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Diversity and distribution of liverworts in Mount Sibuatan, North Sumatra, Indonesia

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Abstract. *Susilo F, Pasaribu N, Syamsuardi, Siregar ES. 2022. Diversity and distribution of liverworts in Mount Sibuatan, North Sumatra, Indonesia. Biodiversitas 23: 4539-4548.* Due to a lack of research and publication, information about the presence of liverworts in North Sumatra and the island of Sumatra is still lacking. Therefore, Sumatran liverworts, especially in North Sumatra, are less well known than those in Java and other areas of Malesia. This research was conducted at Mount Sibuatan, North Sumatra, to analyze the diversity and distribution of liverwort species in this area. A survey along the hiking trail from an altitude of 1500 m to 2500 m was used as the collection method. Sampling was conducted at 60 points on the hiking trail, 100 meters from each end. Eighty-three species of liverworts were recorded from Mount Sibuatan, belonging to 23 genera and eight families. Two species were new records for Sumatra, namely *Drepanolejeunea pentadactyla* and *Radula verrucosa*. The largest family was Lejeuneaceae (12 genera and 26 species), contributing to 31% of the total species. Another dominant species from the collection was Bazzania tridens, with 121 individuals. Mount Sibuatan Liverworts were found on various substrates, and most of them grew on trunks or branches of trees, the ground, rotting logs, and living leaves. The liverworts were distributed from altitudes of 1531 to 2454 m. Twenty-eight species were identified in various elevations, from lower to upper montane forests. Furthermore, fifty-four species were confined to the lower montane forest (1200-2100 m), and one was restricted to the upper montane forest (2100-3000 m). The findings revealed that the montane forest of Mount Sibuatan is teeming with hitherto unknown liverworts.

Keywords: Diversity, geographical distribution, Lejeuneaceae, Mount Sibuatan, new records

INTRODUCTION

The tropical rainforest of Indonesia is known for its diverse plants, including bryophytes. Bryophytes (hornworts, liverworts, mosses) are the earliest terrestrial plants in the plant kingdom that dominate the moist tropical and subtropical forest region (Jiang et al. 2018). However, they appear to have been disregarded in many ecological studies, such as in the community ecology, focusing mainly on vascular or woody plants. These disciplines seek to understand the importance of ecological processes and biotic diversity in sustaining ecosystem function (Loreau and Mazancourt 2013; Ruiz-Benito et al. 2014).

Bryophytes are a vital component of tropical ecosystems, occupying many habitats from the lowlands to the mountains. They are a critical component of forest ecosystems that serves as a moisture retention system. Lichens can also act as substrates for epiphytic species' habitats and provide refuge for some tiny animals (Scheffers et al. 2014; Piznak and Backor 2019). Bryophytes are pioneer plants on bare soil that can withstand torrential rain and prevent erosion. They are also valuable as bioindicators (Oishi and Hiura 2017), pharmaceutical sources (Asakawa and Ludwiczuk 2018), and pesticides (Alves et al. 2020).

Due to their modest size and identification difficulties, bryophytes have received limited attention from Indonesian botanists. As a result, its study and information in Indonesia are still limited compared to other Southeast Asian nations, where foreign researchers primarily investigate. The availability of this data varies from area to region, but the research and records are more extensive in Java than in other places. Ho et al. (2006) published a list of Sumatran true mosses with 490 species, but this paper has no liverwort data. Van Hasselt and Boerlage (1884) published the first paper on Sumatran liverworts. Based on the Indomalaya expedition in April-September 1930, Verdoorn reported the first record of Sumatran liverworts. This publication contains several key species, including those of the Families Frullaniaceae, Lejeuneaceae, and some genera in liverworts. Later, Herzog (1942) described 72 species of liverworts collected in Padang, West Sumatra, after several years of no liverwort study in Sumatra.

The study of liverworts continued in the 1970s. Some Sumatran specimens, including those from West Sumatra and Jambi, were included during the exploration, but none from the North Sumatra region. The latest reports on North Sumatran liverworts was published by Schafer-Verwimp (2006) on Mount Sinabung, with a total of 8 known species and one new species, and subsequently by Siregar et al. (2013; 2014; 2017; 2020), Siregar (2015), Susilo (2019), and Damanik (2022) with about 278 known species and 44

new species for Sumatra. Exploration has not been completed to collect North Sumatran liverwort specimens and floristic studies on North Sumatran liverworts because there are still few mosses experts in North Sumatra, and mosses have not become an exciting research topic in the field of biology, especially in North Sumatra. To add information on liverwort distribution along the altitude, we conducted this study on Mount Sibuatan (syn. *Dolok*/ *Deleng Sibuaten*), located between Karo and Dairi Regency, the highest mountain region in North Sumatra (2,457 m). The montane forest may harbor a variety of floristic diversity, including bryophytes. Susilo et al. (2019) conducted a preliminary exploration of Mount Sibuatan and documented 15 species in *Bazzania* (Lepidoziaceae).

MATERIALS AND METHODS

Study area

This study was conducted from May 2019 to February 2020 in the Mount Sibuatan forest area, North Sumatra, Indonesia. Administratively, the Mount Sibuatan was located in Karo Regency, North Sumatra Province (2º54'32"-2º55'12" N, 98º25'30"-98º28'12" E). The montane forest is 3 hr from Medan City (±105 km), with altitudes from 1500 to 2500 m. The average rainfall in Mount Sibuatan is 2000-2500 mm per year and is regarded as a type B climate according to the classification of Schmidt and Ferguson (1951). High rainfall occurs between September and December, which causes a temperature to range from 13-25°C with an average humidity of 90%, as depicted in Figure 1.

