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Mosses Diversity of Tumpak Sewu Waterfall, Lumajang, East Java

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Abstract

Mosses or bryophytes, belonging to the lower plants, can grow on higher plants (as epiphyte), stone (epilytic), bark (corticolus), and the surface of the soil. One of the important places in East Java and having a variety of potential mosses is Tumpak Sewu Waterfall (TSW). In this place, moss grows well because of the condition of the nature, humidity, and abundant air. This study aimed to identify and calculate the population of mosses at Tumpak Sewu Waterfall, Lumajang, East Java. The research sampling has been performed along hiking trip, riverside and tourist area of Tumpak Sewu Waterfall. Quadratic method by grid lines with a plot size of 1x1 m² on the right and left sides of the river was used to collect and calculate mosses population. Mosses identification was performed using mosses identification key. The population data obtained from this study were analyzed by calculating Frequency, Dominancy and Important Value Index (IVI). This study found 7 species of mosses in which 3 species belong to Family Marcahntiaceae, 2 species belongs to Bryaceae and 1 species belongs to Pottiaceae and Anthocerotaceae, respectively. The highest of IVI value is specimen K2, corresponds to Pohlia flexuosa W.J. Hooker, with 78.178%, and the lowest of IVI value is specimen K6, corresponds to Marchantia sp., with 4.524%. It can be concluded that Tumpak Sewu Waterfall has diversity for mosses that could be useful to conserve Indonesian natural resources especially lower plants.

1. INTRODUCTION

Indonesia has the largest tropical rainforest in the world, and later it is known as a mega biodiversity country. This is because Indonesia is an archipelago consisting of 17,000 islands stretching between Australia and Indomalaya, in which each islands in Indonesia has a high level of biodiversity including endemic species (Achmaliadi et al., 2001; Jenie & Immamudin, 2006). However, there are still many types of plants that have not been completely recorded and

scientifically documented yet, one of which is moss plants (Bryophyta).

Bryophytes or mosses are often found in humid and wet environments. Many of which are found living in various types of substrate, such as soil, rock, rock, peat, tree bark (Tjitrosoepomo, 1994). Reports on mosses research in Java have been carried out from the Dutch colonial era, but focused more on the West Java region (Fleischer 1902 ; Jenie & Immamudin, 2006; Gradstein et al. 2010). Meanwhile, several studies on mosses in East Java were conducted by Edawua (2012) at the R. Soeryo Forest Park focusing nearby hot spring flow. There were recorded three genera from the bryopsida class (Hypnum, Leucobryum, Fissidens). Wati et al. (2016) observed biodiversity of mosses (Bryophyta) in the forest around Kedung Brubus Reservoir, Pilang Keceng Subdistrict, Madiun Regency and found 10 of mosses species including *Leucophanes glaucum*, *Meteorium miquelianum*, *Polytrichum commune*, *Garovaglia plicata*, *Chenidium lychnites*, *Thiudium investa*, *Ricissa sp*, *Pogonotum cirrhatum*, *Fissidens cristatus*, and *Barbella enervis*. One of the places in East Java having the potency for mosses diversity is Tumpak Sewu Waterfall (TSW). TSW located in the highlands and slopes of Mount Semeru. The flow height of TSW is about 180 meters, equipped with several heavy waterfalls, and this condition is believed to be very supportive for the growth of mosses. This statement is in accordance with Tjitrosoepomo (1994) report that mosses generally grow in the highlands rather than in the lowlands. This is because moss plants like habitat or environment with highest humidity, such as highlands. Thus, this study was carried out to identify and inventory moss plants inhabiting TSW area, and calculate their population. In addition, this study is also the first report on mosses diversity in TSW or tourist area in Lumajang District.

