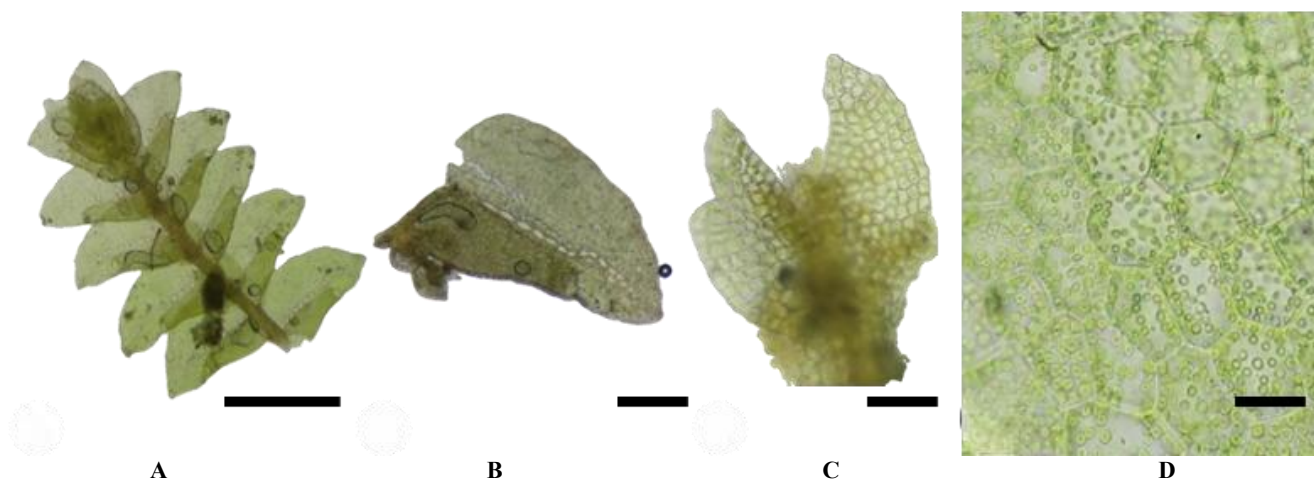
Distribution. Brazil, Madagascar, Malaysia, Singapore, Vietnam, Africa, Papua New Guinea, Indonesia (Sulawesi, Sumatra).

***Colura acroloba*** (Prantl) Jovet-Ast, Rev. Bryol. Lichénol. 22: 297. 1953., *Lejeunea acroloba* Prantl, Hedwigia 29: xiv. 1890.

Diagnosis: Lobes obovate-oblong, with involute apices. Sac tubular, ca.  $\frac{1}{5}$  longer than the lobe.

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 10 Nov 2022; N. Ginting 1217 (MEDA).

Distribution. Australia, Cambodia, China, India, Indonesia (Java, Sumatra), Malaysia, New Caledonia, Papua New Guinea, the Philippines, Samoa, Sri Lanka, Thailand, and Vietnam.



**Figure 4.** *Cheilolejeunea falsinervis*. A. Branch habit (ventral view), B. Leaf, C. Underleaf, D. Median leaf cells with oil bodies. Scale bars: A = 500 µm, B-C = 100 µm., D = 20 µm

*Colura inuii* Horik., J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 1: 68. 1931., *Colura inuii* fo. *integerrima* Horik., Hikobia 1 (2): 80. 1951 [1952].

**Diagnosis:** Lobes obovate. Sac oblong-ovate, ca.  $\frac{1}{2}$  longer than the lobe. Lobules with flat bases, entire margins, and rounded apices (Figure 5).

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 10 Nov 2022; N. Ginting 1048 (MEDA)

Distribution. China, Japan, Malaysia, and Indonesia (new record).

*Lopholejeunea wiltensii* Steph., Hedwigia 35: 112. 1896., *Lopholejeunea serrifolia* Steph., Sp. Hepat. (Stephani) 5: 84. 1912.

**Diagnosis:** Lobules triangular, with curved margins and dentate apices. Underleaves broad, reniform, covering about  $\frac{2}{3}$  of the lobe.

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 10 Nov 2022; N. Ginting 1038 (MEDA).

Distribution. Sri Lanka, Japan, the Philippines, Thailand, Malaysia, Indonesia (Sumatra, Java, Borneo, Sulawesi), Papua New Guinea, and Fiji.

*Lopholejeunea recurvata* Mizut., J. Hattori Bot. Lab. 46: 369. 1979.