Data collection, specimen processing, and species identification

Specimens were collected during survey explorations, which entailed exploring the hiking route and determining the sampling point on the trail, 100 meters apart, indicated in Figure 2, with a total of 60 sampling points. All liverwort samples from different substrates were photographed and labeled with a collection number, date, and the collector's name. Typically, the specimens are placed in envelopes, and a standard envelope can be folded from an A4 paper to be (10-)12 x 14 cm in size. Small specimens, in particular, should be wrapped separately in mini-packets before being placed in the standard-size packets. To collect epiphyllous bryophytes, whole leaves with epiphylls were placed in new papers in a plant press, lightly squeezed, and dried. Subsequently, the epiphyllous species were sorted, and leaves were chopped up in the laboratory using a dissecting microscope. During thalloid liverworts collection, it may also be recommended to dry the specimens in a plant press instead of collecting bags to keep them flat and avoid them from rolling inwards. The information record is similar to that of other plants and includes habitat information; for example, once a species occurs on a tree or rock, the type should be recorded; nature of the surrounding vegetation, elevation, and locality details, including GPS coordinates (Gradstein et al. 2001). To avoid fungal damage, the collected specimens should be dried as soon as possible. In most cases, the packets can be left to air-dry. During extended expeditions in wet periods, drying might become a significant issue and preoccupation, and using a plant dryer can sometimes become necessary (Frahm and Gradstein 1986).

Subsequently, the collected specimens were identified based on the observed morphological characters using a binocular microscope at 40x to 400x magnification. In addition, identification was performed by comparing the samples in the MEDA herbarium with liverworts from the collection and using a species description from various available literature, especially Gradstein et al. (2005), Gradstein et al. (2011), Gradstein (2021), and other monographs on Malesia and Asia. Determination of the scientific name of liverworts was adjusted and examined from various published literature and based on the Tropicos website: https://www.tropicos.org/home. All newly acquired specimens were deposited at Herbarium Medanense (MEDA), Departement of Biology Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan, Indonesia.

Altitudinal distribution of liverworts using image processing

The presentation of the distribution of liverwort species and families on the map was constructed by setting all geographical coordinates of the documented species in the field recorded using a Garmin 64s GPS (Global Positioning System) device. Additionally, the baseline map of North Sumatra and Karo Regency (*Peta Rupabumi Indonesia*/ RBI) was retrieved from the Geospatial Information Agency (https://portal.ina-sdi.or.id/downloadaoi/). The coordinate data were overlaid onto a map using Quantum GIS (QGIS) 3.12 Bucuresti Avril (QGIS.org 2022) to generate a map of the distribution of liverwort species and families.

RESULTS AND DISCUSSION

Diversity of liverworts in Mount Sibuatan

The study identified 83 species of liverworts consisting of 23 genera and eight families. Table 1 shows that Sumatra has two species records. The most prominent family found was Lejeuneaceae (26 species, 12 genera), followed by Lepidoziaceae (19 species, two genera), and Plagiochillaceae (18 species, three genera). Meanwhile, the other family had a small number of species, namely Radulaceae (nine species, one genus), followed by Frullaniaceae (four species, one genus), Lophocoleaceae (three species, one genus), and Marchantiaceae (three species, two genera). The family with the smallest number of species with only one genus and one species was Schistochilaceae.

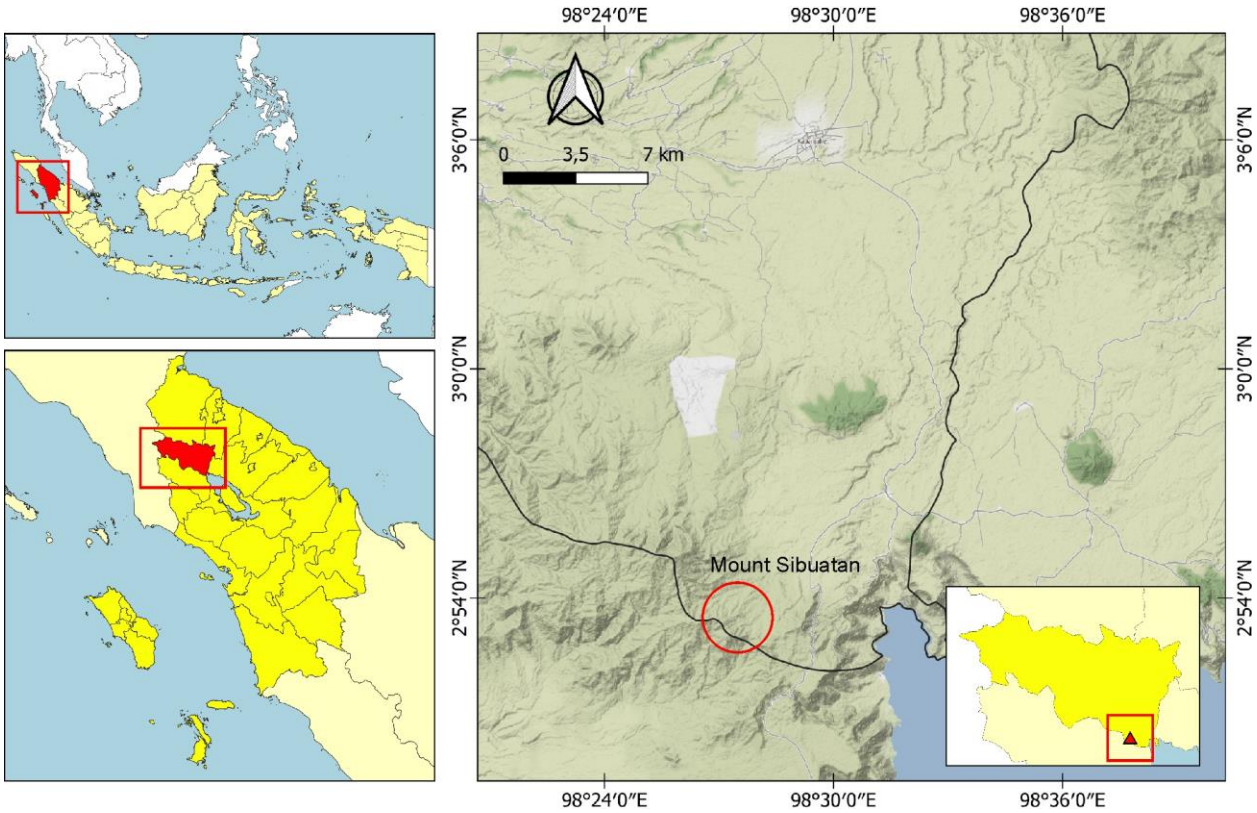

Figure 1. Map location of the study area (shown in green dots) of Mount Sibuatan, North Sumatra, Indonesia