2. MATERIALS AND METHODS

Procedure

This study has been conducted from October to November 2018 at tourist area of Tumpak Sewu Waterfall, Lumajang, East Java (Figure 1.a). The study was performed along hiking trip, riverside, and tourist are of TSW by using transect method, of which each line consists of 1x1 m^2 plot put in the right and left of line. The distance of each transect is 10 – 20 m (Figure 1). This method has been chosen considering the elevation and difficulty of hiking and riverside directed to TSW. In addition, since the habitus of bryophytes is small size or less than 20 cm, each plot was also divided into 4 line using vertical and horizontal line with 20 x 20, in size. This method is also called as cover quadrat which is usually calculated as percentage both the relative or absolute cover. This method is also convenient and easy for collecting data for small habitus of plants or bryophytes. All bryophytes obtained from this study were preserved and used for herbarium collection as well as further identification. Identification of bryophytes was performed by determining the morphological character of each specimen with key identification of bryophytes such as Guide to the Liverworts and Hornworts of Java (Gradstein, 2011), Mosses and liverworts of Britain and Ireland: a field guide (Atherton et al., 2010) Koleksi Bryophyta Taman Lumut Kebun Raya Cibodas (Jenie dan Immamudin, 2006), Mengenal Bryophyta (Lumut) Taman Nasional Gunung Gede Pangrango Volume 1 (Hasan dan Ariyanti, 2004). To ensure the validity of identified specimen, all specimen were sent to Indonesian Institute of Science (LIPI) Bogor for further identification.

Figure 1. Transect mapping for collecting mosses/bryopyte

Data Analysis

The population data of bryophytes were tabulated in record table for further analysis. In order to find out dominant species of bryophytes, we calculated the data of bryophytes population using dominance, frequency and important value index (IV).

3. Results

In this study, we observed the diversity of mosses around TSW and found 7 species belonging to 4 genera and families, respectively (Table 1). Among those genera, genus Marchantia is the most frequently found, followed by genus Pohlia.

Table 1. Mosses taxa found in Tumpak Sewu Waterfall

Code Specimen	Family	Genus	Species
K1	Anthocerotaceae	Anthoceros	*Anthoceros* sp.
K2	Bryaceae	Pohlia	*Pohlia flexuosa* W.J. Hooker
K3	Bryaceae	Pohlia	*Pohlia elongata* Hedw.
K4	Marchantiaceae	Marchantia	*Marchantia polymorpha* L.
K5	Marchantiaceae	Marchantia	*Marchantia* sp.1
K6	Marchantiaceae	Marchantia	*Marchantia* sp. 2
K7	Pottiaceae	Barbula	*Barbula consanguiena* A.J

Thallus's color of specimen K1 is dark green, circular in its shape, and it is usually 2-3 cm in size. There are several curves on the edge of the thallus. In the sporophyte section, there is a set of structure that is elongated and tapered at the end of the seta. The horn of the sporangium is mixed between the archegonium and the new horn grow on the thallus. Based on these characteristics, specimen K1 has similarity with *Anthoceros sp.*

Figure 2. Characteristic of specimen K1 which is similar with Anthoceros sp. A. General morphology; (B) Gametophyte (1) and sporophyte (2) phase

Specimen K2 has a characteristic belonging to the acrocarp group, where the acrocarp is a bryopsida that grows upright. On the gametophyte part of specimen K2, leaves appeared around the stem. The lancet leaf with pointed leaf tips, with flat structure of leaf edge, and leaves color with pale green. No part of sporophyte has been found in this type of plant. From those characteristics explained

above, specimen K2 has similarity with the characteristic of *Pohlia flexuosa*.

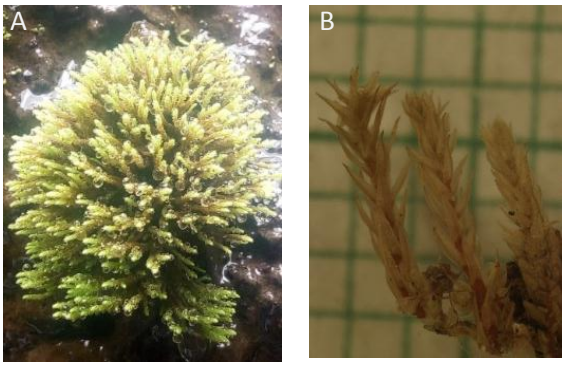

Figure 3. Characteristic of specimen K2 which is similar with Pohlia flexuosa. A. Whole thallus morphology; (B) Part of thallus

Specimen K3 has a thallus with the average length between 0.5-5 cm, with pale green or dull color. Gametophyte part grows upright with leaves growing very tightly around the stem and irregular branching of the stem. The leaf's shape is lancet with the tip of a pointed leaf and at the base like a stick on the stem. The sporophytes are found in the seta section which began to elongate at the end of the thallus, but there is no sporophyte capsule. The characteristic of specimen K3 is similar to *Pohlia elongata*.

