

The family Plagiochilaceae (Marchantiophyta) in Batang Toru Forest, North Sumatra, Indonesia

RISJUNARDI DAMANIK^{1,2}, NURSAHARA PASARIBU^{1,*}, ETTI SARTINA SIREGAR¹, SYAMSUARDI³

¹Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara. Jl. Bioteknologi No.1, Kampus USU Padang Bulan, Medan 20155, North Sumatra, Indonesia. Tel.: +61-822-3564. *email: nursahara@usu.ac.id

²Department of Biology Education, Universitas Simalungun, Jl. Sisingamangaraja Barat, Pematangsiantar, Indonesia

³Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Andalas. Jl. Unand, Limau Manis, Padang 25163, West Sumatra, Indonesia

Manuscript received: 30 March 2022. Revision accepted: 28 May 2022.

Abstract. Damanik R, Pasaribu N, Siregar ES, Syamsuardi. 2022. The family Plagiochilaceae (Marchantiophyta) in Batang Toru Forest, North Sumatra, Indonesia. Biodiversitas 23: 3127-3134. Investigation on the liverwort family Plagiochilaceae in Batang Toru Forest, North Sumatra, Indonesia resulted in ten taxon of Plagiochilaceae namely *Plagiochilion oppositum*, *Plagiochila bantamensis*, *Plagiochila dendroides*, *Plagiochila denticulate*, *Plagiochila frondescens*, *Plagiochila junghuhniana*, *Plagiochila propinqua*, *Plagiochila sciophila*, *Dinckleria singularis*, *Plagiochila sumatrana*, distributed under three genera *Dinckleria* (1 species), *Plagiochila* (8 species) and *Plagiochilion* (1 species). *Plagiochila junghuhniana* was the most observed species, while *Plagiochila sciophila* was the least frequently encountered species in the forest.

Keywords: Batang Toru Forest West block, Indonesia, Marchantiophyta, North Sumatra, Plagiochilaceae

INTRODUCTION

Marchantiophyta is a liverwort which consists of two types, namely thallus liverworts and leafy liverworts. Leaf liverworts are the liverworts group that has the highest diversity (Bączkiewicz 2013). Liverworts have a wide distribution in lowland forests and upper mountain forests (Glime 2019). Liverworts has as many as 5000 species worldwide (Söderström et al. 2022). Liverworts mostly thrives in humid and shaded environmental conditions. They grow submerged in water or periodically inundated and are primarily terrestrial in nature (Althoff and Zachgo 2020). One of the families that includes leaf liverworts is Plagiochilaceae. Plagiochilaceae have special characteristics in the form of serrated leaf edges, ccurrent leaf bases and succubous leaf arrangement (Juárez-Martínez and Delgadillo-Moya, 2017).

Plagiochilaceae is a leafy liverwort family with a very wide range of distribution in the world (Bakalin and Vilnet 2020). Amongst Marchantiophyta, Plagiochilaceae is one of the largest families, with an estimated 450 taxa from ten genera (Söderström et al. 2016). Plagiochilaceae is typically found as epiphytes growing on tree branches and attached to the leaves (epiphyte) in moist environments or in lowland forests (Gradstein 2016). They can grow on various substrates such as tree trunks, rock surfaces, rotting wood, bases and above tree (Kruse 2015). It can be found in warm-moderate temperatures, subtropical and tropical areas that receive high rainfall. The family Plagiochilaceae comprises 10 genera namely, *Acrochila*, *Chiastocaulon*, *Dinckleria*, *Pedinophyllopsis*, *Pedinophyllum*, *Plagiochila*, *Plagiochilidium*, *Plagiochilion*, *Pseudolophocolea* and

Xenochila (Söderström et al. 2016) transferred *Xenochila* from Plagiochilaceae to Jungermanniaceae.

In general, the leaf shape of Plagiochilaceae varies, such as oval, oval, inverted oval, round, kidney shape, spatula and square. The leaf margins also have several forms such as double-toothed, convex, single-toothed, small and short-toothed, rough-toothed, short and dense-toothed, and 2-toothed (Inoue 1984). Some species have 2-3 rows of leaves attached to the stem, divided into two rows of dorsal leaves (lobe), one row of ventral leaves (under leaf) which usually have a smaller size than the dorsal leaf (So 2001). Leaf cells have trigone of varying shape and size. Usually, the size of the trigon is smaller in humid conditions and larger in dry conditions (Gradstein 2016).

There is little information about the distribution of Plagiochilaceae in Indonesia. Previous studies on Plagiochilaceae have been observed in several areas, including Mount Ungaran, Central Java. Mount Patuha, West Java, the lowland forest of Toro Sulawesi, the lowland forest of Bariri Sulawesi, and the upper forest of the Rorekatimbu mountains of Sulawesi. There is a dearth of information regarding Plagiochilaceae in North Sumatra. Plagiochilaceae reported from North Sumatra are 21 species in the Sibayak Forest (Siregar 2015); single species in Lau Kawar Karo district (Pasaribu 2013); 12 species in the Deleng Lancuk Forest Tourism Park (Firina 2015); 18 species in Mount Lubuk Raya (Siregar et al. 2018); and 16 species in the Eden Garden 100 (Siregar and Pasaribu 2019). Significant information regarding the family Plagiochilaceae in Batang Toru Forest, North Sumatra, Indonesia, is lacking.

