The liverworts family Lepidoziaceae in Aek Nauli Parapat natural forests, North Sumatra, Indonesia

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Abstract. Information on the liverworts family Lepidoziaceae of Sumatra is still limited. The aim of this study is to explore the diversity of Lepidoziaceae in Aek Nauli, Parapat Natural Forests, North Sumatra. Exploration was carried out along the hiking trails of study site. Seventeen species of Lepidoziaceae were found, consist of 2 genera: Bazzania (15 species, and Lepidozia (2 species). All liverworts species of Lepidoziaceae were found as epiphyte on the tree trunk, and some species on the decaying wood, rocks and soil. The most common species found in the study sites was Bazzania tridens while the rare species found were Bazzania japonica, Bazzania longicaulis, Bazzania paradoxa and Bazzania spiralis.

1. Introduction

Indonesia's forest area is a tropical rainforest known for its high diversity of flora including Bryophyte [1]. Bryophyte consists of about 17.100 species spread out all over the world. Bryophyte was mainly found in both moderate light intensity, and humid area compare with another plant. They usually grow on different substrates such as trees, stones, decayed wood and on the ground [2].

Bryophyte is classified as a non-vascular plant that has no roots, stems, and true leaves. They are attaching to the substrate by the structure like root, namely as rhizoid [3]. Bryophytes were divided into three groups systematically, hornworts (Anthocerotophyta), liverworts (Marchantiophyta), and mosses (Bryophyta) [4]. According to their body structure, liverworts are classified into two group, leafy and thalloid liverworts. The group that has leaves is called leafy liverworts, while the group with the structure of thallus is called the thallus liverworts [5].

The types of leafy liverworts is more common than the types of thallus liverworts. Leafy liverworts commonly lives as epiphytes on the tree trunk and tree branches, somewhat grow on the leaves in lowland rain forest, one of them is Lepidoziaceae [1]. The species of Lepidoziaceae generally grows in tropical forests on the soil substrate, decayed wood, bark, and rock on the riverside with humid conditions. Lepidoziaceae is estimated about 440 species, including in 29 genera [6]. One of the most common genus of Lepidoziaceae is Bazzania, with 100 species spread out all over the world [7].

Some studies on the liverworts of North Sumatra were recently published, such as [8], [9]; [10]; [11]; [12]. However, the liverwort family Lepidoziaceae was neglected. The species of Lepidoziaceae that has been reported in North Sumatra are: 1 species in Lau Kawar Regency of Karo [13], 26 species in Mount Sibayak [14], 2 species in Simancik 1 Deli Serdang [11]. But so far, collections and information about Lepidoziaceae from Aek Nauli Parapat Natural Forest has not been reported.
Aek Nauli Parapat Natural Forest is one of the potential forest for Bryophyte habitat. Unfortunately, the condition of the forest has been disturbed due to the human activity. It is feared some species of Liverworts in the area will disappear before being investigated. So, it is necessary to study the liverwort family Lepidoziaceae to obtain data of their species richness in Aek Nauli, Parapat Natural Forests, North Sumatra.

2. Methods
The field research was conducted in Aek Nauli Parapat Natural Forest Area, Sub-district of Girsang Simpangan Bolon, Regency of Simalungun, North Sumatra Indonesia. The locality has an altitude of about ± 1200-1750 m, annual rainfall intensity of 2,525.22 mm, and air humidity average of 62.7%, with an area of ± 1,750 ha. Exploration was carried out along the tracks in the study site. Samples of Lepidoziaceae were collected using sharp knife from many substrates such as tree trunks, decaying woods, and rotten logs. Samples collected were put into paper envelopes separately. All information gathered on the specimens were written in the field notebook. Characteristics of the living liverworts such as color, growth form were noted. The data recorded from habitat were: the kind of substrate, humidity and altitudinal (measured using altimeter). GPS (Global Positioning System) was used for recording the coordinates of the collecting sites. The specimens collected were identified based on morphological characters, using Gradstein (2011) and other publications of Lepidoziaceae mainly from Asia. The collected specimens are deposited at Herbarium Medanense (MEDA), Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan. Description and identification key to the species of Lepidoziaceae from Aek Nauli Parapat Natural Forest are provided

3. Results and Discussions
There are seventeen species of liverworts family Lepidoziaceae belonging to 2 genera namely: Bazzania (15 species) and Lepidozia (2 species). In this study, there was no new record species found for Sumatra.

