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Thalloid Liverworts in Waterfall and Stream Habitats of Deli Serdang Regency, North Sumatera

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Abstract: Indonesia is known as a country that has very abundant biodiversity, one of which is moss. Mosses are non-vascular plants, small in size, and play a crucial role in forest ecosystems as pioneer plants, water reservoirs, erosionreducers, bioindicators, andmedicinal resources. Theresearchaims tocollect data and information regarding liverwort species in Deli Serdang Regency, North Sumatra, specifically focusing on sampling points along rivers and waterfalls as potential habitats for liverwort life. Thalloid liverwort sampling was conducted using an exploratory survey method, which involved exploring along the courseof rivers and waterfalls. The research findings revealed 6 species of liverworts, consisting of 3 genera and classified into 2 families: Marchantiaceae (Marchantia with 4 species, Dumortiera with 1 species) and Metzgeriaceae (Metzgeria with 1 species). Commonly found species at the location include Dumortiera hirsuta, Marchantia paleacea, and Metzgeria, while the least encountered species are Marchantia treubii, Marchantia pinnata, and Marchantia emarginata.

Keywords: Deli serdang regency; Exploratory surveys; Marchantiaceae; Metzgeriaceae; Thalloid liverwort.

Introduction

Indonesia is renowned as a country with an incredibly rich biodiversity, one of which includes mosses. Mosses are small, non-vascular plants that exhibit an alternating life cycle between haploid and diploid generations, with a more dominant gametophyte phase (Azwir et al., 2022; Dey & Nath De, 2011; Endang et al., 2020). These plants are vital components of tropical ecosystems, inhabiting regions from lowlands to mountainous areas. Mosses play essential roles in forest ecosystems, functioning as pioneer species, water reservoirs, erosion reducers, bioindicators, and sources of medicinal compounds (Atwood & Buck, 2020; Firdaus, 2020; Frahm, 2003; Tan, 2003; Susilo et al., 2022).

Mosses are classified into three groups: liverworts (Marchantiophyta), hornworts (Anthocerotophyta), and true mosses (Bryophyta). Liverworts are the simplest in terms of morphological structure, typically consisting of a single cell layer (unicellular). Based on gametophyte structure, liverworts are further divided into two groups: thallose liverworts and leafy liverworts (Ginting et al., 2021; Govindapyari et al., 2010; Utami et al., 2020).

Mosses have not received significant attention from Indonesian botanists due to their small size and the challenges involved in their identification. As a result, research and knowledge about mosses in Indonesia remain limited compared to other Southeast Asian countries. Liverwort research in Sumatra experienced a long hiatus and was only revived in the 1970s (Azwir et al., 2022; Kofuji & Hasebe, 2014; Linde et al., 2023; Mohanasundaram & Pandey, 2022).

Moreover, mosses, especially liverworts, hold promise as medicinal plants, creating opportunities for further research and exploration of this plant group. Their application in ethnopharmacology has been observed in various cultures globally, notably in traditional medicine practices in China, India, and among Native American communities. A total of 109 wild

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Bryophyta taxa have been documented for ethnomedicine purposes (Motti et al., 2023).

The diversity of liverworts in North Sumatra is notably high, as evidenced by studies conducted in various locations, including Mount Sinabung, Law Kawar, Mount Sibayak, Sicike-cike Nature Park, Sibuatan, and Batang Toru. Reported liverwort diversity includes findings by Schafer-Verwimp (2006) of species from the genus Diplasiolejeunea; (Pasaribu, 2013), who reported five species from four families: Marchantiaceae, Pallavicineaceae, Ricciaceae, and Pleuroziaceae; (Kasiani et al., 2019), who reported two species from two families: Marchantiaceae and Pallavicineaceae; (Susilo et al., 2022), who reported 84 liverwort species; (Damanik et al., 2022a), who reported 13 species from the family Plagiochilaceae; and (Azwir et al., 2022), who reported three species from the family Marchantiaceae.