The Batang Toru Forest has a tropical climate with high

rainfall ranging from 4500 to 5000 mm each year which results in an ideal humidity for the growth of liverworts, particularly those belonging to the family Plagiochilaceae. The temperature at night can drop to 14°C and reach 31°C during the day. The humidity ranges from 33%-95%. Currently the threat to the Batang Toru Ecosystem comes from the development of the gold mining industry by PT. Agincourt resources, forest encroachment and poaching. The construction of the gold mine plans to expand the mining area, this will destroy the forest surface area, so that the *Plagiochila* habitat around the mine area will be extinct. Forest encroachment mostly occurs in the West Block and is carried out by immigrants. These immigrants depend a lot on the products of the Toru stem forest, so that several species of plants including *Plagiochila* are threatened with extinction and their important ecological functions may be lost. Based on this thought, the researchers collected data on liverworts from the Plagiochilaceae family. *Plagiochila* diversity has not been reported to date, so it is necessary to conduct a study and provide information about the diversity of *Plagiochila* in the Batang Toru Forest Area, West Block, North Sumatra, Indonesia.

MATERIALS AND METHODS

The research was conducted in the Batang Toru Forest West Block, North Sumatra, Indonesia. Batang Toru Forest covers an area of 133.841 hectares. This forest is divided into two blocks of territory separated by the Sumatran fault. The west block is 78.891 hectares wide, while the east block is 54.950 hectares. The location of Camp *Mayang*

West Block is a Flora and Fauna monitoring station area of 12.000 hectares located between 49°93'31" East Longitude and 18°63'20" North Latitude (Kuswanda et al. 2021). Exploratory survey work was carried out, collecting liverworts specimens of the Plagiochilaceae along a hiking trail in the Batang Toru forest. The research location can be seen in Figure 1.

The liverworts specimens were collected by exploring along the research path in the year??. All samples found were photographed and collected using a sharp knife from various substrates such as soil, tree trunks, rocks, rotted wood and leaves. We often collect samples in dry as well as in wet conditions. Dry ones are directly used in herbarium while the wet ones collected in the field are gradually air-dried and herbarium is prepared. Another method is the wet specimens (most thalloids) are pickled in specimen tubes for further usage and long-term storage.

Collected specimens were identified using identification keys and descriptions available in Erzberger 2021; Glime 2021; Bakalin and Vilnet 2020; Engel and Gary 2013 and other publications on Malaysian and Asian liverworts such as Inoue 1984; So 2001; Lai et al. 2008; Verma et al. 2013; Pócs et al. 2016; Patzak et al. 2016; Bakalin and Vilnet 2020; Siregar and Pasaribu 2020; Singh et al. 2010; Singh and Singh 2020; Nadhifah et al. 2021; Majumdar 2021. Some important morphological characters include plant width, lateral leaf (shape, base, sac, margin, apex, trigones), and under leaves. Identification was carried out at the Plant Taxonomy Laboratory, Department of Biology, Universitas Sumatra, Utara. It is mandatory to provide the place of deposition (Herbarium, if possible, with an acronym) of all the specimens collected during the field survey.

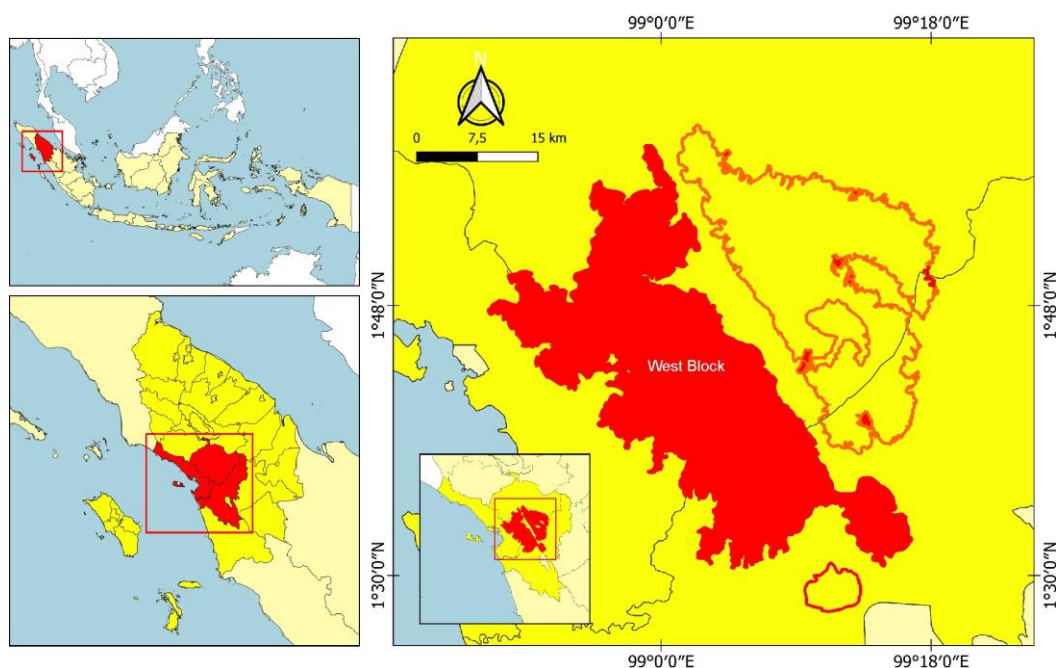


Figure 1. Research location and map of Batang Toru Forest West Block, North Sumatra, Indonesia

RESULTS AND DISCUSSION

In the Batang Toru forest area of the West block of North Sumatra, thirteen species of the Plagiophilaceae family were collected and identified which are classified under three genera, namely *Dinckleria* (1 species), *Plagiophilion* (1 species) and *Plagiophila* (8 species).