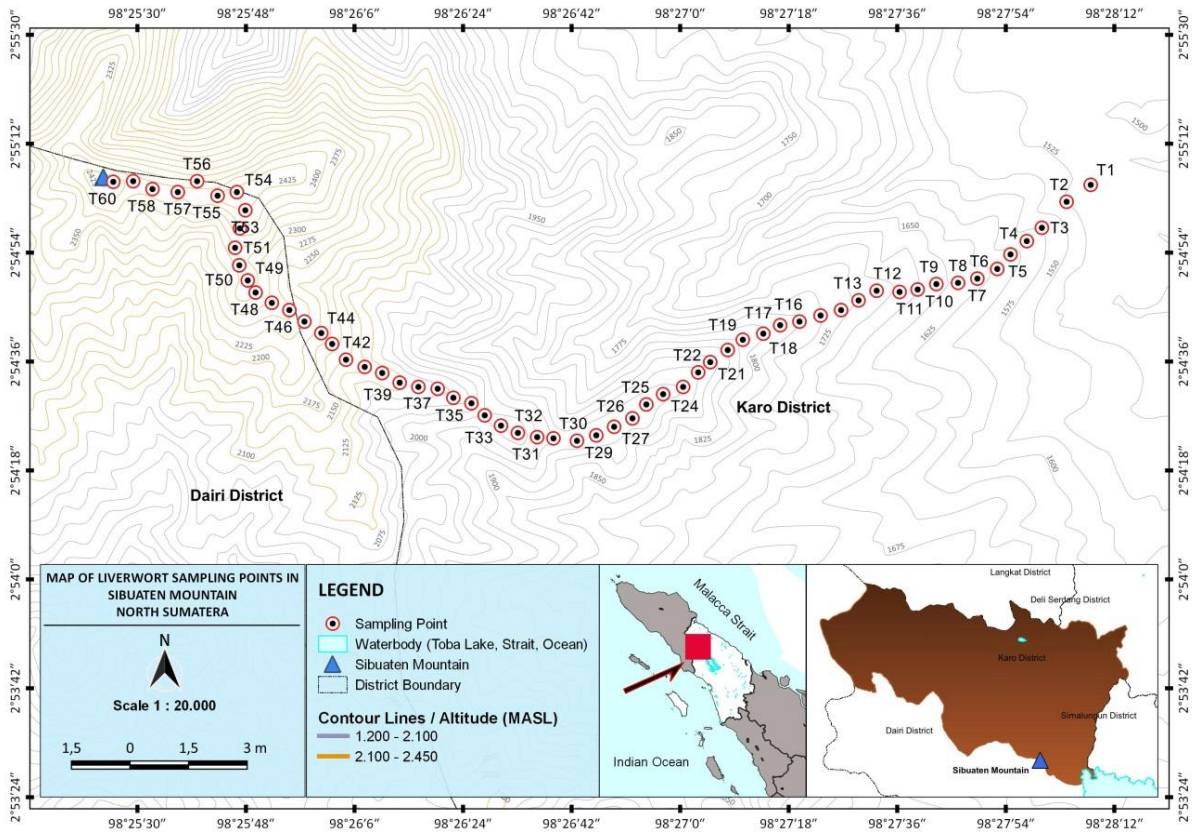

Figure 2. Map of liverwort sampling points on Mount Sibuatan, North Sumatra, Indonesia

Table 1. Number of family, genera, species, and new records of liverworts in Mount Sibuatan

Family	Num. of genera	Num. of species	Num. of new record and species
Frullaniaceae	1	4	-
Lejeuneaceae	12	26	1
Lepidoziaceae	2	19	-
Lophocoleaceae	1	3	-
Marchantiaceae	2	3	-
Plagiochillaceae	3	18	-
Radulaceae	1	9	1
Schistochilaceae	1	1	-
Total	23	83	2

Lejeuneaceae was found to be the most diverse family in Mount Sibuatan, and this finding was similar to that of other studies on montane and highland forest regions, including tropical America (Gradstein 2020), Sabah and Peninsular Malaysia (Sarimi et al. 2021), and Latin America (da Costa et al. 2015). It comprises the largest liverwort family, with about 1700 species belonging to 81 genera (He and Zhu 2011). Members of Lejeuneaceae exist on a variety of substrates (oligophotic) such as tree trunks, twigs, living plants (lianas), living leaves or leaf litter, rotting wood, and soil surfaces (Campos et al. 2019). The preferred habitats of this family also existed in Mount Sibuatan, which supports the presence of the Lejeuneaceae family in the area. In addition, two species are new records to Sumatra, i.e., are *Drepanolejeunea pentadactyla* (Lejeuneaceae) and *Radula verrucosa* (Radulaceae).