3.1. Identification Key of Lepidoziaceae in Aek Nauli Parapat

| Step | Option 1            | Option 2                          | Option 3                          | Option 4                          | Option 5                          |
|------|---------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| 1    | Pinnate branching   | B. loricata                       | B. vittata                        | B. paradoxa                       | B. calcarata                      |
| 2    | Leaves quadrate-oval, apex is lobed to \(\frac{1}{7}\) of leaf length | L. haskarliana                    | L. trichodes                      | B. praerupta                      | B. spiralis                       |
| 3    | Leaves rounded     | Bazzania sp.                      | B. praerupta                      | B. spiralis                       |                                   |
| 4    | Leaves are with vitta | B. vittata                      |                                   |                                   |                                   |
| 5    | Leaves are without vitta |                                   |                                   |                                   |                                   |
| 6    | Leaves apex with two teeth |                                   |                                   |                                   |                                   |
| 7    | Leaves margin entire |                                   |                                   |                                   |                                   |
| 8    | Leaves bases without an appendage |                                   |                                   |                                   |                                   |
| 9    | Leaves bases with an appendage |                                   |                                   |                                   |                                   |
| 10   | Underleaves rounded |                                   |                                   |                                   |                                   |
| 11   | Underleaves bases with an appendage |                                   |                                   |                                   |                                   |
| 12   | Underleaves bases without an appendage |                                   |                                   |                                   |                                   |
11. a. Underleaves bases with an appendage ................................. 2 B. caudistipula  
b. Underleaves bases entire .................................................... 13
12. a. Underleaves margin with hyaline cells (2-4 lines) .................... 4 B. erosa  
b. Underleaves margin without hyaline cells ............................... 14
13. a. Underleaves margin coarsely toothed ..................................... 7 B. japonica  
b. Underleaves margin crenulate ............................................... 15
14. a. Underleaves margin serrulate ................................................. 5 B. francana  
b. Underleaves margin crenulate ............................................... 6 B. indica
15. a. Underleaves apex are rounded .............................................. 3 B. densa  
b. Underleaves apex are crenulate ............................................. 16
16. a. Underleaves are with hyaline cells......................................... 13 B. tridens  
b. Underleaves are without hyaline cells ................................. 8 B. longicaulis

3.2. Species description
1) Bazzania calcarata (Sande Lac.) Schiffn.
Plant greenish to yellowish in the specimen; 2.1-2.8 mm wide. Leaves remote, lanceolate, 1.2-1.6 mm long and 0.4-0.6 mm wide; attachment of leaves on the stem curved, bases entire with an appendage, margin entire, apex with 3 sharp teeth, 2-6 cells long, 1-4 cells wide at the base; leaf cells rectangular-polygonal, thin-walled, trigones large, nodulose, cuticle cells verrucose. Underleaves are remote, quadrate, 0.6 mm long and 0.4 mm wide; attachment of lobe on the stem plane, bases with appendage; margin coarsely toothed, apex coarsely toothed. Generative organ not seen.
Specimens examined : Nababan 31, 99, 189, 191, 261, 266, 269, 301, 303, 355, 432
Distribution : Malaysia, The Philippines, Indonesia (Sumatra, Java, Borneo), Papua New Guinea
Ecology : Growing on the tree root, tree trunks, dead wood from 1199-1400 m asl.

2) Bazzania caudistipula (Steph.) Inoue & H. A. Miller
Plant yellowish green to blackish green in the specimen; 3-4.1 mm wide. Leaves imbricate, oval, 1.7-2.3 mm long and 1.2-1.5 mm wide; attachment of leaves on the stem curved, bases entire, margin entire, apex with 3 sharp teeth, 5-10 cells long, 5-8 cells wide at the base; leaf cells quadrate polygonal, thick-walled, trigones large, cuticle cells smooth. Underleaves imbricate, quadrate, 0.8-1.3 mm long and 0.5-1.2 mm wide; attachment of lobe on the stem plane, bases with appendage; margin coarsely toothed, apex with short teeth. Generative organ not seen.
Specimens examined : Nababan 16, 30, 44, 169, 235, 299, 333, 335, 338
Distribution : The Philippines, Indonesia (Sumatra, Java, Borneo), Papua New Guinea, Australia, Fiji
Ecology : Growing on the tree trunks, dead wood, rotten logs from 1240-1400 m asl.