As the key characteristics features of the following taxon are missing in the key

1. a. Leaves are opposite, the position of the leaves to the stem forms an angle 90° *Plagiophilion oppositum*
b. Leaves are crosswise, the position of the leaves to the stem forms an angle $<90^\circ$ 2
2. a. Leaves arranged sparsely *Plagiophila propinqua*
b. Leaves arranged tight 3
3. a. Leaves stature resembling a tree with many branches *P. dendroides*
b. Leaves stature with a few branches 4
4. a. Ventral leaves base is curved outwards *P. bantamensis*
b. Ventral leaves base is curved inward 5
5. a. The ventral and dorsal leaves margins long ciliated *P. sumatrana*
b. The ventral and dorsal leaves margins serrated ... 6
6. a. The lateral leaves are tightly packed *P. frondescens*
b. The lateral leaves are alternately 7
7. a. Lateral leaves oval to rounded *P. denticulata*
b. Lateral leaves breech egg-shaped 8
8. a. Cell surface is rough *Dinckleria singularis*
b. Cell surface is smooth 9
9. a. The leaves have a flat attachment ... *P. junghuhniana*
b. The leaves have a curved attachment..... *P. sciophilina*

Plagiophilion oppositum (Reinw., Blume & Nees) S.Hatt., Biosphaera 1: 7. 1947.

Figure 2. A-B

Patzak SDF, Renner MAM, Schäfer-Verwimp A, Feldberg K, Heslewood MM, Fernandez Peralta D, Matos de Souza A, Schneider H, Heinrichs J. A phylogeny of Lophocoleaceae-Plagiophilaceae-Brevianthaceae and a revised classification of Plagiophilaceae. *Organisms, Diversity and Evolution* 16: 481-495. (2016).

Plant light green to dark green, 1.7-2.3 mm wide in stature and has simple branches. The leaves are laterally opposite, the position of the leaves to the stem forms an angle $<90^\circ$, rarely arranged, rounded shape, 3.5 mm long and 2.1-2.4 mm wide, curved attachment, dorsal base, and ventral side wide, tooth length 2-5 cells, tip rounded, square cell shape, thin cell walls, smooth cell surface, large trigons are triangular. The plant does not have ventral leaves. The generative organ is not found in these plants. Branching ventral intercalar, surface wax occurring, leaves opposite, no differentiation of a creeping stoloniform that gives rise to leafy shoots, rhizoids present on creeping and arising shoots, rhizoids fasciculated at ventral leaf bases, asexual reproduction missing, androecia simple, perianth

shape cylindrical or campanulate, perianth unwinged, capsule shape globose, spores unicellular at time of release, elaters bispiral. Habitat: Epiphytes on tree trunks, roots and rotten wood at an altitude of ± 876 -1035 m a.s.l.; Ecology: humidity $\pm 89\%$ and temperature $\pm 24.9^\circ\text{C}$. Distribution: North Sumatra (Batang toru), Australia, Fiji, Papua New Guinea, Philippines, Taiwan, Japan, China, Sri Lanka, Myanmar, Thailand, Vietnam, Malaysia (Thouvenot et al. 2011; Wang et al. 2011). Specimens examined: Batang Toru Forest (Indonesia) RD 74, 132, 254, 267, 579, 1306, 1432.

Plagiophila bantamensis (Reinw. et al.) Mont. in d'Orbigny, Voy. Amér. Mérid. 7, Bot. (2): 82. 1839; M.L. So, Aust. Syst. Bot. 14: 677-688. 2001 & Syst. Bot. Monogr. 60: 21. 2001. *Jungermannia bantamensis* Reinw. et al., Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 12: 235. 1825.-Type: Indonesia, Java, Bantam, C.L. Blumes.n. (STR). *Plagiophila nicobarensis* Reichardt, Verh. K. K. Zool.-Bot. Ges. Wien 16: 959. 1866.Type: India, Nicobar Islands, 1870, E.Jelinek 58 (W). *Plagiophila didrichsenii* Steph., Bull. Herb. Boissier, sér 2, 4: 27. 1904.-Type: India, Nicobar Islands, F. Didrichsen s.n. Nova Acta Phy. Med. Acad. Caes. Leop.-Carol. Nat. Cur. 12: 235. 1825.

The plant specimen is light green to dark green. It has simple branching, and a stature width of 4.1-5.9 mm. In alternating laterals, the position of the leaves to the stem forms an angle $<90^\circ$, tightly arranged, oblong in shape, with a length of 2.2-3.1 mm and a width of 1.3-1.9 mm. Leaves have a flat attachment, the base of the ventral wide. The ventral base has a pocket; egg-shaped sac. There are teeth on the entire edge of the leaf with a width of 0.4-0.6 mm. The base of the leaf is flat with the dorsal and ventral parts equally large. The dorsal and ventral edges have long, pointed cilia. On the whole leaf, the dorsal edge is flat, and the ventral edge has long, dense teeth like cilia. The length of the teeth is 3-10 cells with rounded ends and short teeth. The shape of the cell is ovoid, the cell wall is thin, and the cell surface is smooth and trigon, which is large and triangular. This plant also has ventral leaves with a width of 0.8-0.9 mm, oval shape, flat base, where the dorsal and ventral bases are the same size with rounded ends. The generative organs are not found in these plants.

Habitat: Epiphytes on tree trunks at an altitude of ± 876 -910 m a.s.l.; Ecology: humidity $\pm 88\%$ and temperature $\pm 25.1^\circ\text{C}$. Distribution: China, Fiji, Japan, Papua New Guinea, the Philippines, Indonesia, Kampuchea, Malaysia, Melanesia, Samoa, Singapore, Sri Lanka, Sulawesi, Thailand, Vietnam (So 2001 a, b). Specimens examined: Batang Toru Forest (Indonesia) RD 75, 130, 183, 424, 1986. (See So 2001).

Plagiophila dendroides (Ness) Lindenbg.

Spec. Hepat. 1-5: 146. 1844; Inoue, *Plagiophila* Southeast Asia: 1984; Piippo. Ann. Bot. Fennici 26: 1989; *Jungermannia dendroides* Nees, hepat. Jav.: 77. 1830.