**Diagnosis:** Lobes ovate, with rounded and inwardly curved apices. Underleaves orbicular,  $\geq 0.5$  mm long. Leaf bases curved ventrally and dorsally; ventral leaf attachment line curved.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 9 Nov 2022; N. Ginting 684, 839 (MEDA); 10 Nov 2022; N. Ginting 1196 (MEDA).

Distribution. Indonesia (Sumatra, Bali, Java), Malaysia, and Papua New Guinea.

*Lopholejeunea applanata* (Reinw., Blume & Nees) Schiffn., Hepat. (Engl.-Prantl): 129. 1893., *Lejeunea applanata* (Reinw., Blume & Nees) Nees, Syn. Hepat.: 314. 1845., *Jungermannia applanata* Reinw., Blume & Nees, Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 12: 210. 1825.

**Diagnosis:** Lobes elongate, with acute to acuminate apices. Underleaves reniform. Lobules small, ovate, ca.  $\frac{1}{2}$  the length of the lobe, with pointed apices.

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 9 Nov 2022; N. Ginting 795 (MEDA).

Distribution. Indonesia (West Papua, Java, Sumatra, Sulawesi), Malaysia, Papua New Guinea, Samoa, India, Myanmar, the Philippines, and Thailand.

*Lopholejeunea subfusca* (Nees) Schiffn., Bot. Jahrb. Syst. 23: 593. 1897., *Jungermannia subfusca* Nees, Enum. Pl. Crypt. Jav.: 36. 1830.

**Diagnosis:** Lobes ovate, with rounded apices and dorsally curved margins. Underleaves orbicular,  $\leq 0.5$  mm

long. Lobules ovate, flat at the base, with curved margins bearing a single tooth and truncate apices.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 10 Nov 2022; N. Ginting 913, 1062 (MEDA).

Distribution. Pantropical: Sri Lanka, India, Nepal, Bhutan, China, Japan, the Philippines, Thailand, Cambodia, Vietnam, Malaysia, Indonesia (Sumatra, Java, Bali, Sulawesi, Maluku), Singapore, and Papua New Guinea.

*Metalejeunea cucullata* (Reinw., Blume & Nees) Grolle, Bryophyt. Biblioth. 48: 100. 1995., *Eulejeunea cucullata* (Reinw., Blume & Nees) Schiffn., Consp. Hepat. Arch. Ind.: 254. 1898., *Jungermannia cucullata* Reinw., Blume & Nees, Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 12: 227. 1825.

**Diagnosis:** Lobes ovate, nearly parallel to the stem, with rounded apices. Lobules ovate,  $\frac{1}{2}$ – $\frac{1}{4}$  the length of the lobe, with two short apical teeth.

Specimens examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous and epiphyllous; 19 Oct 2022; N. Ginting 350 (MEDA); 20 Oct 2022; N. Ginting 429 (MEDA); 9 Nov 2022; N. Ginting 792 (MEDA); 10 Nov 2022; N. Ginting 962 (MEDA).

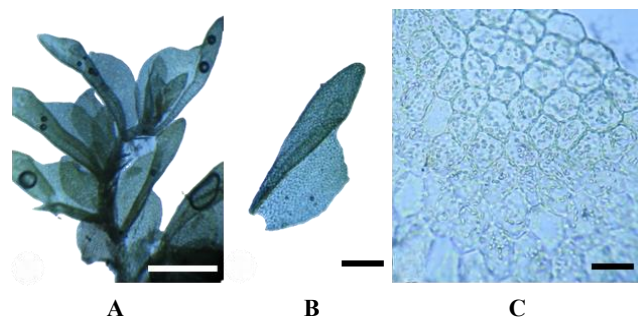
Distribution. Brazil, Hawaii, India, Madagascar, Malaysia, Solomon Islands, Indonesia (Lesser Sunda Islands, Sumatra, Sulawesi), and Laos.

*Diplasiolejeunea rudolphiana* Steph., Hedwigia 35(2): 79. 1896., *Diplasiolejeunea unidentata* (Lehm. & Lindenb.) Schiffn. Bot. Jahrb. Syst. 23: 583. 1897., *Lejeunea unidentata* (Lehm. & Lindenb.) Mont., Hist. Phys. Cuba, Bot., Pl. Cell.: 478. 1842.