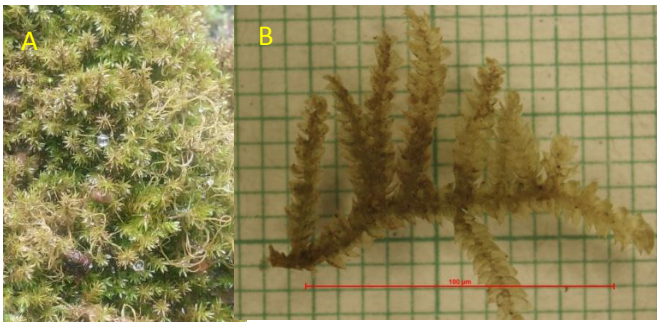

Figure 4. Characteristic of specimen K3 which is similar with Pohlia elongata. A. Whole thallus morphology; (B) Part of thallus

Specimen K4 is one of the thickened liverworts, with the branching thallus. The size of thallus grows up to 2 cm. It was also found to be widely grown on rocky soil. Thallus color is pale green or yellowish green, but turn on the brown when it starts to dry out. Thallus specimen of K4 has also a thick and rigid structure, with flat edges and two lobes at the end of the thallus. The upper surface of the thallus has striking points or air pores. The thallus with gemma where the gemma container looks like a glass cup. Archegonium and anteredium are found in the sporophyte section. The anteredium part is also different among each other. It can be concluded that specimen K4 is similar with *Marchantia polymorpha L*

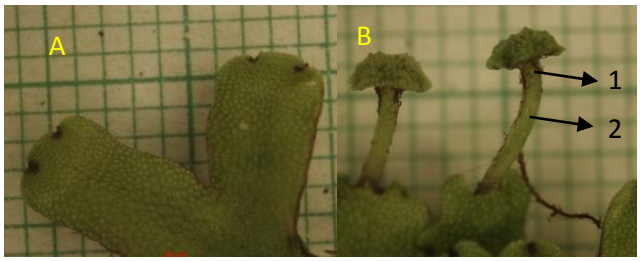

Figure 5. Characteristic of specimen K4 which is similar with *Marchantia polymorpha* L. A. thallus morphology; (B) sporofit 1) seta 2) anteredium

Specimen K5 found in this study also included in the thickened liverworts. The thallus color is green, its size is about 1.5 cm, with a thick and stiff structure. The dorsal portion of the thallus is smooth, while the ventral part is smooth cilia and rhizoids attaching to the substrate. Smooth cilia are also found on the dorsal part. The thallus edge of specimen K4 is flat. In the sporophyte section, anteredium and archegonium are found as reproductive organs. We conclude that specimen K5 belonged to the type of Marchantia genus

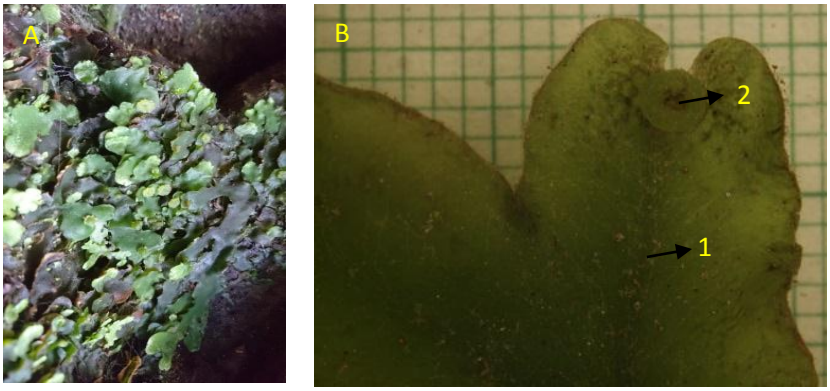

Figure 6. Characteristic of specimen K5 which is similar with Marchantia sp.1; A. Whole thallus morphology found in rocky habitat; (B) Part of thallus 1) gametofit 2) gemmae cup

Specimen of K6 has gametophyte with dull green color. There is gemmae which shape like cup. Thallus of specimen K6 looks very wide with dichotomous branching or scratching, the branching of the thallus can still be distinguished between the middle and top of the thallus. The thallus structure looks thin and has fine cilia, at the end of the thallus there is a curve or lobe that is very clear. From those characteristics mentioned above, it can be postulated that specimen K6 has similar characteristic with the family Marchantiaceae or later we called as *Marchantia sp*.