These studies have predominantly focused on liverworts as a whole. However, research specifically on thallose liverworts remains limited and has only been conducted in a few locations in North Sumatra. Therefore, there is a need for further exploration to collect specimens of thallose liverworts from North Sumatra and to conduct floristic studies on these liverworts, which have not been fully explored. This research aims to enhance our understanding of the diversity of liverworts, particularly thallose liverworts, including both recorded species and new records in North Sumatra.

Method

The study was conducted in two locations, specifically within the Deli Serdang Regency area, comprising four sites: (1) Satu Hati Waterfall, (2) Batu Belah Waterfall, (3) Sampuren Putih River Stream, and (4) Sikulikap Waterfall and River Stream in Negeri Suah. Subsequently, the research was carried out at the Plant Taxonomy Laboratory, Faculty of Science and Technology, Universitas Medan Area.

The equipment used in the study included a knife (a chisel tool), specimen envelopes, plastic clips, tissue paper, a 15-20x magnifying glass, GPS, a microscope, glass slides, cover slips, razor blades, syringes, writing tools, label paper, a camera, a ruler, a raincoat, and identification books. The materials used in this study were thalloid liverworts and distilled water.

The research employed an exploratory survey method by conducting field exploration along river and waterfall pathways. The selection of research locations and samples was carried out purposively, focusing on locations within the Deli Serdang Regency that feature waterfalls and river streams, which have the potential to serve as habitats for thalloid liverworts, the target species collected in this study.

The GPS (Global Positioning System) coordinates of each sampling site were recorded to create a distribution map of the thalloid liverwort species found. The samples collected were as complete as possible, including both vegetative and generative organs, which were photographed and collected using a chisel tool. The samples were then placed in specimen envelopes labeled with collection numbers, dates, and the name of the collector.

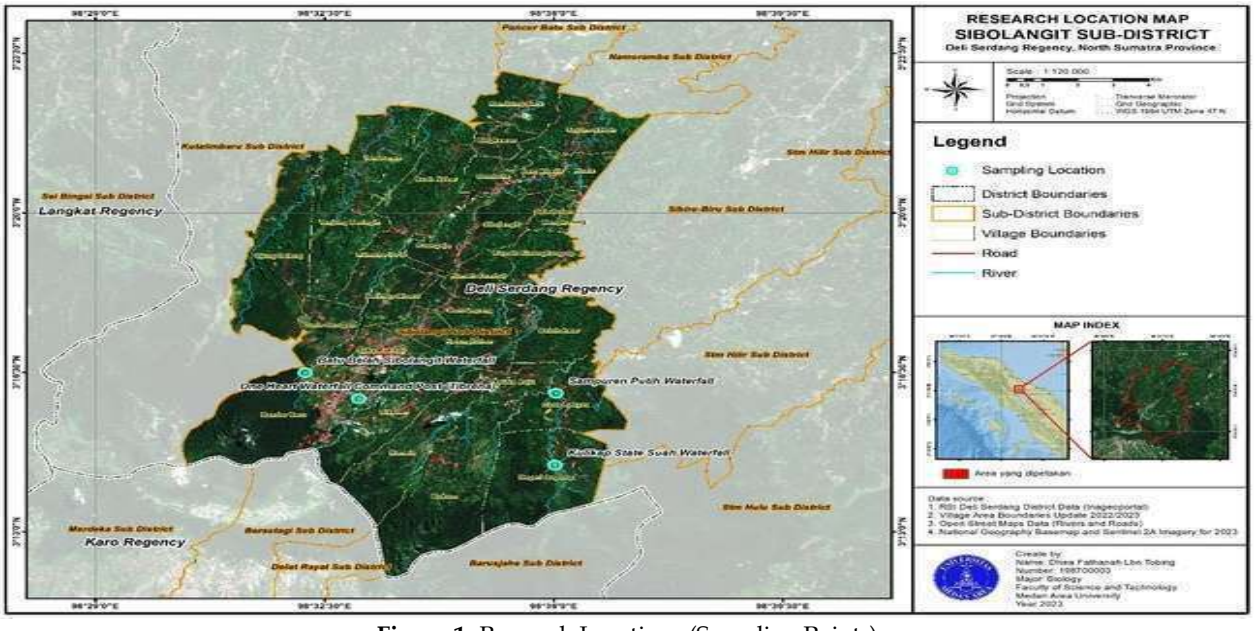

Figure 1. Research Locations (Sampling Points)