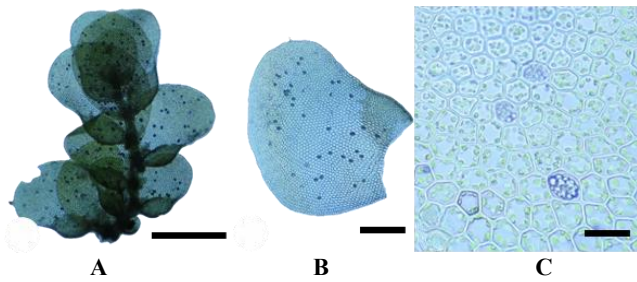
**Diagnosis:** Lobes ovate, with numerous ocelli, typically  $\geq 20$  cells, usually 28–35 per lobe. Lobules ovate,  $\frac{1}{2}$ – $\frac{2}{3}$  the length of the lobe, with entire margins and bidentate apices; first tooth longer, composed of 5–6 cells, second tooth shorter and delicate (Figure 6).

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; epiphyllous; 9 Nov 2022; N. Ginting 859 (MEDA).

Distribution. Peru, Brazil, Mauritius, Madagascar, Cambodia, Vietnam, Sri Lanka, Hainan, and Indonesia (new record).



**Figure 5.** *Colura inuii*. A. Branch habit (ventral view), B. Leaf, C. Median leaf cells. Scale bars: A: 500  $\mu$ m, B: 100  $\mu$ m, C: 10  $\mu$ m



**Figure 6.** *Diplasiolejeunea rudolphiana*. A. Branch habit (ventral view), B. Leaf, C. Median leaf cells. Scale bars: A: 500  $\mu\text{m}$ , B: 100  $\mu\text{m}$ , C: 10  $\mu\text{m}$

*Caudalejeunea recurvistipula* (Gottsche) Schiffn., Hepat. (Engl.-Prantl): 129. 1893. *Caudalejeunea circinata* Steph., Sp. Hepat. (Stephani) 5: 13. 1912. *Caudalejeunea lessonii* Steph., Hedwigia 34: 233. 1895.

Diagnosis: Lobes oblong, with irregularly dentate margins and curved dorsal bases. Underleaves reniform, with a curved line of attachment.

Specimen examined. Indonesia: North Sumatra: Sopotinjak, Batang Gadis National Park; corticolous; 10 Nov 2022; N. Ginting 1136 (MEDA).

Distribution. Taiwan, Vietnam, and Indonesia (Sumatra, Papua).

## Discussion

The present study constitutes the first taxonomic treatment of Lejeuneaceae from Sopotinjak, BGNP, North Sumatra. The dichotomous key strengthens the taxonomic value of this study by providing a practical tool for identifying all Lejeuneaceae species listed in Table 1. Its inclusion is useful for future bryological surveys in BGNP and contributes to regional bryophyte taxonomy by supporting consistent species-level identification. In total, five species were identified as new distributional records: three species new to Indonesia, i.e., *C. surinamensis*, *C. inuii*, and *D. rudolphiana*, and two species new to Sumatra, i.e., *D. angustifolia* and *C. falsinervis*. The illustrated new records shown in Figures 2-6 provide morphological support for the taxonomic findings of this study. Their diagnostic characters, including leaf-lobe shape, lobule structure, underleaf morphology, and reproductive features, when present, are important for confirming species identity and distinguishing them from morphologically similar taxa. The discovery of these taxa is not unexpected given the ecological amplitude of Lejeuneaceae. Members of this family are oligophytic and able to colonize a variety of substrates, including tree trunks, branches, lianas, living and fallen leaves, decaying wood, and sometimes soil surfaces (He and Zhu 2011). They occur particularly frequently on bark and leaves (Sukkharak and Gradstein 2017), and Lejeuneaceae account for most epiphyllous liverworts. Bryophyte richness and composition may vary along elevational gradients because changes in altitude influence humidity, temperature, and light conditions (Gradstein 1991; Gradstein and Culmsee 2010). Regional records from Indonesia provide baseline information for interpreting local species distributions (Ariyanti et al. 2008), while Coelho et al. (2021) further support the role of