Altitudinal and geographical distribution of liverworts in Mount Sibuatan

The liverwort species in Mount Sibuatan are distributed based on altitudes and geographical areas. Liverworts occur at various heights, from lower mountain forests at altitudes of 1200-2100 m to upper mountain forests at altitudes of 2100-3000 m. According to the geographic distribution of bryophytes based on Hyvonen (1989), the liverworts in Mount Sibuatan are classified into ten distribution groups, as summarized in Table 2. It includes cosmopolitan or widely distributed; pantropical or all tropical; paleotropical covering tropical regions, except America; Asia-Oceanian; Asia-Oceania-Australia; Asia-Australia; Southeast Asia encompassing Asia 2 to Asia 4; Malesian corresponds to Asia 4; endemic or only found in Sumatra; miscellaneous or not included in any of the geographical areas as mentioned above. Asia 2 group consists of China, Japan, and Korea; Asia comprises of Bangladesh, Bhutan, Burma, Cambodia, India, Laos, Nepal, Pakistan, Sikkim, Thailand, and Vietnam. Meanwhile, Asia 4 consists of Indonesia, Malaysia, Singapore, Brunei, Sabah, Papua New Guinea, and the Philippines.

In general, the liverworts in Mount Sibuatan were predominantly distributed at altitudes of 1200-2100 m with 54 species, while only a small portion occurred at altitudes of 2100-3000 m with one species. Meanwhile, the most geographical distribution type was the Malesian type with 23 species (27.71%), followed by the Southeast Asia type with 22 species (26.50%), Asian Oceanic and Pantropical type with 9 species (10.84%). This result is similar to that of Siregar's study (2015) on Mount Sibayak, North Sumatra, with the most Southeast Asian distribution type (34.16%), followed by Malesian type (18.63%), and Asian Oceanic type (15.53%).

The distribution of liverworts on Mount Sibuatan varied greatly depending on altitude, ranging from 1531 m to 2454 m. Two or more families of liverworts occupied each elevation (area), and one family dominated each area. The purpose of the local elevation grouping of the outpost to shelter V at the research site was to identify the dominant families and species at a given altitude. According to Table 3, the area with the most liverworts was the area I with six families, followed by areas II and III, which had up to five families, and areas IV and V, which had up to three families. Compared to other families, the occurrence of Lophocoleaceae (*Schistochilacea*) and Frullaniaceae was quite limited, with only records at altitudes of 1531-2083 m. Some studies reports suggest that these two families are present in lowland forests, including lower montane forests between altitudes of 300 m and 1200 m (Lu and Huang 2017). According to the neutral theory, bryophytes reproduce by spore dispersal, and dispersion restriction is one of the primary factors controlling the geographical pattern of bryophyte distribution (Chen et al. 2016; Hidalgo et al. 2017).

At each altitude, members of Lejeuneaceae were dominant, as demonstrated by the presence of varying species. The results revealed that the diversity of liverworts was greatest at 1531-1715 m (area I) based on the six families with a total of 50 species. However, at 1900-2083 m (area III), there were only four documented families, but with a higher number of species, i.e.,52, because species from the Lejeuneaceae and Lepidoziaceae were frequently found in area III, where climatic variables of environmental temperature 17-24^{o}c and humidity 92-96% are particularly favorable for the species' survival. Also, the number of families and species in areas IV and V has dropped, indicating that the variety of species has diminished because the higher the area, the more significant the ecological pressure on moss species to grow and flourish.

Table 3 demonstrates that the four predominant families on Mount Sibuatan at each height were the Lejeuneaceae, Lepidoziaceae, Plagiochillaceae, and Radulaceae, except for Radulaceae, which was not found at 2084-2268 m; all families were evenly distributed at each altitude. This exception is most likely due to the numerous open fields at that altitude altering environmental conditions for species in this family to exist. Figure 3 depicts the distribution of the four major families. In addition, Table 4 presents the complete species checklist of liverworts in Mount Sibuatan and the ecological distribution.

The family with the highest number of species was Lejeuneacea, with 26 species distributed evenly at altitudes of 1531-2325 m and 2300-2425 m, indicating that this family was evenly distributed in regions with a small altitude variation. Similarly, the Lepidoziaceae spread at altitudes of 1550-1575 m, 1800-2150 m, and 2325 m, while Plagiochillaceae spread at altitudes of 1531-1925 m and

2050-2325 m. According to the data, the three families above had a total altitude range of 1531-2300 m, with only a minor portion beyond 2300 m. This phenomenon has been observed elsewhere in the tropics and may explain the decline in species and individual numbers as altitude increases (Gradstein 2017; Gradstein and Yanez 2020). Unlike others, Radulaceae spread unevenly at altitudes of 1530-1575 m, 1625-1725 m, 1875-1925 m, and 2425 m.

The species of the families Lejeuneaceae, Lepidoziaceae, and Plagiochillaceae were evenly distributed at each altitude, as shown in Figures 4.A, 4.B, and 4.C, because epiphytes of these species can live on a variety of substrates, including tree trunks, twigs, roots, dead wood, soil surface, leaves, and leaf litter. However, in the Radulaceae family, only epiphytes were found on tree trunks, so their distribution was uneven at each height. The map shows that the distribution of Radulaceae was limited to a few altitudes. They were not found at altitudes of 1850-2375 m because they were only found in tree trunks. Some heights on Mount Sibuatan only have a few trees compared to others.

New records of liverwort species for Sumatra in Mount Sibuatan

Drepanolejeunea pentadactyla (Mont.) Steph. Sp. Hepat. 5:357 1913. *Lejeunea pentadactyla* Mont. Ann. Sci. Nat., Bot., sér. 3, 10: 113.

The plants are dark green to brown on the specimen, with a width of 0.28-0.50 mm. They are irregular branched, with ventral mesophytes of 3 cell lines. Lateral leaf arrangement is distant, flat attachment and lobes are oval, with a length of 0.17-0.30 mm, a width of 0.11-0.16 mm, flat dorsal base, flat ventral base, 2-5 toothed upper edge, and a pointed tip. It has a six-square leaf cell shape, with a width of 0.12-0.18 mm, thick walls, and a smooth surface. Also, the trigon is less evident with a triangular shape; lobules are elongated, 1/2 in length from the lobe, flat base, flat edge, and flat edge. The ventral leaves are spaced, the attachment is slightly curved, the shape of the horn, length is 0.20-0.25 mm, width is 0.18-0.20 mm, base flat, edge flat, and tip split to the base of the lobe. Lobes are linear to lanceolate, with pointed ends, 8 cell lines long, and 2 cell lines wide, as illustrated in Figure 5.