3) Bazzania densa (Sande Lac.) Schiffn.
Plant greenish to yellowish in the specimen; 1.9-2.85 mm wide. Leaves imbricate, oblong-ovate, 0.7-1.4 mm long and 0.4-0.8 mm wide; attachment of leaves on the stem plane, bases entire, margin entire, apex with three sharp teeth, two cells long, 1-2 cells wide at the base; leaf cells rounded, thick-walled, trigones large, cuticle cells smooth. Underleaves remote, rounded-quadrate, 0.4-0.5 mm long and 0.3-0.5 mm wide; attachment of lobe on the stem plane, bases entire; margin crenulate, apex rounded. Generative organ not seen.
Specimens examined: Nababan 29, 56, 226, 315, 369, 437, 439
Distribution: Malaysia, The Philippines, Indonesia (Sumatra, Java), Australia
Ecology: Growing on the tree trunks, rotten logs from 1209-1400 m asl.

4) **Bazzania erosa** (Reinw. *et al.*) Trevis.

Plant greenish to yellowish in the specimen; 2.8-3.4 mm wide. Leaves contiguous, ovate, 0.6-1.9 mm long and 0.4-1.2 mm wide; attachment of leaves on the stem plane, bases entire, margin serrulate, apex with three teeth and doubly serrulate; leaf cells polygonal, thick-walled, trigones large, cuticle cells smooth. Underleaves contiguous, rounded-quadrately, 0.2-0.5 mm long and 0.3-0.6 mm wide; attachment of lobe on the stem curved, bases entire; margin entire, surrounded by a 2-4 line of hyaline cells, apex crenulate. Generative organ not seen.

Specimens examined: Nababan 09, 17-21, 30, 37, 41, 46, 51-64, 75-80, 84-97, 103, 108, 119-122, 124, 134, 143-147, 160-166, 172, 181-185, 195, 221, 232, 250-259, 270, 334, 336, 380, 391, 397, 413, 415, 427, 440, 447
Distribution: The Philippines, Thailand, Malaysia, Sabah, Indonesia (Sumatra, Java, Celebes, Halmahera), Papua New Guinea, Australia, Fiji
Ecology: Growing on the tree root, tree trunks, dead wood, rotten logs from 1213-1400 m asl.

5) **Bazzania francana** (Steph.) N. Kitag.

Plant greenish to yellowish in the specimen; 3.3-3.9 mm wide. Leaves contiguous, ovate, 1.5-1.8 mm long and 0.7-1 mm wide; attachment of leaves on the stem plane, bases entire, margin serrulate, apex with three teeth and doubly serrulate; leaf cells rectangular polygonal, thick-walled, trigones large, cuticle cells smooth. Underleaves contiguous, rounded-quadrately, 0.8-0.9 mm long and 0.6-0.8 mm wide; attachment of lobe on the stem plane, bases entire; margin serrulate, apex entire. Generative organ not seen.

Specimens examined: Nababan 426, 442, 444, 459
Distribution: The Philippines, Indonesia (Sumatra, Java, Borneo), Australia, New Caledonia
Ecology: Growing on the tree trunks from 1221-1303 m asl.

6) **Bazzania indica** (Gottsc & Lindenb.) Trevis.

Plant greenish to yellowish in the specimen; 2.1-2.9 mm wide. Leaves contiguous, ovate, 0.7-1.5 mm long and 0.5-0.9 mm wide; attachment of leaves on the stem plane, bases entire, margin serrulate, apex with three teeth and doubly serrulate; leaf cells rectangular polygonal, thick-walled, trigones large, cuticle cells smooth. Underleaves imbricate, rounded-quadrately, 0.2-0.4 mm long and 0.3-0.6 mm wide; attachment of lobe on the stem plane, bases entire; margin crenulate, apex crenulate. Generative organ not seen.