habitat and environmental variation in shaping bryophyte communities. In the present study, the occurrence of Lejeuneaceae across the surveyed elevational range may reflect the humid and shaded conditions of montane forest habitats. Nearly half of the recorded species in BGNP are epiphyllous, including *Colura*, *Cololejeunea*, *Leptolejeunea*, and *Diplasiolejeunea*. The dominance of these taxa reflects the consistently humid and shaded microclimatic conditions of the montane forest canopy, where stable moisture and reduced light intensity favor colonization on living leaves. Because the sampling was non-quantitative and the environmental variables were not statistically analyzed, these patterns are best interpreted as descriptive rather than as evidence of elevational or microclimatic effects. Epiphyllous liverworts play a critical role in canopy ecosystems by contributing to microhabitat complexity and nutrient cycling (Zhu and So 2001). The discovery of *C. surinamensis*, *C. inuii*, *D. rudolphiana*, *D. angustifolia*, and *C. falsinervis* as new records for Sumatra expands the known distribution of these taxa in western Malesia. Of these, *C. surinamensis*, *C. inuii*, and *D. rudolphiana* are also newly recorded for Indonesia. The species, *C. surinamensis*, a species originally described from South America, has been reported sporadically across tropical regions, suggesting a pantropical distribution pattern with possible Neotropical-Paleotropical dispersal links (Pócs et al. 2014). Such transoceanic affinities highlighted the complex dispersal history of *Lejeuneaceae*, facilitated by lightweight spores and the humid equatorial wind currents. Similarly, *C. falsinervis* and *C. inuii*, previously known from Sulawesi and Japan, respectively, confirmed floristic connections between western Malesia and the broader Indo-Pacific region (Mizutani 1982a, 1982b). Despite extensive field effort, the study was limited to a single resort area (Sopotinjak) and one sampling season (July–November). Seasonal variation may influence the detectability of epiphyllous taxa, particularly during drier periods. Future surveys should expand to additional sectors of BGNP and employ standardized quantitative approaches (e.g., plot-based frequency sampling) to assess species abundance and community structure better.

In conclusions, this study documents 31 species of Lejeuneaceae belonging to 12 genera and two subfamilies from Sopotinjak, BGNP, North Sumatra. Five species represent new distributional records, including three new to Indonesia (*C. surinamensis*, *C. inuii*, and *D. rudolphiana*) and two new to Sumatra (*D. angustifolia* and *C. falsinervis*). The assemblage is dominated by epiphyllous taxa, reflecting the humid and shaded conditions of montane forest habitats. These findings confirm BGNP as an important reservoir of Lejeuneaceae diversity in western Malesia and contribute to the expansion of regional bryophyte distribution data. However, this study is limited by its non-quantitative design, restricted spatial coverage (single sector), and sampling within a single period, which may underestimate total species richness and limit ecological inference. Environmental variables recorded were not analyzed statistically, further constraining the interpretation of habitat relationships. Further research could also examine microhabitat-specific richness, such as bryophyte

associations with particular phorophyte tree species and canopy versus understory strata. In addition, incorporating molecular phylogenetic data would help clarify generic boundaries that remain under revision within Lejeuneaceae.