The plant specimen is yellowish-green to brownish in color. The arrangement of leaves on the stem forms an

angle of $<90^\circ$ and the leaves have pinnate branches. The lateral leaves are dense and have an elongated shape with a length of 0.6-0.9 mm and a width of 0.3-0.6 mm. The plant has curved leaf attachments; pointed and narrowed leaf base; the dorsal and ventral edges of the leaf are even; The tip of the leaf has 2-3 teeth with a length of 5-6 cells. Leaf cells have a square shape, thin walls, smooth surfaces, and are trigone in shape. The plant has neither ventral nor Androsium leaves. The plant has axillary gynae, 7 bracts with an elongated shape and a length of 1.1-1.4 mm and a width of 0.4-0.7 mm. The base of the leaf is broad, but the dorsal and ventral edges are flat. The tips of the leaves are rounded and have 3 short and pointed serrations with an average length of 4-16 cells.

See Inoue (1984)

Habitat: Epiphytes on tree trunks, at an altitude of ± 863 -914 m a.s.l.; Ecology: humidity $\pm 89\%$ and temperature $\pm 23.5^\circ\text{C}$. Distribution: Japan, Taiwan, Philippines, Malaysia, Indonesia (North Sumatra, Java, Kalimantan, Irian Jaya), Papua New Guinea, New Zealand, Fiji (Inoue 1958; Inoue 1984). Specimens examined: Batang Toru Forest (Indonesia) RD 19, 1203

***Plagiochila denticulata* Mitt.**, J. Proc. Linn. Soc., Bot. 5: 95. 1861.

Figure 3. A-B

Plagiochila horridula Stephani, Sp. Hepat. 6. 1918.

The plant specimen is light green to yellowish in color. The plant has simple branching with a stature width of 3.1-3.3 mm. The lateral leaves are alternate, where the position of the leaf to the stem forms an angle of $<90^\circ$. The leaves are tightly arranged, oblong to ovoid, 1.2-1.5 mm long and 0.4-1.0 mm wide. The leaves of this plant have curved attachments, where the ventral and dorsal bases are of the same size. The dorsal and ventral edges are long-toothed like cilia. The base to the tip of the blunt leaf has 8-15 serrated cells. The cells are ovoid and have thick walls, smooth surfaces, and small to medium-sized trigone that can bulge into a triangular shape. The ventral leaf of the plant reduces. The generative organs are not found in this plant.

Habitat: Epiphytes on tree trunks and weathered wood at an altitude of ± 876 -910 m asl; Ecology: humidity $\pm 78\%$ and temperature $\pm 25.4^\circ\text{C}$. Distribution: Indonesia, (North Sumatra) China, Nepal, India, Thailand (So 2001). Specimens examined: Batang Toru Forest (Indonesia) RD 120, 478, 481, 875.

Key characters missing

See So (2001); Rawat & Srivastava (2007); Dey & Singh (2012)

***Plagiochila frondescens* (Ness) Lindenb.** Sp. Hepat. (*Plagiochila* fasc. 2-4): 52. 1840.

Figure 4. A, B, C

Jungermannia frondescens Ness, Linnaea 6: 610. 1831.

The plant specimen is green to yellowish in color. The arrangement of leaves on the stem forms an angle $<90^\circ$, the branches are pinnate. The lateral leaves are tightly packed, elongated, 1.1-1.7 mm long and 0.2-0.6 mm wide. The plant leaves have a curved attachment with a pointed base

and are narrow with grooves on both sides. The dorsal edge is serrated 3. The serrations are short to long and pointed. The length of the teeth is 3-5 cells. The ventral edge has 2-3 long, pointed serrations with 6-8 cells long. The blunt tip of the leaf has 3-5 serrations with a length of 5-9 cells. Leaf cells are rounded and have thick walls, smooth surfaces and triangle-shaped trigone. This species does not have ventral leaves or generative organs.

Habitat: Epiphytes on tree trunks, at an altitude of ± 752 -908 m asl.; Ecology: humidity $\pm 77\%$ and temperature $\pm 26.3^\circ\text{C}$. Distribution: Sri Lanka, India, Philippines, Cambodia, Malaysia, Indonesia (North Sumatra, Java, Kalimantan) (So 2001). Specimens examined: Batang Toru Forest (Indonesia) RD 268, 518, 569.

***Plagiochila junghuhniana* Sande Lac.** Ned. Kruidk. Arch. 3: 416. 1855.

Figure 5. A, B, C

Ned. Kruidk. Arch. 3: 416. 1855; Inoue, *Plagiochila* Southeast Asia. 1984; So, Syst. Bot. Monogr. 60. 2001.

The plant specimen is yellowish-green in color and has pinnate branching. The leaf stature is about 2.4-3.1 mm wide. The plant has alternating lateral leaves, where the position of the leaves to the stem forms an angle of $<90^\circ$. The leaves of the plant are tightly arranged, oblong in shape with a length of 1.3-1.8 mm and a width of 0.5-1.2 mm. The leaves have a flat attachment and flat base (ventral base and dorsal part have the same size). The rounded tips of the leaves have 2 short teeth and form a pine. These plants have leaf cells that are ovoid in shape. The cell walls are thin, but the cell surface is smooth. The leaf cell has a small to medium-sized triangular trigone. This plant has reduced ventral leaves. This species does not have a generative organ.

See So (2001) Inoue (1984)

Characteristics features are missing in the description

Habitat: Epiphytes on tree trunks, at an altitude of ± 876 -1035 m asl.; Ecology: humidity $\pm 79\%$ and temperature $\pm 24.2^\circ\text{C}$. Distribution: Myanmar, Thailand, Philippines, Malaysia, Sumatra (Dolok Barus, Mt. Singgalang, Hutan Batang Toru), Java, Papua New Guinea (Inoue 1984; So 2001; Lai et al. 2008). Specimens examined: Batang Toru Forest (Indonesia) RD 124, 265, 569, 733, 743, 1931, 2139, 2256.