The liverwort samples collected in the field were subsequently replaced with fresh envelopes and air-dried to prevent damage, moisture, and mold growth. The dried specimens were stored at the Plant Taxonomy Laboratory, Faculty of Science and Technology, Universitas Medan Area, Medan. Collected specimens were identified using identification keys and species descriptions from various available literature sources, particularly (Crandall-Stotler & Stotler, 2012; Gradstein, 1992; Gradstein et al., 2001) and other publications on Malesian and Asian liverworts, such as (Damanik et al., 2022a, 2022b; Siregar et al., 2018, 2020; Siregar & Pasaribu, 2019; Susilo et al., 2019, 2022, 2023). The identification process, based on morphological characteristics, was conducted at the Plant Taxonomy Laboratory, Faculty of Science and Technology, Universitas Medan Area, using a magnifying glass and microscope. The observed specimens were measured and documented using a camera. The implementation of the research can be presented in the following flowchart:

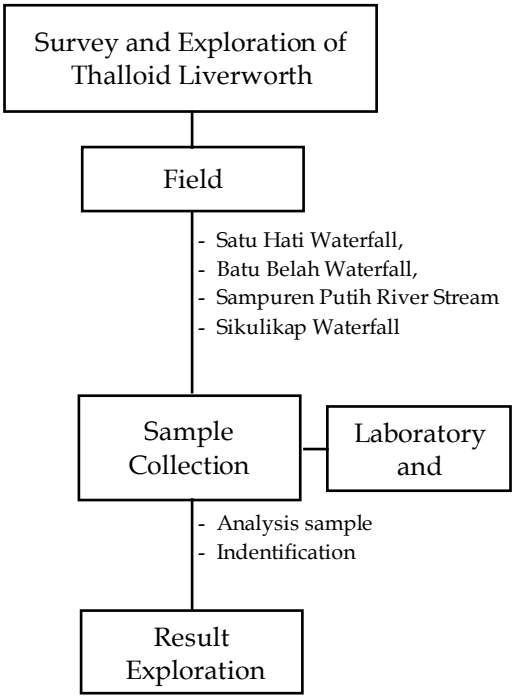

Figure 2. Research Stage

Result and Discussion

Diversity and Distribution of Thalloid Liverwort Species in Deli Serdang, North Sumatra

The results of the study on the diversity and distribution of thalloid liverworts across four waterfall and stream locations in Deli Serdang Regency (Figure 1) revealed the presence of six thalloid liverwort species belonging to two families (Marchantiaceae and Metzgeriaceae) and three genera: *Marchantia*, *Dumortiera*, and *Metzgeria*. The Marchantiaceae family had the highest number of species (five), while Metzgeriaceae contained only one species (Table 1). The identified thalloid liverwort species were *Dumortiera hirsuta, Marchantia emarginata, Marchantia paleacea, Marchantia pinnata, Marchantia treubii,* and *Metzgeria sp.*

Table 1. Number of families, genera, and thalloid liverwort species in the waterfalls and streams of Deli Serdang Regency

Family	Number of Genera	Number of Species
Marchantiaceae	2	5
Metzgeriaceae	1	1

The distribution of species was recorded based on sample locations with varying substrate types, including soil and rocks, in both open and closed, humid areas. The results indicated that *Dumortiera hirsuta* was the most frequently encountered species. According to observations, this species was found at three waterfall locations: Satu Hati Waterfall, Batu Belah Waterfall, and Sikulikap Waterfall and Stream in Negeri Suah (Table 2), with rocky substrates (rocky walls) as its growing habitat.