Specimens examined: North Sumatra: Sibuatan Mountain, epipyllous, May 2020, alt. 1531-2304 m, T. 20.3-22.3^{0}C, H. 86-89%, F. Susilo 33, 643, 682, 690, 694, 695, 696, 709, 713, 715, 726, 729, 747, 749, 754, 760, 763, 764, 765, 771, 772, 782, 783, 799, 800, 801, 802, 831, 833, 848, 909, 917, 921, 922, 924, 935, 938, 940, 946, 958, 959, 960, 965, 976, 995, 997, 998, 1034, 1036, 1042, 1044, 1046, 1062, 1063, 1071, 1081, 1089, 1090, 1103, 1122, 1128, 1154, 1174, 1180, 1245, 1302, 1314, 1342, 1461, 1486, 1499, 1508, 1539, 1576, 1587, 1591, 1594, 1637, 1654, 1709, 1731, 1760, 1786.

Distribution: India, China, Taiwan, Cambodia, Hawaii, Malaysia, Indonesia (Seram Is., West Irian, Sumatra-a new record based on a recent study), Philippines, Thailand, Vietnam, Madagascar, New Caledonia, Samoa Is., Tahiti, Australia.

Note: *Drepanolejeunea pentadactyla* has a distinctive character, namely leaf edges with 2-5 serrations of cells, ventral leaves are spaced, the attachment is slightly curved, and the shape of the horn.

Table 2. The number of liverwort species is based on the type of geographical and altitudinal distribution on Mount Sibuatan, . Lmf: lower mountain forest; umf: upper mountain forest

Distribution type	Num. of species	Percentage (%)	Num. of species based on altitude		
			Lmf	Umf	Lmf & umf
Asian Australia	5	6.02	5		
Asian Oceanic	9	10.84	2		7
Asian-Oceanic-Australian	6	6.02	4		2
Asiatic	2	2.41	1	1	
Malesian	23	27.71	17		6
Miscellaneous	1	1.20	1		
Paleotropical	6	7.23	4		2
Pantropical	9	10.84	7		2
Southeast Asia	22	26.50	13		9
Total	83	100	54	1	28

Table 3. Distribution of liverworts and number of species based on the altitude observation area

Observation area	Altitude (m)	Family	No. of species
I (outpost-shelter I)	1531-1715	Lejeuneaceae	18
		Lepidoziaceae	9
		Lophocoleaceae	3
		Marchantiaceae	3
		Plagiochillaceae	13
		Radulaceae	4
II (shelter I-shelter II)	1716-1899	Lejeuneaceae	12
		Lepidoziaceae	13
		Plagiochillaceae	9
		Radullaceae	1
		Schistochilaceae	1
III (shelter II-shelter III)	1900-2083	Frullaniaceae	4
		Lejeuneaceae	21
		Lepidoziaceae	16
		Plagiochillaceae	8
		Radullaceae	3
IV (shelter III-shelter IV)	2084-2268	Lejeuneaceae	15
		Lepidoziaceae	6
		Plagiochillaceae	2
V (shelter IV-shelter V)	2269-2454	Lejeuneaceae	4
		Lepidoziaceae	3
		Radulaceae	3

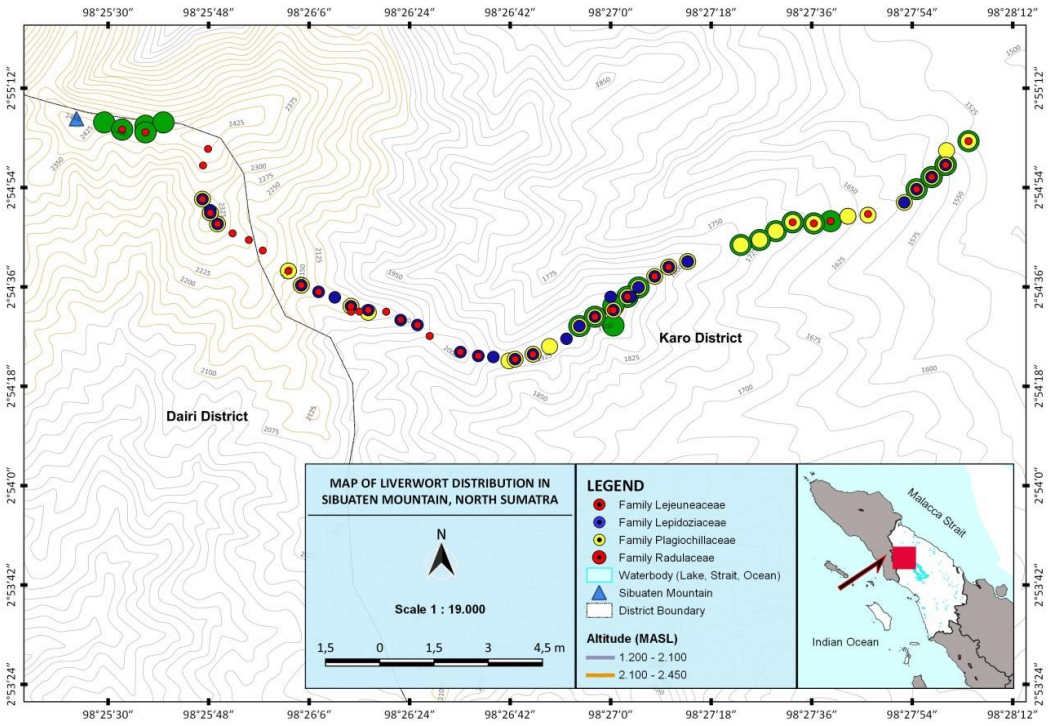

Figure 3. Map of the distribution of the four largest liverwort families on Mount Sibuatan, North Sumatra, Indonesia