***Plagiochila propinqua* Sande Lac.**, Ned. Kruidk. Arch. 4: 93. 1856.

Figure 6. A, B, C

Schiffner, *Österreichische Botanische Zeitschrift*, Vol. 49, No. 4 (April 1899), pp. 127-132; The plant specimen is light green to yellowish in color and has branching pinnate leaves with a stature width of 3.6-4.1 mm. The lateral leaves are alternate, where the position of the leaf to the stem forms an angle of $<90^\circ$. The leaves are sparsely arranged, oblong in shape, 1.1-1.9 mm long and 1 mm wide. The leaves have a flat attachment with the base of the ventral and dorsal parts being equally large. The dorsal edge is flat, but the ventral edge is blunt and has rough serrations with 2-5 cells long. Leaf cells are ovoid in shape

and have thin walls, smooth surfaces, and trigone of medium size. The plant has no ventral leaves and no generative organs.

See Inoue (1984) characteristics features are not provided

Habitat: Epiphytes on tree trunks, at an altitude of ± 872 -1006 m asl.; Ecology: humidity $\pm 83\%$ and temperature $\pm 25.7^\circ\text{C}$. Distribution: Indonesia (North Sumatra, Padang, Java, Bali, Kalimantan) Philippines (Inoue 1984). Specimens examined: Batang Toru Forest (Indonesia) RD 272, 613, 734, 1302, 1411, 1673.

Plagiophila sciophila Nees ex Lindenb., Sp. Hepat.

(*Plagiophila* fasc. 2-4): 100. 1840.

Figure 7. A, B, C

(*Plagiophila* fasc 2-4: 100. 1840; M.L.So in Syst. Bot.Monog. 60: 112. 2001; K.K.Rawat & S.C.Srivast., Genus *Plagiophila* in Eastern Himalaya (India), 116. 2007. *Plagiophila acanthophylla* Gottsche, Bot. Zeitung (Berlin) 16, Beil. 37, 38. 1858. *Plagiophila chiloscyphoidea* Steph., Sp. hepat. 2: 301. 1906. *Plagiophila flavovirens* Steph., Sp. hepat. 6: 156. 1918. *Plagiophila orientalis* Taylor in J. Bot. 5: 261. 1846. *Plagiophila trochantha* Schiffn. ex Steph., Sp. hepat. 6: 226. 1921. *Plagiophila vygensis* Steph., Sp. hepat. 5: 237. 1921.

The plant have medium stature, 2.7-6 mm wide stature, yellowish green in the specimen, leaf arrangement on the stem at an angle $< 90^\circ$, branching pinnate. The lateral

leaves are tightly packed, elongated, 1.9-2.5 mm long, 0.6-1.4 mm wide; curved attachment; pointed and broad base; the dorsal side of the ciliated 14, long and pointed cilia, long of cilia 1-5 cells, the ventral edge of the whole ciliated, long and pointed cilia, long of cilia 4-7 cells; rounded tip, long and pointed cilia, long of serrations 4-7 cell; Leaf cells are rounded, thin walls, smooth surface, trigon has a triangular shape. Ventral leaves arranged sparsely; ovoid shape, 0.3-0.5 mm long, 0.1-0.4 mm wide, curved adhesions; wide base; ciliated edge 7, cilia long and pointed, 2-4 cells long; rounded tip. Generative organ not seen.

See So (2001); Rawat & Srivastava (2007)

Characteristics features are missing in the description

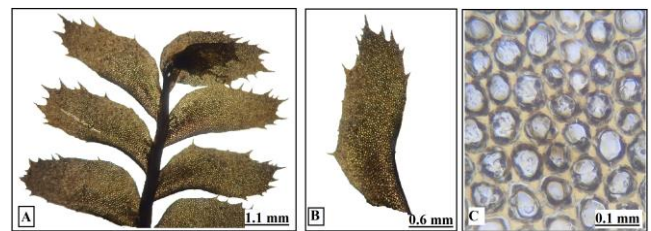


Figure 4. *Plagiophila frondescens* A. habit, B. lateral leaf, C. Lateral leaf cells

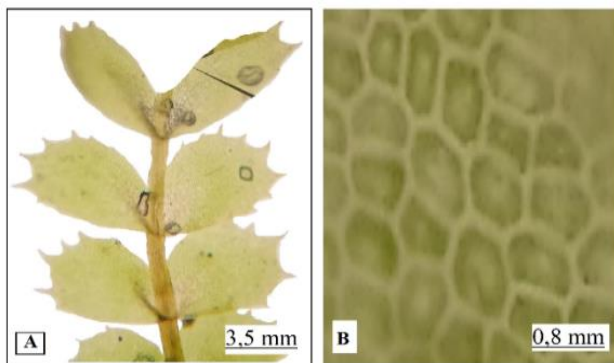


Figure 2. *Plagiophilon oppositum* A. Habit, B. lateral leaf cells (from which specimen it has been photographed, have to be mentioned)