Several locations in North Sumatra have been identified as habitats for the thalloid liverwort genera Dumortiera and Marchantia, which typically thrive in soil and rocky environments (Siregar et al., 2013; Siregar & Susilo, 2025).

Table 2. Diversity and Distribution of Thalloid Liverworts in the Waterfalls and Streams of Deli Serdang Regency (I = Satu Hati Waterfall; II = Batu Belah Waterfall; III = Sampuren Putih Stream; IV = Sikulikap Waterfall and Stream in Negeri Suah)

Family	Genus	Spesies	Growing Substrate	Location
Marchantiaceae	Marchantia	*M. treubii*	Soil or rock in open areas	I
		M. pinnata	Soil, rocky areas	II
		M. paleacea	Brick in open areas	III, IV
		M. emarginata	Soil, moist rocks	II
	Dumortiera	*D.hirsuta*	Rocky walls	I, II, IV
Metzgeriaceae	Metzgeria	*Metzgeria* sp	Moist rocks	II, IV

Dumortiera hirsuta, Marchantia paleacea, and Metzgeria sp. were the species most commonly found in waterfall locations, while Marchantia treubii, Marchantia pinnata, and Marchantia emarginata were the least encountered species. Among the six species identified at the research sites, the Marchantiaceae family was the most dominant at each location. The Marchantiaceae family is a group of thalloid liverworts that are often found to be dominant in various locations due to their broad habitat tolerance, making them easily found in a wide range of habitat types.

Additionally, Marchantiaceae have two modes of reproduction: generative reproduction through spores and vegetative reproduction through gemmae located at the tips of their leaves. When these gemmae detach from the leaf tips and land on a suitable substrate supported by favorable environmental conditions, they can grow and develop into new liverwort plants. The presence of these two reproductive methods allows for a wider distribution compared to other liverwort species, making them frequently encountered in nature (Ho, 2013; Siregar et al., 2013; Susilo et al., 2019).

The research site most densely populated with thalloid liverwort species was location II (Batu Belah Waterfall). This site hosted four thalloid liverwort species: Marchantia pinnata, Marchantia emarginata, Dumortiera hirsuta, and Metzgeria sp. Conversely, the site with the fewest thalloid liverwort species was location III, Sampuren Putih Stream (Figure 2).