Table 4. A species checklist of liverworts in Mount Sibuatan, North Sumatra, Indonesia and the information of its substrate, altitudinal and geographical distribution (scientific name and author were based on Tropicos website: https://www.tropicos.org/home)

Family/species	Substrate	Geographical distribution	Altitudinal distribution (m asl)
Frullaniaceae			
Frullania apiculata (Reinw., Blume & Nees) Nees	tt, b	PAN	1977
F. cordistipula (Reinw., Blume & Nees) Nees	tt	PAL	2044
F. hasskarliana Lindenb.	tt, b	AS	2087
F. ternatensis Gottsche.	tt, b	AS	2033-2065
Lejeuneaceae			
Archilejeunea planiuscula (Mitt.) Steph.	tt	AA	1606-2033
Cheilolejeunea ceylanica (Gottsche) R.M. Schust & Kachroo.	tt, rl, lf	AA	1558-2065
C. incisa (Gottsche) R.M.Schust & Kachroo.	r, lf	AO	1950-2131
C. longiloba (Steph. ex G. Hoffm.) Kachroo & R.M. Schust. ex J.J. Engel & B.C. Tan	tt, lf	AOA	1950-2180
C. trapezia (Nees) Kachroo & R.M.Schust.	Tt	AOA	1558
Cololejeunea denticulata (Horik.) S. Hatt.	lf	AOA	1531-2065
C. hasskarliana (Lehm. & Lindenb) Schiffin.	lf	AOA	1978
C. inflata (Stepth.)	lf	AOA	1840-2432
Colura acroloba (Month. Ex Steph.)	tt, lf	M	1558-2422
Diplasiolejeunea cavifolia (Steph.)	lf	M	1950-2100
Drepanolejeunea levicornua (Steph.)	rl, lf	M	1840-2351
D. pentadactyla (Mont.) Steph.*	e	M	1531-2304
D. ternatensis (Gottsche) Schiffn.	tt, r, lf, rl, b, l	PAL	1558-2342
D. thwaitesiana (Mitt.) Stepth.	lf	PAL	1950-2100
Lejeunea dipterota (Eifrig) G.E.Lee.	tt, ln	PAL	1558-2033
L. flava (Sw.) Ness.	tt, b, rl, l	PAL	1531-2180
L. obscura (Mitt.)	l	PAN	1558
L. tuberculosa Steph.	tt, rl, lf		1558-2065
Lopholejeunea eulopha (Tayl.) Schiffn.	tt	PAN	2131
L. herzogiana Verd.	tt, b	PAN	1558-1935
L. latilobula Verdoom	tt, b, ln	PAN	1558-2169
L. subfusca (Nees) Schiffn.	tt, rl, lf	SA	1531-2131
Metalejeunea cucullata (Reinw., Blume & Ness) Grolle.	tt, rl, lf	SA	1558-2342
Pycnolejeunea nicobarica Steph.	tt	SA	1558-1978
Spruceanthus polymorphus (Sande Lac.) Verd.	tt, rl	SA	1606-1685
Thysananthus spathulistipus (Reinw., Blume & Nees) Lindenb.	tt, b, r, rl	SA	1531-2131

Lepidoziaceae			
Bazzania calcarata (Sande Lac.) Shiffn.	tt	AA	1615-2033
B. caudistipula (Steph.) Inoue et H.A.Mill.	tt, r	AO	1872-2169
B. densa (Sande Lac.) Schiffn.	tt, r, rl	M	1606-2131
B. erosa (Reinw., Bl. et Nees) Trevis.	tt, l	AO	1606-2360
B. fallax (Sande Lac) Schiffn.	tt, r	AA	1901-2033
B. filiformis (Steph.)	rl	AA	1840-1872
B. francana (Steph.) N.Kitag.	tt, r	M	1820-1978
B. indica (Gottsche & Lindenb.) Trevis.	Tt	SA	1976-2087
B. japonica (Sande Lac.) Lindb.	r, rl, l	SA	1558-2159
B. longicaulis (Sande Lac.) Schiffn.	tt	M	1606-1975
B. loricata (Reinw., Bl. et Nees) Trevis.	tt, r, l	SA	1558-2351
B. paradoxa (Sande Lac.) Schiffn.	L	AO	1820
B. pectinata (Lindenb. & Gottsche) Schiffn.	tt, r, lf	AO	1935-2169
B. praerupta (Reinw. *et al*.) Trevis.	tt	SA	1901
B. spiralis (Reinw., Bl. et Nees) Meijer.	tt, r, rl, l	SA	1872-2360
B. subtilis (Sande Lac.) Trevis.	tt, rl, l	M	1820-1872
B. tridens (Reinw., Blume et Nees) Trevis.	tt, r, rl	M	1558-2033
Lepidozia haskarliana (Lindenb.) Steph.	tt, r	M	1606-1950
L. microphylla (Hook.) Lindenb.	tt, rl	M	1606-1970
Lophocoleaceae			
Heteroscyphus argustus	tt	PAN	1531-1606
Heteroscyphus sp1.	tt	PAN	1531
Heteroscyphus sp2.	tt	PAN	1558
Marchantiaceae			
Dumotiera hirsuta (Sw.) Nees	l	MIS	1531
Marchantia geminata Reinw.et.al.	l	SA	1531
Marchantia polymorpha	l	SA	1531
Plagiochilaceae			
Pedinophyllum interruptum (Nees) Kaal.	tt, rl	M	1641-1872
Pedinophyllum sp.	tt	M	1820-1961
Plagiochila bantamensis (Reinw., Blume & Ness) Mont.	tt	AO	1558-1615
P. dendroides (Nees) Lindenb.	tt, r	AO	1531-2131
P. denticulata (Mitt.)	tt	M	1685
P. infirma (S. Lac.)	tt	M	1641-1979
P. javanica (Sw.) Ness & Mont.	tt	M	1707-1961
P. junghuhniana (S. Lac)	tt	M	1531-1558
P. laxissima (Schiffin.)	tt	M	1820
P. peculiaris (Schiffin.)	tt, r, l	M	1606-2351
P. propinqua (Sande Lac.)	tt	M	1531-2360
P. salacensis (Gottsche)	tt	M	1641
P. sandei (Dozy ex Sande Lac.)	tt	SA	1606
P. sciophila (Nees ex Lindenb.)	tt	SA	1558-1685
P. singularis (Schiffin.)	tt	SA	1558-2180
P. sumatrana (Schiffin.)	tt	SA	1935-1978
P. ungarangana (Sande Lac.)	tt	SA	1725
Plagiochilion oppositum (Reinw., Blume & Nees) S. Hatt.	tt, rl	SA	1558-2180
Radulaceae			
Radula campanigera Mont.	tt, rl	SA	1707-1725
Radula formosa (C.F.W. Meissn. ex Spreng.) Nees	tt	AO	1901-2426
Radula iwatsukii K. Yamada	tt	AO	2422-2424
Radula javanica Gottsche	tt, rl	AOA	1558-1606
Radula meyeri Steph.	tt, b, rl	PAL	1668-1685
Radula retroflexa Taylor	tt	M	1558-1961
Radula tjibodensis K.I. Goebel.	tt, rl	M	1531
Radula verrucosa K. Yamada*	tt	SA	1935-1950
Radula yangii K.Yamada	tt	SA	2422-2424
Schistochilaceae			
Schistochila aligera (Nees & Blume) J.B. Jack & Steph.	tt, rl	SA	2820