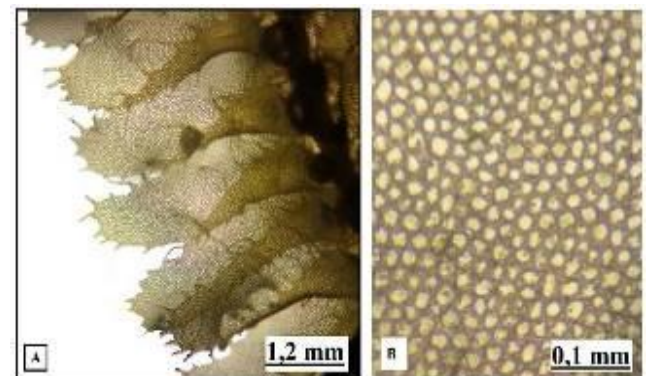


Figure 3. *Plagiophila denticulata* A. habit, B. lateral leaf cells

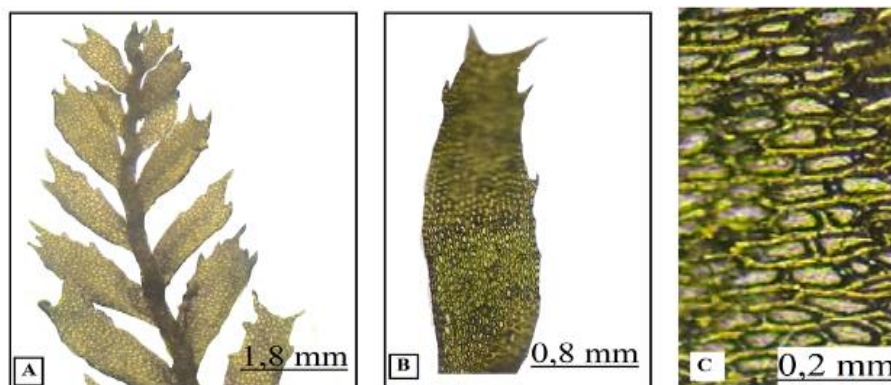


Figure 5. *Plagiophila junghuhniana* A. Habit, B. lateral leaf, C. Lateral leaf cells

Habitat: Epiphytes on tree trunks and rotten wood at an altitude of ± 878 m asl.; Ecology: humidity $\pm 92\%$ and temperature $\pm 23.9^\circ\text{C}$. Distribution: India [Western Himalaya (Himachal Pradesh, Jammu & Kashmir, Uttarakhand), Eastern Himalaya (Arunachal Pradesh, Assam, Meghalaya, Manipur-present study, Sikkim, West Bengal), Western Ghats (Kerala, Tamil Nadu), Andaman & Nicobar Islands (South Andaman)], Pakistan, Nepal, Bhutan, China, Japan, Korea, Philippines, Malaysia, Thailand, Vietnam, Indonesia, Papua New Guinea, Samoa, eastern North America, Australia (Tan & Engel 1986; Piippo 1990; Long & Grolle 1990; So 2001; Yamada & Iwatsuki 2006; Song & Yamada 2006; McCarthy 2006; Rawat & Srivastava 2007; Singh & Singh 2007a, 2009; Verma & Srivastava 2008; Singh et al. 2008a; Lai et al. 2008; Dey et al. 2009). Specimens examined: Batang Toru Forest (Indonesia) RD 133.

***Dinckleria singularis* (Schiffn.) M. A. M. Renner, Schäf.-Verw. & Heinrichs**, in Austral. Syst. Bot. 29: 112 (2016).-*Plagiochila singularis* Schiffn., Hep. Fl. Buitenzorg: 158. 1900.

See also Singh Deo & Singh (2020) and Renner et al. (2016)

Denkschr. Math. Nat. Cl. K. Akad. Wiss. Wien 70: 187. 1900; Inoue, *Plagiochila* Southeast Asia: 118-120. 1984.

The plant specimen is dark green to dark brown. The leaves have pinnate branches with a stature width of 2.4-3.1 mm. The lateral leaves are alternate, where the position of the leaf to the stem forms an angle of $<90^\circ$. The leaves are tightly packed, oblong in shape with a length of 1.6-2.1 mm and a width of 0.9-1.1 mm. The leaves have a flat attachment, where the size of the base of the ventral and dorsal are the same. The dorsal and ventral edges are flat, sharp-toothed, and short at the tip. The number of sharp teeth on the leaves is 2-4 (two dominant teeth). The length of the serrations is 2-9 cells with rounded edges. The leaf cell shape is ovoid. These leaf cells have thin cell walls,

rough cell surfaces, and bulging trigone. The plant has no generative organs.

Habitat: Epiphytes on tree trunks, at an altitude of ± 894 -1006 m asl.; Ecology: humidity $\pm 95\%$ and temperature $\pm 23.5^\circ\text{C}$. Distribution: Indonesia (So 2001, Söderström et al. 2016), India [Eastern Himalaya (Arunachal Pradesh)-present study], Myanmar (So 2001), Thailand (Lai et al. 2008), China (So 2001; Zhu 2006), Malaysia (Chuah-Petiot 2011), Philippines (So 2001), Taiwan (Wang et al. 2011), Papua New Guinea (So 2001; Grolle and Piippo 1984), Australia and Vanuatu (Renner et al. 2016) Specimens examined: Batang Toru Forest (Indonesia) RD 01, 145, 164, 278, 288, 803, 1929. **INDIA**. Eastern Himalaya, Arunachal Pradesh, West Siang District; between Zupuk and Damingla forests, ca. 3500 m, 8 May 2011, S. Singh Deo 50834B (CAL).

***Plagiochila sumatrana* Schiffn., Denkschr. Kaiserl.**

Akad. Wiss., Math.-Naturwiss. Kl. 70: 183. 1900.

Figure 8. A, B, C

See Piippo (1989); Inoue (1984)

Provide key characters

Denkschr. Math. Nat. Cl. K. Akad. Wiss. Wien 70: 183. 1900; Inoue, *Plagiochila* Southeast Asia: 111-112. 1984; Piippo, Ann. Bot. Fennici 26: 227. 1989.