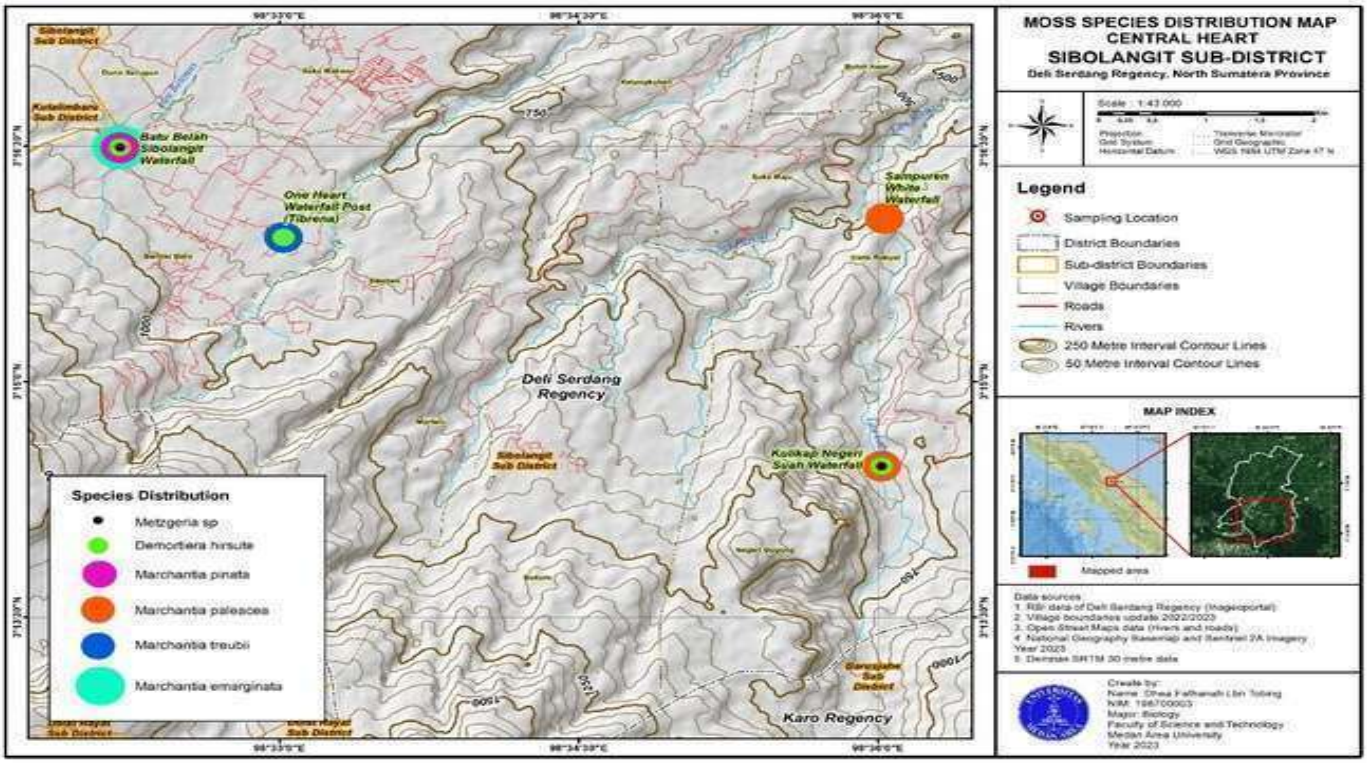

Figure 2. Distribution map of thalloid liverwort species in Deli Serdang Regency, North Sumatra

The distribution of thalloid liverwort species across the research sites varied, indicating species differences at each location. This variation is likely due to differences in elevation and habitat characteristics at the research sites, such as temperature, humidity, light intensity, and altitude. Typically, liverworts thrive within a temperature range of 15-30°C, humidity at 45%, and light intensity between 100-1050 Cd (Sulistyowati et al., 2014; Rohmah, 2018; Endang et al., 2020).

The high number of thalloid liverwort species found at location II (Batu Belah Waterfall) is attributed to the suitability of this site as a habitat for thalloid liverworts, particularly the genera *Marchantia*, *Dumortiera*, and *Metzgeria*. Batu Belah Waterfall is situated at coordinates N 30°16'30.7" E 98°32'12.5" at an elevation of 859 meters above sea level. The waterfall is surrounded by dense, shaded vegetation, which results in minimal sunlight penetrating the forest, creating a cool and humid environment. These moist conditions support the growth of thalloid liverworts, which are commonly found on cliff walls and rocks along the riverbanks in this area.

Identification Key

1. a. The thallus surface has small pores or lacks pores, with ventral scales in 2 rows or without ventral scales 2
   b. The thallus surface has pores, with ventral scales

covering nearly the entire ventral surface in 4-6 rows 3

2. a. Thallus is dark green, thick, with more than one cell layer, and the thallus size is large (0.8 – 2 cm) ..... 1. *Dumortiera hirsute*
   b. Thallus is light green, thin, single-layered, with a small thallus size of less than 3 mm ..... 2. *Metzgeria* sp
3. a. Thallus has a distinct midline (median line) 4
   b. Thallus lacks a midline (median line) 5
4. a. Thallus apex with 2-3 notche…… ……3. *Marchantia pinnata*
   b. Thallus apex with 3-4 notches……..... …… 4. *Marchantia treubii*
5. a. Thallus is large, with a size greater than 5 mm, without appendages ..... 5. *Marchantia paleacea*
   b. Thallus is small, with a size less than 5 mm, with appendages ..... 6. *Marchantia emarginata*