Specimens examined: Nababan 19, 23-26, 70, 74, 107, 111, 112, 125, 131-149, 153, 156-165, 168, 170, 171, 173, 176-178, 183, 187, 192, 193, 196-198, 200, 201, 205, 206, 208-213, 217, 237, 243, 260, 287, 293, 311, 323-329, 331, 332, 337, 339, 346, 360, 362, 363, 370, 378, 389, 398, 402-406, 430, 449, 454, 462
Distribution: Thailand, Malaysia, Singapore, Indonesia (Sumatra, Java)
Ecology: Growing on the tree root, tree trunks, dead wood, rotten logs, ground from 1199-1400 m asl.
7) **Bazzania japonica** (Sande Lac.) Lindb
Plant greenish to yellowish in specimen; 3.1-3.5 mm wide. Leaves imbricate, oblong, 1.4-1.7 mm long and 0.3-0.7 mm wide; attachment of leaves on the stem plane, bases entire, margin entire, apex with 3 sharp teeth, 1-2 cells long, 1-2 cells wide at the base; leaf cells rounded-quadrat, thin-walled, trigones large, cuticle cells smooth. Underleaves imbricate, quadrat, 0.3-0.5 mm long and 0.2-0.4 mm wide; attachment of lobe on the stem plane, bases entire; margin coarsely toothed, apex coarsely toothed. Generative organ not seen.
Specimens examined : Nababan 180, 322
Distribution : Japan, Korea, Taiwan, Hongkong, Thailand, Vietnam, Indonesia (Sumatra, Java)
Ecology : Growing on the tree trunks from 1247-1400 m asl.

8) **Bazzania longicaulis** (Lac.) Schiffn.
Plant greenish in specimen; 3.8-4.5 mm wide. Leaves imbricate, oblong, 1.8-2.5 mm long and 1-1.2 mm wide; attachment of leaves on the stem plane, bases entire, margin entire, apex with 3 sharp teeth, 3-5 cells long, 3-5 cells wide at the base; leaf cells rectangular, thick-walled, trigones large, cuticle cells smooth. Underleaves remote, quadrat-rounded, 0.5-0.8 mm long and 0.4-0.8 mm wide; attachment of lobe on the stem curved, bases plane; margin crenulate, apex crenulate. Generative organ not seen.
Specimens examined : Nababan 10, 11
Distribution : The Philippines, Sabah, Indonesia (Sumatra, Java, Borneo)
Ecology : Growing on the tree trunks from 1213 m asl.

9) **Bazzania loricata** (Reinw., Blume & Nees) Trevis.
Plant brownish green in the specimen; 2.8-3.1 mm wide. Leaves contiguous, rounded-quadrat, 0.8-1.3 mm long and 0.6-1.5 mm wide; attachment of leaves on the stem curved, bases entire, margin entire, apex entire; leaf cells rectangular polygonal, thick-walled, trigones large, cuticle cells smooth. Underleaves contiguous, rounded, 0.6-1.0 mm long and 0.8-1.2 mm wide; attachment of lobe on the stem curved, bases with appendage; margin entire, apex crenulate. Generative organ not seen.
Specimens examined : Nababan 62, 211, 274, 340, 401, 457, 463
Distribution : Hawaii, Thailand, Malaysia, The Philippines, Indonesia (Sumatra, Java), Australia
Ecology : Growing on the tree root, tree trunks, dead wood from 1221-1303 m asl.

10) **Bazzania paradoxa** (Sande Lac.) Steph.
Plant yellowish green in the specimen; 3.5-4.1 mm wide. Leaves imbricate, lanceolate, 1.5-2.1 mm long and 0.8-1.2 mm wide; attachment of leaves on the stem curved, bases entire with an appendage, margin entire, apex with three sharp teeth, 6-7 cells long, 3-5 cells wide at the base; leaf cells rectangular rounded, thick-walled, trigones large, cuticle cells smooth. Underleaves remote, quadrat, 0.5-1.1 mm long and 0.6-0.9 mm wide; attachment of lobe on the stem curved, bases entire and with an appendage; margin with long toothed, apex with long toothed. Generative organ not seen.
Specimens examined : Nababan 214, 357
Distribution : Thailand, Malaysia, Singapore, Indonesia (Sumatra, Java, Borneo), Fiji, Tonga, Samoa
Ecology : Growing on the tree trunks from 1199-1247 m asl.