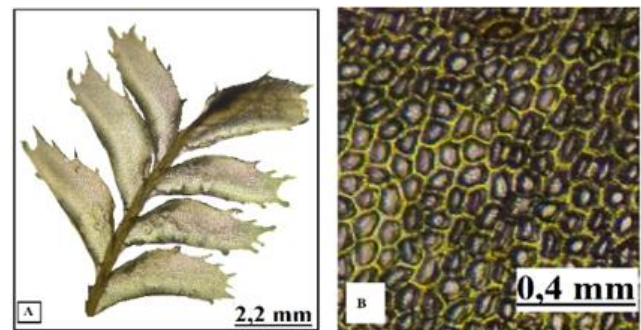


Figure 6. *Plagiochila propinqua* A. habit, B. lateral leaf cells

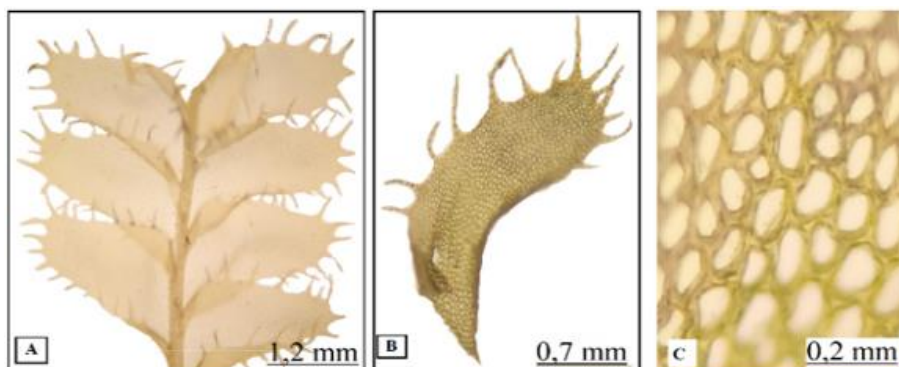


Figure 7. *Plagiochila sciophila* A. habit, B. lateral leaf, C. Lateral leaf cells

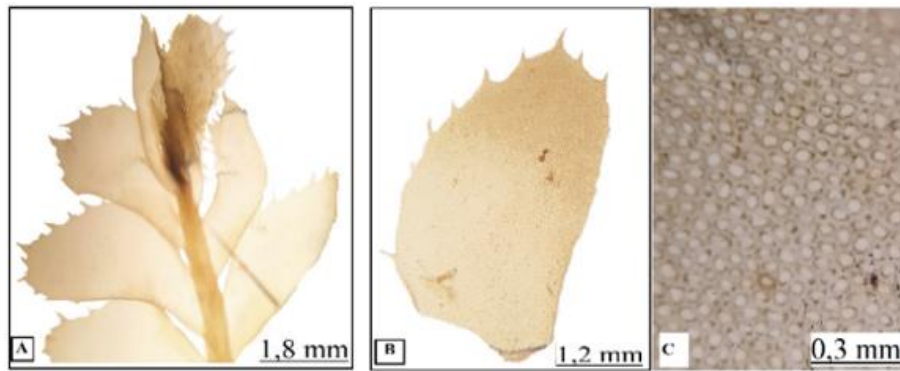


Figure 8. *Plagiochila sumatrana* A. habit, B. lateral leaf, C. Lateral leaf cells

The plant is light green to dark green. The leaves have dichotomous branches with a stature width of 4.5-5.3 mm. The lateral leaves are alternate, where the position of the leaf to the stem forms an angle of $<90^\circ$. The leaves are tightly packed, oblong in shape, 1.8-2.2 mm long and 1.5-1.7 mm wide. The leaves have a flat attachment. The ventral edge is rough and tightly serrated from the base to the tip of the leaf. The length of the teeth is 1-3 cells. The dorsal edge at 1/3 of the base is curved inward. The tip of the leaf is rounded, while the shape of the cell is oval. Leaf cell walls are thin and have a smooth surface and large, bulging trigones. The plant has neither ventral leaves nor generative organs.

Habitat: Epiphytes on tree trunks, at an altitude of ± 876 -877 m asl.; Ecology: humidity $\pm 92\%$ and temperature $\pm 23.9^\circ\text{C}$. Distribution: Borneo, Java, Papua New Guinea, the Philippines, North Sumatra (Mount Singgalang, Batang Toru Forest) (Inoue 1984; So 2000). Specimens examined: Batang Toru Forest (Indonesia) RD 118, 1818.

In this study, which was conducted in the West Block Batang Toru Forest Area, North Sumatra, 10 species of liverworts of the Plagiochilaceae family were found. These plant species can be classified into three genera, namely *Plagiochilon* (1 species) and *Plagiochila* (8 species). Liverworts from the Plagiochilaceae family live on three substrates, namely tree trunks, rotten wood, and tree twigs, with tree trunks being the most dominant substrate found in this study.

ACKNOWLEDGEMENTS

This research is part of a doctoral dissertation at the Biological Sciences Study Program, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan, Indonesia. This research is also supported by TALENTA research with contract number: 38/UN5.2.3.1.R/PPM/SPP-TALENTA USU/2021 TANGGAL 28 June 2021". We would also like to thank the teamwork of specimen collection in the field. The permission provided by the concerned authority for exploration work should be duly acknowledged.