Notes: tt: tree trunk; b: branch; lf: leaf; rl: rotten logs; s:stone; l: land; r: root; ln: liana; e: epipylous. AA: Asia-Australia, C: Cosmopolite, AO: Asian-Oceanic, AOA: Asian-Oceanic-Australian, M: Malesian, MIS: Miscellaneous, Pal: Paleotropic, Pan: Pantropic, SA: southeastasia; A: Asia *: new record for Sumatra

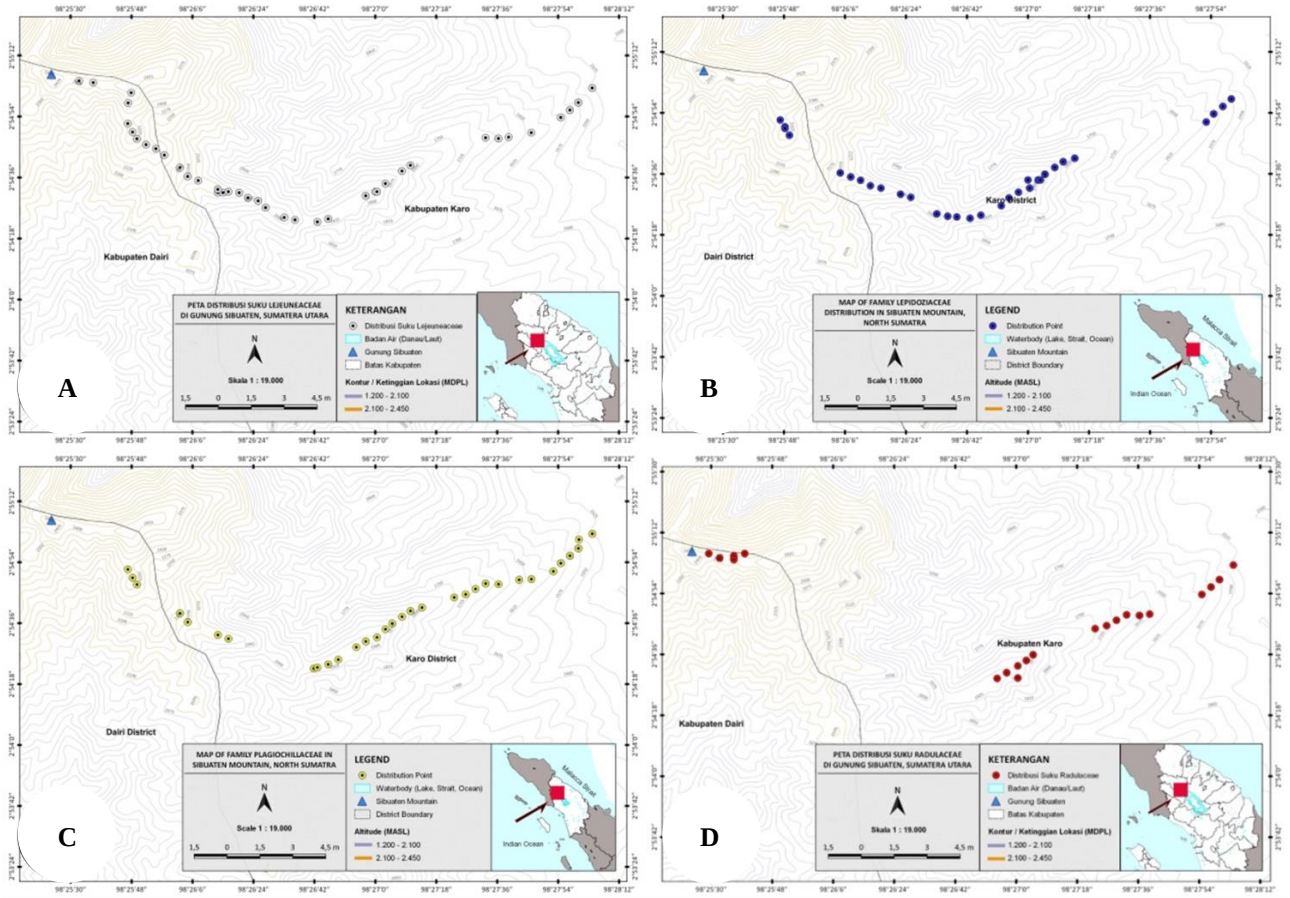

Figure 4. Map of the distribution of the four largest liverworts of each family on Mount Sibuatan, North Sumatra; A. Lejeuneaceae, B. Lepidoziaceae, C. Plagiochillaceae, D. Radulaceae