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## Supplementary

**Table S1.** Lejeuneaceae species recorded in the study area

Species	Habitat	Sample code	Collection site	Collection date	Coordinate sample	Altitude (masl)	Location
<i>Drepanolejeunea levicornua</i> Steph.	Leaves	NG 866	Titik 14	09 November 2022	0°42'58"N, 99°31'0"E	1487	T
	Leaves	NG 80	Titik 03	02 July 2022	0°42'37"N, 99°31'19"E	1278	RA
	Leaves	NG 60	Titik 02	02 July 2022	0°42'37"N, 99°31'18"E	1299	RA
<i>Cololejeunea appressa</i> (A.Evans) Benedix	Leaves	NG 612	Titik 08	20 October 2022	0°42'27.47"N, 99°31'41.63"E	1344	DK
<i>Cheilolejeunea longiloba</i> (Steph. ex G. Hoffm.) Kachroo & R.M. Schust. ex J.J. Engel & B.C. Tan	Leaves	NG 1063	Titik 09	10 November 2022	0°42'24"N, 99°31'6"E	1312	D
	Leaves	NG 1205	Titik 01	10 November 2022	0°42'33"N, 99°31'0"E	1286	D
	Tree bark	NG 1204	Tower	10 November 2022	0°42'55"N, 99°31'19"E	1390	D
<i>Lopholejeunea wiltensii</i> Steph.	Decaying wood	NG 1038	Titik 08	10 November 2022	0°42'22"N, 99°31'8"E	1279	D
<i>Drepanolejeunea tricornua</i> Herzog	Leaves	NG 856	Titik 13	09 November 2022	0°42'58"N, 99°31'15"E	1491	T
<i>Lopholejeunea recurvata</i> Mizut.	Tree bark	NG 839	Titik 11	09 November 2022	0°42'59"N, 99°31'11"E	1520	T
	Decaying wood	NG 684	Titik 6	09 November 2022	0°42'59"N, 99°31'7"E	1521	T
	Decaying wood	NG 1196	Tower	10 November 2022	0°42'55"N, 99°31'19"E	1390	D
<i>Ptychanthus striatus</i> (Lehm. & Lindenb.) Nees	Decaying wood	NG 795	Titik 7	09 November 2022	0°42'59"N, 99°31'7"E	1525	T
	Tree bark	NG 455	Titik 3	20 October 2022	0°42'21.17"N, 99°31'42.71"E	1379	DK
	Tree bark	NG 429	Titik 1	20 October 2022	0°42'23.80"N, 99°31'42.35"E	1337	DK
<i>Metalejeunea cucullata</i> (Reinw., Blume & Nees) Grolle	Leaves	NG 350	Titik 19	19 October 2022	0°42'56.77"N, 99°31'17.36"E	1476	T
	Leaves	NG 792	Titik 7	09 November 2022	0°42'30"N, 99°30'54"E	1525	T
	Leaves	NG 962	Titik 3	10 November 2022	0°42'15"N, 99°31'9"E	1361	D
	Tree bark	NG 03	Titik 01	02 July 2022	0°42'41"N, 99°31'19"E	1282	RA
	Tree bark	NG 73	Titik 02	02 July 2022	0°42'39"N, 99°31'18"E	1299	RA
	Decaying wood	NG 1104	Titik 12	10 November 2022	0°42'27"N, 99°31'14"E	1307	D
<i>Cheilolejeunea ceylanica</i> (Gottsche) R.M.Schust. & Kachroo	Leaves	NG 1095	Titik 11	10 November 2022	0°42'33"N, 99°31'0"E	1291	D
	Tree bark	NG 1005	Titik 5	10 November 2022	0°42'24"N, 99°31'6"E	1351	D
	Leaves	NG 107	Titik 6	02 July 2022	0°42'39"N, 99°31'18"E	1257	RA
<i>Caudalejeunea recurvistipula</i> (Gottsche) Schiffn.	Leaves	NG 1136	Titik 14	10 November 2022	0°42'57"N, 99°31'15"E	1295	D
<i>Drepanolejeunea angustifolia</i> (Mitt.) Grolle	Leaves	NG 756	Titik 5	09 November 2022	0°42'16"N, 99°31'7"E	1531	T
<i>Colura acroloba</i> (Prantl) Jovet-Ast	Leaves	NG 1217	Tower	10 November 2022	0°42'55"N, 99°31'19"E	1390	D
<i>Leptolejeunea epiphylla</i> (Mitt.) Steph.	Leaves	NG 25	Titik 1	02 July 2022	0°42'41"N, 99°31'19"E	1282	RA
<i>Diplasiolejeunea rudolphiana</i> Steph.	Leaves	NG 859	Titik 13	09 November 2022	0°42'55"N, 99°31'19"E	1491	T
<i>Drepanolejeunea ternatensis</i> (Gottsche) Schiffn.	Leaves	NG 1015	Titik 6	10 November 2022	0°42'59"N, 99°31'7"E	1290	D
	Leaves	NG 777	Titik 6	09 November 2022	0°42'59"N, 99°31'7"E	1526	T
<i>Lejeunea tuberculosa</i> Steph.	Tree bark	NG 122	Titik 2	3 July 2022	0°42'28"N, 99°30'43"E	1205	RA
	Leaves	NG 111	Titik 1	3 July 2022	0°42'27"N, 99°30'43"E	1221	RA
	Tree bark	NG 21	Titik 1	2 July 2022	0°42'41"N, 99°31'19"E	1282	RA
	Leaves	NG 664	Titik 10	20 October 2022	0°42'27.32"N, 99°31'42.92"E	1329	DK
<i>Cololejeunea falcata</i> (Horik.) Benedix	Leaves	NG 445	Titik 2	20 October 2022	0°42'24.37"N, 99°31'41.56"E	1364	DK
<i>Thysananthus spathulistipus</i> (Reinw., Blume & Nees) Lindenb.	Tree bark	NG 1136	Titik 14	10 November 2022	0°42'32"N, 99°31'12"E	1295	D
	Tree bark	NG 1025	Titik 6	10 November 2022	0°42'59"N, 99°31'7"E	1290	D