REFERENCES

- Althoff F, Zachgo S. 2020. Transformation of *Riccia fluitans*, an amphibious liverwort dynamically responding to environmental changes. *Intl J Mol Sci* 21 (15): 1-16. DOI: 10.3390/ijms21155410.
- Bakalin V, Vilnet A. 2020. *Plagiochila xerophila* (Plagiochilaceae, Marchantiophyta)-a highly xerophilous new species from the Tibetan Spur (China). *Plant Ecol Evol* 153 (1): 120-131. <https://www.jstor.org/stable/26906816>. DOI: 10.5091/plecevo.2020.1560.
- Engel JJ, Smith M, Gary L. 2013. Austral Hepaticae. 49. New section names and synonymy in *Plagiochila*, with reference to New Zealand species [Plagiochilaceae (Jörg.) K. Müll.]. *Nova Hedwigia* 96 (3/4): 399-408. DOI: 10.1127/0029-5035/2013/0085.
- Erzberger P. 2021. Keys for the identification of bryophytes occurring in Hungary. *Acta Biologica Plantarum Agriensis* 9 (2): 3-260. DOI: 10.21406/abpa.2021.9.2.3.
- Firina EN. 2015. Jenis-jenis lumut hati berdaun Famili Plagiochilaceae di Taman Wisata Alam Deleng Lancuk Kabupaten Karo Sumatera Utara. Universitas Sumatera Utara, Medan. [Indonesian]
- Glime JM. 2019. Tropics: submontane and montane chapter 8-9. *J Bryol* 4, 1-32.
- Glime JM. 2021. Chapter 1-15 Aquatic and Wet Marchantiophyta, Pallaviciniales. 4, 1-18.
- Gradstein R. 2016. The genus *Plagiochila* (Marchantiophyta) in Colombia. *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales* 40 (154): 104. DOI: 10.18257/raccefyn.272.
- Kruse DA. 2015. Floristics and biogeography of the bryophyte flora in the big Thicket National Preserve, Southeast Texas. Texas A&M University.
- Kuswanda W, Harahap RH, Alikodra HS, Sibarani R. 2021. Causal factors and models of human-Tapanuli orangutan conflict in Batang Toru landscape, North Sumatra, Indonesia. *Agric Nat Resour* 55 (3): 377-386. DOI: 10.34044/j.anres.2021.55.3.07.
- Lai G-Y, Liu H-C, Kuo AJ, Huang C-Y. 2020. Epiphytic bryophyte biomass estimation on tree trunks and upscaling in tropical montane cloud forests. *PeerJ* 8 (2020): e9351. DOI: 10.7717/peerj.9351.
- Majumdar S. 2021. Comments on the typification of *Plagiochila cuspidata* with a note on the morphology of *Plagiochila cuspidata* and *Plagiochila parvifolia* (Plagiochilaceae: Marchantiophyta). *Phytotaxa* 489 (1): 94-98. DOI: 10.11646/phytotaxa.489.1.8.
- Nadhifah A, Söderström L, Hagborg A, Iskandar EAP, Haerida I, Von Konrat M. 2021. An archipelago within an archipelago: A checklist of liverworts and hornworts of Kepulauan Sunda Kecil (Lesser Sunda Islands), Indonesia and Timor-Leste (East Timor). *PhytoKeys* 180, 1-30. DOI: 10.3897/phytokeys.180.65836.
- Pasaribu N. 2013. Studi pendahuluan lumut di lau Kawar, Kabupaten Karo. Prosiding Semirata 1 (1).
- Patzak SDF, Renner MAM, Schäfer-Verwimp A, Feldberg K, Heslewood MM, Peralta DF, de Souza AM, Schneider H, Heinrichs J. 2016. A phylogeny of Lophocoleaceae-Plagiochilaceae-Breviantaceae and a revised classification of Plagiochilaceae. *Org Divers Evol* 16 (3): 481-495. DOI: 10.1007/s13127-015-0258-y.

- Pócs T, Ochyra R, Bednarek-Ochyra H. 2016. *Lepidozia cupressina* (Marchantiopsida, Lepidoziaceae) in Sub-Saharan Africa, with a note on the taxonomic status of *L. chordulifera*. Cryptogam Bryol 37 (2): 125-147. DOI: 10.7872/cryb/v37.iss2.2016.125.
- Singh D, Dey M, Singh DK. 2010. A synoptic flora of liverworts and hornworts of Manipur.
- Singh D, Singh DK. 2020. *Dinckleria singularis* (Marchantiophyta: Plagiochilaceae)-An Addition to the Indian Liverwort Flora from Arunachal Pradesh. Shokubutsu Kenkyu Zasshi.
- Siregar ES, Pasaribu N. 2019. The liverworts family Plagiochilaceae of Taman Eden 100 Natural Park, North Sumatra Indonesia. IOP Conf Ser Earth Environ Sci 374, 12020. DOI: 10.1088/1755-1315/374/1/012020.
- Siregar ES. 2015. The Liverworts (Marchantiophyta) of Mount Sibayak North Sumatra. [Dissertation] Institut Pertanian Bogor, Bogor. [Indonesian]
- Siregar ES, Pasaribu N, Fitriana. 2018. Species of liverworts Family Plagiochilaceae of Mount Lubuk Raya North Sumatera Indonesia. J Phys Conf Ser 1116 (5). DOI: 10.1088/1742-6596/1116/5/052062.
- Siregar ES, Sartina E, Pasaribu N. 2020. The liverwort family Lejeuneaceae (Marchantiophyta) of Mount Lubuk Raya, North Sumatra, Indonesia. Biodiversitas 21 (6): 2767-2776. DOI: 10.13057/biodiv/d210653.
- So ML. 2001. Plagiochila (Hepaticae, Plagiochilaceae) in China. Syst Bot Monogr. DOI: 10.2307/25027887.
- Söderström L, Hagborg A, von Konrat M. 2022. Notes on early land plants today 75. Rejection of *Taxilejeunea parvibracteata* from SE Asia. Lindbergia 2022 (1). DOI: 10.25227/linbg.01153.
- Söderström L, Hagborg A, von Konrat M, Bartholomew-Began S, Bell D, Briscoe L, Brown E, Cargill DC, Costa DP, Crandall-Stotler BJ, Cooper ED, Dauphin G, Engel JJ, Feldberg K, Glenny D, Gradstein SR, He X, Heinrichs J, Hentschel J, ... Zhu R.-L. 2016. World checklist of hornworts and liverworts. PhytoKeys 59 (1): 828. DOI: 10.3897/phytokeys.59.6261.
- Verma PK, Rawat KK, Yadav A. 2013. *Plagiochila bantamensis* (Reinw. et al.) Mont. of the subgenus *Metaplagiochila* Inoue (Marchantiophyta: Plagiochilaceae) new to the liverwort flora of the Indian Mainland. Taiwania 58 (2): 124-127. DOI: 10.6165/tai.2013.58.124.