11) **Bazzania praerupta** (Reinw. et al.) Trevis.
Plant greenish to yellowish in the specimen; 0.8-2.6 mm wide. Leaves imbricate, ovate, 0.9-1.7 mm long and 0.5-1.1 mm wide; attachment of leaves on the stem plane, bases entire, margin entire, apex
with three teeth, three cells long, 6-8 cells wide at the base; leaf cells quadrate-oval, thick-walled, trigones large, cuticle cells smooth. Underleaves remote, rounded, 0.2-0.4 mm long and 0.4-0.7 mm wide; attachment of lobe on the stem curved, bases with an appendage; margin coarsely toothed, apex coarsely toothed. Generative organ not seen.

Specimens examined : Nababan 29, 45, 83, 126

Distribution : Hawaii, Nepal, India, Assam, Burma, Japan, Taiwan, Thailand, Vietnam, the Philippines, Indonesia (Sumatra, Java, Borneo, Celebes)

Ecology : Growing on the tree trunks from 1234-1242 m asl.

12) **Bazzania spiralis** (Gottsche & Lindenb.) Trevis.

Plant greenish in the specimen; 2.6-3.8 mm wide. Leaves contiguous, oblong, 1.4-1.9 mm long and 0.4-0.6 mm wide; attachment of leaves on the stem plane, bases entire, margin entire, apex with three teeth and double serrulate; leaf cells quadrate polygonal, thick-walled, trigones small, cuticle cells smooth. Underleaves remote, rounded, 0.2-0.3 mm long and 0.3-0.4 mm wide; attachment of lobe on the stem curved, bases curved toward the ventral; margin entire, apex crenulate. Generative organ not seen.

Specimens examined : Nababan 73, 127

Distribution : Thailand, Malaysia, Indonesia (Sumatra, Java, Borneo)

Ecology : Growing on the tree trunks from 1234-1242 m asl.

13) **Bazzania tridens** (Reinw. et al.) Trevis.

Plant greenish to dark green in the specimen; 2.3-3.1 mm wide. Leaves contiguous, oblong-ovate, 0.9-1.6 mm long and 0.3-0.7 mm wide; attachment of leaves on the stem plane, bases entire, margin entire, apex with three sharp teeth, four cells long, five cells wide at the base; leaf cells rectangular-ovul, thin-walled, trigones small, cuticle cells smooth. Underleaves imbricate, quadrate, made up of hyaline cells, 0.2-0.6 mm long and 0.2-0.5 mm wide; attachment of lobe on the stem plane, bases entire; margin crenulate, apex crenulate. Generative organ not seen.

Specimens examined : Nababan 05, 20, 22, 38-43, 47, 55, 60, 61, 67-72, 79, 87, 98, 101, 109, 117, 118, 123, 135, 152, 155, 159, 164, 167, 174, 175, 182, 186, 199, 202, 203, 207, 213, 215, 218, 222, 227, 239, 263-271, 276-285, 321, 348, 350, 358, 359, 364-368, 372, 373, 377-388, 393-404, 418, 422-426, 429, 433-441

Distribution : India, Taiwan, Thailand, Vietnam, Malaysia, Singapore, Indonesia (Sumatra, Java, Borneo, Celebes)

Ecology : Growing on the tree root, tree trunks, rocks, rotten logs, dead wood, ground from 1199-1400 m asl.

14) **Bazzania vitata** (Lindenb. & Gottsche) Trevis.