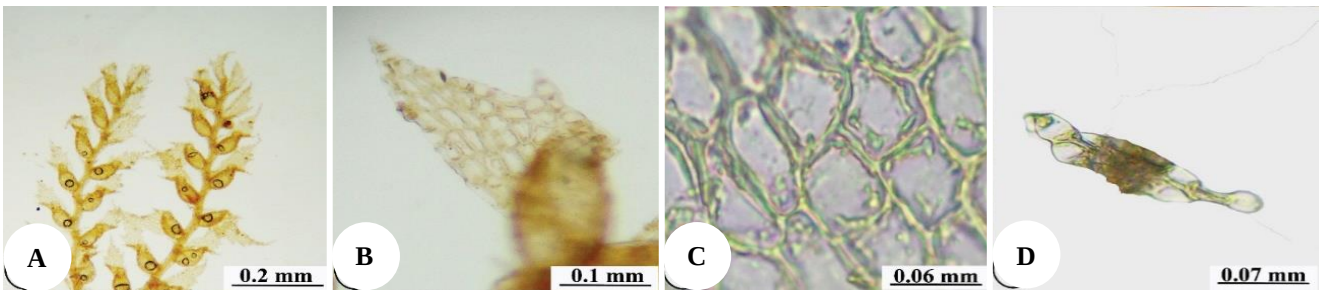

Figure **5.** A. *Drepanolejeunea pentadactyla*. A. Habit, B. Lateral leaves, C. Cells of Lateral leaves, D. Ventral leaves. Magnification at 4× for A, 40× for B, and 100× for C and D.

Radula verrucosa Yamada. J. Hatt. Bot. Lab. 45: 201-322. 1979.

This is a medium-sized plant with a brownish-yellow on the specimen. Its stem is 11-15 mm long, 0.1-0.2 mm in diameter, with 1.8-2 mm broad leaves, irregular pinnate, oblique spreading branches, 2-3 mm long with 0.1 mm in diameter, and 1.3 mm wide. The amentulose branches are 1.6-3 mm long, with 12-18 pairs of leaves (new character), usually with curved (like coiled) ends. These branches spread at an angle of 0º-30º from the stem, while the lobes are slightly overlapping, widely distributed, brittle, marginally concave, oblong-ovate, and curved like a sickle. It is 1-1.2 mm long and 0.8-0.9 mm wide, apex rounded or often blunt, dorsal base cover the stem, and the cell walls are thin with a large trigone. Furthermore, the leaf lobules are rectangular, 1/2 of the length of the leaf lobe, 0.4 mm long, 0.18-0.2 mm wide, with blunt and broad apex, straight or slightly curved abaxial and adaxial edges. The base does not cover the stem and is slightly rhizoid, brown in color, and keel elongated at an angle of 60º from it. In addition, the leaf lobules do not have a transparent edge (hyaline), and generative organs were not found, as shown in Figure 6.

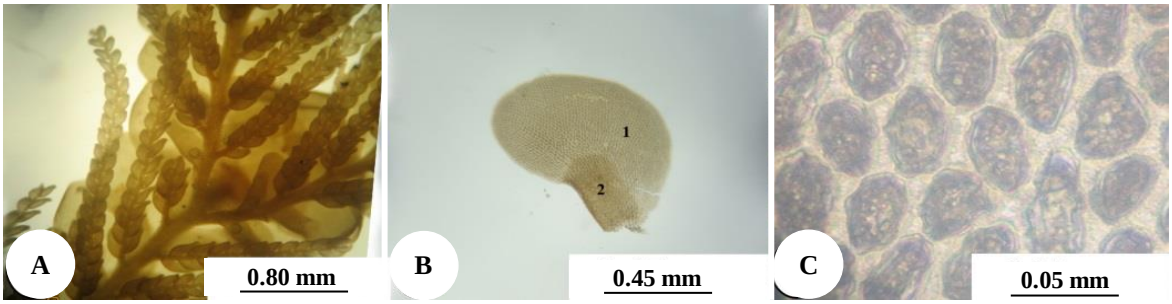

Figure 6. *Radula verrucosa*. A. Habit, B. (1) Lobus, (2) Lobules, C. Cells of lateral leaves. Magnification at 4× for A, 40× for B, and 100× for C

Specimens examined: North Sumatra: Sibuatan Mountain, corticolous, May 2020, alt. 1935-1950 m asl, T. 18.5-19.7^{0}C, H. 92-93%, Ferdinand Susilo 633, 635, 672, 677, 685.

Distribution: Endemic of New Guinea, Sumatra (a new record based on a recent study).

Note: *Radula verrucosa* have amentulose branches 1.6-3 mm long, with 12-18 pairs of leaves (new character). These branches spread at an angle of 0^o-30^o from the stem.

In conclusion, Lejeuneaceae was the most predominant in Mount Sibuatan, as shown by its many species and wide distribution across altitudinal and geographical areas. Three other prominent families, i.e., Lejeuneaceae, Lepidoziaceae, and Plagiochillaceae, were also found at each altitude, indicating their cosmopolite feature and adaptability to environmental conditions. Based on habitat occupancy, the liverworts in Mount Sibuatan strongly rely on tree trunks for their distribution despite the ecological pressure with the increased altitudes. Two liverwort species namely *Drepanolejeunea pentadactyla* and *Radula verrucosa* were documented as new records for Sumatra.

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