Species Descriptions

1. ***Dumortiera hirsuta* (Sw.) Nees.** Reference: Reinwardt, C. G. C., C. L. von Blume & C. G. D. Nees von Esenbeck. 1825. *Hepaticarum Iavanicarum, in hoc volumine a pag. 181–238 illustratarum, supplementum*. Nova Acta Phys.-Med. Acad. Caes. Leop-Carol. Nat. Cur. 12(1): 409–417.
   Thallus: Dark green with hairs along the edges, dichotomously branched, 1-1.4 cm wide. Dorsal surface: No median line, absence of epidermal pores and air chambers.
   Ventral surface: Indistinct, small, hyaline scales arranged in two rows. Antheridiophore: Disc-shaped with hairs along the edge, concave in the center, with a short stalk and sessile. Archegoniophore: With 6-9 lobes, the stalk with two rhizoid grooves. Spores: Brown and tuberculate on the proximal side. Geographical Distribution: Sri Lanka, Indonesia (Java) (Li et al., 2019; Liu et al., 2012; Piippo & Koponen, 2013). Habitat and Ecology: Found on soil (in wet areas, waterfalls) and on riverbank rocks in semi-shaded areas, at an elevation of 860 meters above sea level.
2. ***Marchantia emarginata* Reinw., Blume & Nees subsp. Tosana (Steph.) Biscl.** Reference: Crypt. Bryol. Lichenol.10:77, 1989; Bischler in *Bry. Alkitab.* 38: 195, 1989; Lin, *Flora Lumut Hati dari Taiwan* 235, 2000.
   Thallus: Green or dark green, branched, 0.5-0.8 cm wide, relatively slender with edges. Dorsal surface: Indistinct or absent median line, characteristic compound air pores, cup-shaped gemmae cups, lobes usually linear, uneven, without serrations at the edges. Ventral surface: Pale yellowish rhizoids; scales are crescent-shaped; appendages are diamond-shaped with serrated edges. Reproduction: Dioecious. No generative organs were observed. Geographical Distribution: Japan, Korea, China, India, Sri Lanka, Andaman and Nicobar Islands, Thailand, Malaysia, Indonesia (Sumatra, Java, Lesser Sunda Islands, Bali, Maluku, Papua), Kalimantan (Sabah, Sarawak), Philippines, Marianas, Guam, New Guinea, New Britain, Solomon Islands (Lu & Huang, 2017; Piippo & Koponen, 2013; Zheng & Shimamura, 2022b, 2022a). Habitat and Ecology: Found on soil, rocks (moist, damp or wet, shaded, semi-open areas along riverbanks and streams) at elevations ranging from 870 to 1450 meters above sea level.
3. ***Marchantia paleacea* Bertol., Opusc. Sci.** 1(4): 242. 1817. Thallus: green to grayish-green, branched, 1-2 cm wide, relatively large, with wavy edges. Dorsal surface: no median line; characteristic compound air pores; cupules are cup-shaped; lobes are triangular with 2-3 teeth at the base. Ventral surface: rhizoids are pale yellowish; scales are crescent-shaped, purple or pale; appendages are triangular to ovate-triangular, tapering at the apex, with slight serrations or smooth edges. Dioicous. Archegoniophore: with a knobbed apex, has 6-9 lobed lamina; stalk length is 1.3-2.3 cm. Antheridiophore: irregularly lobed, with 7-9 lobed lamina; stalk length is 1.5-2.5 cm. Geographical distribution: Turkey, Lebanon, Iran, Yemen, Russia, Soviet Union, Afghanistan, Pakistan, India, Bhutan, China, Taiwan, Korea, Japan, Thailand, Vietnam, Indonesia (Sumatra, Java, Irian Jaya), Kalimantan, the Philippines, New Guinea (Bischler & Piippo, 1991; Piippo & Koponen, 2013; Singh & Singh, 2013; Zheng & Shimamura, 2022b, 2022a).
   Habitat and ecology: soil (wet areas, waterfalls); riverbank rocks in semi-shaded areas, at elevations from 1150 to 1250 meters above sea level.
4. ***Marchantia pinnata* Steph., Candollea** 14: 109. 1953. Thallus: grayish-green, branched, 0.4-0.7 cm wide, entirely along the edges, typically adhering to the substrate. Dorsal surface: a distinct median line is present, with scattered and characteristic compound pores, cupules are cup-shaped. Ventral surface: numerous pale yellowish rhizoids are present; scales are purple or dark purple, crescent-shaped, with appendages that are ovate to elongated with fins. Archegoniophore: absent on one side, initially fist-like, spreading and divided at maturity, with 4-5 unequal lobed lamina; stalk length is 0.3-0.5 cm. Geographical distribution: Japan, Ryukyu Islands, and Taiwan (Bischler & Piippo, 1991). Habitat and ecology: on moist soil below 1500 meters above sea level.
5. ***Marchantia treubii* Schiffn. Denkschr. Kaiserl. Akad. Wiss.**, Wien Math.-Naturwiss. Kl. 67: 160.