Plant greenish in the specimen; 1.2-2.6 mm wide. Leaves remote, oblong-ovate, 0.5-1.2 mm long and 0.2-0.3 mm wide; attachment of leaves on the stem plane, bases entire, margin entire, apex with 3 teeth, obtuse; leaf cells quadrate-ovul, has vitta (4-6 lines), thin-walled in center and thick-walled in margin, trigones large, papillose, cuticle cells verrucose. Underleaves imbricate, quadrate, hyaline cells, 0.2 mm long and 0.2 mm wide; attachment of lobe on the stem plane, bases entire; margin entire, apex entire. Generative organ not seen.
Specimens examined : Nababan 66, 279, 361, 386, 419
Distribution : Taiwan, Thailand, Malaysia, Indonesia (Sumatra, Java, Borneo, Celebes, Ambon), Papua New Guinea, Fiji
Ecology : Growing on the tree trunks, rocks, rotten logs from 1221-1293 m asl.

15) **Bazzania sp.**
Plant greenish to yellowish in the specimen; 2-2.8 mm wide. Leaves remote, lanceolate, 0.8-1.4 mm long and 0.2-0.3 mm wide; attachment of leaves on the stem plane, bases entire, margin entire, apex with two sharp teeth, 3-4 cells long, 2-3 cells wide at the base; leaf cells quadrate polygonal, thin-walled, trigones small, cuticle cells smooth. Underleaves remote, quadrate, 0.2-0.4 mm long and 0.2-0.3 mm wide; attachment of lobe on the stem plane, bases entire; margin coarsely toothed, apex coarsely toothed. Generative organ not seen.
Specimens examined : Nababan 66, 279, 361, 386, 419
Ecology : Growing on the tree trunks from 1234-1283 m asl.

16) **Lepidozia haskarliana** (Gottsche, Lindenb. & Nees) Steph.
Plant greenish to yellowish in the specimen; 0.1-0.3 mm wide. Leaves remote, quadrate-oval, 0.05-0.12 mm long and 0.03-0.07 mm wide; attachment of leaves on the stem curved, bases entire, margin entire, apex lobed to \( \frac{1}{7} \) of leaf length; leaf cells rectangular, thick-walled, trigones small, cuticle cells smooth. Underleaves remote, quadrate, 0.01-0.02 mm long and 0.01-0.02 mm wide; attachment of lobe on the stem curved, bases entire; margin entire, apex with four teeth, three cells long, one cell wide at the base. Generative organ not seen.
Specimens examined : Nababan 13, 14, 50, 63, 223, 229, 240, 244-247, 258, 272, 288-291, 297, 302, 307, 317, 330, 344, 408, 410-412, 416, 421, 428, 444, 448, 452, 461, 464
Distribution : Thailand, Malaysia, The Philippines, Indonesia (Sumatra, Java, Borneo, Celebes, Maluku, Papua), Papua New Guinea
Ecology : Growing on the tree trunks from 1213-1400 m asl.

17) **Lepidozia trichodes** (Reinw. ex Blume & Nees).
Plant greenish to yellowish in the specimen; 0.9-1.2 mm wide. Leaves imbricate, rectangular, 0.4-0.6 mm long and 0.1-0.2 mm wide; attachment of leaves on the stem plane, bases entire, margin entire, apex lobed to \( \frac{1}{4} \) of leaf length; leaf cells quadrate polygonal, thick-walled, trigones large, cuticle cells smooth. Underleaves imbricate, quadrate-rounded, 0.3-0.4 mm long and 0.3-0.4 mm wide; attachment of lobe on the stem plane, bases entire; margin entire, apex with four sharp teeth, six cells long, 1-2 cells wide at the base. Generative organ not seen.
Specimens examined : Nababan 209, 234, 312, 409, 414
Distribution : India, Japan, Malaysia, The Philippines, Indonesia (Sumatra, Java, Borneo, Ambon), Papua New Guinea
Ecology : Growing on the ground, tree trunks from 1221-1400 m asl.

4. **Conclusions**
A total of 17 species of liverworts family Lepidoziaceae were recorded from Aek Nauli Parapat Natural Forest, North Sumatra, including in 2 genera: *Bazzania* (15 species) and *Lepidozia* (2 species). The most common species recorded in the study is *Bazzania tridens*. The uncommon species recorded are *Bazzania japonica, Bazzania longicaulis, Bazzania paradoxa, and Bazzania spiralis*. 
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