	Tree bark	NG 1013	Titik 6	10 November 2022	0°42'59"N, 99°31'7"E	1290	D
	Tree bark	NG 1002	Titik 5	10 November 2022	0°42'16"N, 99°31'7"E	1351	D
	Tree bark	NG 993	Titik 5	10 November 2022	0°42'16"N, 99°31'7"E	1351	D
<i>Thysananthus retusus</i> (Reinw., Blume & Nees) B.M.Thiers & Gradst.	Tree bark	NG 986	Titik 4	10 November 2022	0°42'15"N, 99°31'8"E	1308	D
	Tree bark	NG 973	Titik 4	10 November 2022	0°42'15"N, 99°31'8"E	1308	D
	Tree bark	NG 851	Titik 12	09 November 2022	0°42'30"N, 99°30'54"E	1511	T
	Tree bark	NG 1136	Titik 14	10 November 2022	0°42'32"N, 99°31'12"E	1295	D
	Tree bark	NG 87	Titik 4	02 July 2022	0°42'36"N, 99°31'20"E	1288	RA
<i>Lopholejeunea applanata</i> (Reinw., Blume & Nees) Schiffn.	Decaying wood	NG 795	Titik 7	09 November 2022	0°42'59"N, 99°31'7"E	1525	T
<i>Drepanolejeunea pentadactyla</i> (Mont.) Steph.	Leaves	NG 79	Titik 3	2 July 2022	0°42'37"N, 99°31'19"E	1278	RA
	Leaves	NG 613	Titik 8	20 October 2022	0°42'27.47"N, 99°31'41.63"E	1344	DK
	Leaves	NG 696	Titik 1	09 November 2022	0°42'58"N, 99°31'14"E	1375	T
	Leaves	NG 791	Titik 7	09 November 2022	0°42'59"N, 99°31'7"E	1525	T
	Leaves	NG 842	Titik 11	09 November 2022	0°42'59"N, 99°31'11"E	1520	T
<i>Leptolejeunea maculata</i> (Mitt.) Schiffn.	Tree bark	Ng 1022	Titik 5	10 November 2022	0°42'16"N, 99°31'7"E	1351	D
	Leaves	NG 962	Titik 3	10 November 2022	0°42'15"N, 99°31'9"E	1361	D
<i>Lejeunea eifrigii</i> Mizut.	Tree bark	NG 928	Titik 2	10 November 2022	0°42'12"N, 99°31'9"E	1299	D
	Decaying wood	NG 657	Titik 10	20 October 2022	0°42'27.32"N, 99°31'42.92"E	1329	DK
<i>Lopholejeunea subfusca</i> (Nees) Schiffn.	Tree bark	NG 1062	Titik 9	10 November 2022	0°42'24"N, 99°31'6"E	1312	D
	Tree bark	NG 913	Titik 1	10 November 2022	0°42'33"N, 99°31'0"E	1286	D
<i>Cololejeunea denticulata</i> (Horik.) S.Hatt.	Leaves	NG 1144	Titik 15	10 November 2022	0°42'34"N, 99°31'13"E	1280	D
	Leaves	NG 898	Titik 1	10 November 2022	0°42'33"N, 99°31'0"E	1286	D
<i>Drepanolejeunea thwaitesiana</i> (Mitt.) Steph.	Leaves	NG 107	Titik 6	02 July 2022	0°42'48"N, 99°31'36"E	1257	RA
<i>Lejeunea sordida</i> (Nees) Mont.	Decaying wood	NG 119	Titik 2	03 July 2022	0°42'28"N, 99°30'43"E	1205	RA
<i>Cheilolejeunea falsinervis</i> (Sande Lac.) R.M. Schust. & Kachroo	Tree bark	NG 420	Titik 1	20 October 2022	0°42'23.80"N, 99°31'42.35"E	1337	DK
<i>Colura inuii</i> Horik.	Leaves	NG 1048	Titik 8	10 November 2022	0°42'22"N, 99°31'8"E	1279	D
<i>Cololejeunea surinamensis</i> Tixier	Leaves	NG 418	Titik 1	20 October 2022	0°42'23.80"N, 99°31'42.35"E	1337	DK

Note: D, T, DK, and RA indicate survey-site codes for Danau Kiri, Tower, Danau Kanan, and Rest Area, respectively. Masl: Meter above sea level