1898. Thallus is light green with black veins and appears to have white dots across its surface. It is 0.5-0.8 cm wide, ribbon-shaped with dichotomous branching, and has a wavy thallus apex. Dorsal surface: no gemma cups are present. Ventral surface: the ventral scales are purple, with median scales shaped like ovals. The plant is dioecious. Archegoniophore: protrusions on top with 6-9 lobes and a stalk length of 1-3 cm. Antheridiophore: irregularly bordered, with 7-9 lobes and a stalk length of 1.5-2.5 cm. Geographical distribution: Indonesia (Sumatra, Java, Lesser Sunda Islands), Borneo, Malaysia (Bischler & Piippo, 1991; Piippo & Koponen, 2013). Habitat and ecology: Soil or rock in open and semi-shaded areas, at an altitude of 870-1610 meters above sea level.

6. ***Metzgeria sp.*** **H. Klinggr., Höh. Crypt**. Preuss.: 10. 1858. Thallus: light green, thin, single-layered, and small, less than 3 mm in size, with dichotomous branching. The thallus has narrow laminae with hairy edges. The laminae have large epidermal cells without a central strand. The oil bodies are homogeneous. Ventral surface: the rhizoids are colorless, and the ventral scales are sparse. No reproductive organs were observed. Geographical distribution: Japan, Indonesia (Java, Sumatra, and Sulawesi), New Zealand, Africa, North America, California, New Mexico, and South America, known from southern Brazil to Colombia, Chile, Argentina, and Iran (Li et al., 2019; Zheng & Shimamura, 2022b, 2022a). Habitat and ecology: Soil (in wet areas, near waterfalls) and riverbank rocks in semi-shaded areas, at an altitude of 859 meters above sea level.

Conclusion

The study of thalloid liverworts in various waterfall and stream habitats in Deli Serdang Regency, North Sumatra, identified six species of thalloid liverworts belonging to two families: the Marchantiaceae family (five species) with two genera, *Marchantia* and *Dumortiera*, and the Metzgeriaceae family (one species) with the genus *Metzgeria*. The species commonly found at the locations were *Dumortiera hirsuta*, *Marchantia paleacea*, and *Metzgeria*. The least frequently encountered species were *Marchantia treubii*, *Marchantia pinnata*, and *Marchantia emarginata*. The distribution of thalloid liverworts varied, with the highest species count observed at location II (Batu Belah Waterfall) and the lowest at location III (Sampuren Putih Stream).

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We would like to express our sincere gratitude to the North Sumatra Natural Resources Conservation Agency for granting permission to conduct research at the designated sampling sites. The support and cooperation provided have been instrumental in ensuring the smooth progress of this research. We hope that this positive relationship will continue, contributing to the advancement of scientific knowledge, particularly in the field of plant taxonomy, while also preserving the biodiversity of North Sumatra's flora. Thank you for your attention and assistance.

Author Contributions
The following statements should be Ferdinand Susilo, Dhea Fathanah Lbn Tobing, Rahmiati and Jamilah Nasution, used Conceptualization contributed to the data collection process, data processing, article writing.

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Conflicts of Interest
The outhors declare no conflict of interest.

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