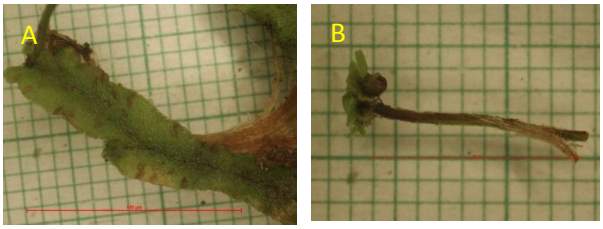

Figure 7. Characteristic of specimen K6 which is similar with Marchantia sp.2 A. Dorsal thallus morphology; (B) Ventral of thallus

Characteristics of specimens K7 is almost the same as other bryopsida classes, and it is also classified as acrocarp which grows upright upwards. From the other specimens, specimen K7 has a different color, which is light green. Gametophytes are 0.5-2 cm in size, and have rather diffuse leaves that look very tight. The length of the leaves is about 1 mm in size, the arrangement of leaves overlaps and has a tapered tip. The leaf nerve ends at the tip in a high-level plant commonly called a parallel leaf. the sporophyte phase is seta and the sporophyte capsules are very small and brittle, based on these characteristics explain that specimen 5 is *Barbules consanguiena.*

Figure 8. Characteristic of specimen K7 which is similar with Barbula consanguiena A.J. A. thallus morphology found in rocky habitat; (B) thallus with anteridium

In this study we also calculated the frequency (F), dominancy (D) important value index (IVI) of mosses species found in Tumpak Sewu Waterfall. The highest value of frequency, dominancy and important value index are found in *Pohlia flexuosa* W.J. Hooker with a value (78%), then followed by two species with the largest IVI, *Pohlia elongata* Hedw. (57,179 %) and *Marchantia sp.* (22,299 %), other mosses found to have IVI less than 20 (Table 4.2). Important Value Index is obtained by summing the relative frequency and relative dominance that has been measured.

Code Specimen	Species	F	FR (%)	D	DR (%)	INP (%)
K1	*Anthoceros* sp.	0.100	6.557	0.007	2.778	9.335
K2	*Pohlia flexuosa* W.J. Hooker	0.475	31.148	0.123	47.031	78.178
K3	*Pohlia elongata* Hedw.	0.425	27.869	0.077	29.310	57.179
K4	*Marchantia polymorpha* L.	0.175	11.475	0.013	4.981	16.456
K5	*Marchantia* sp. 1	0.175	11.475	0.028	10.824	22.299
K6	*Marchantia* sp. 2	0.050	3.279	0.003	1.245	4.524
K7	*Barbula consanguiena* A.J	0.125	8.197	0.010	3.831	12.028
	Total	1,525	100	0,261	100	200

Table 2. Important Value Index (IVI) of mosses found in Tumpak Sewu Waterfall

4. DISCUSSION

The study on mosses or bryophytes diversity in Indonesian habitat has been successfully reported by several researchers. Sporn et al (2010) reported that 146 bryophyte species (87% of the estimated) were collected including 84 species of liverworts (85% of the estimated) and 62 species of mosses (91% of the estimated) inhabited Indonesian rainforest. While Gradstein et al. (2010) presented their results of a two-day survey of the bryophyte flora of Mt. Patuha and its surroundings near Bandung, West Java, of which a total of 159 bryophyte species were identified, including 98 mosses, 60 liverworts, and 1 hornwort, representing almost 1/6 of the total bryophyte flora of Java. Formerly Gradstein et al. (2005) also reported on the occurrence of mosses in Sulawesi island which up to 476 species are listed, including 340 of moss (in 145 genera), 134 of liverwort (in 46 genera), and 2 of hornwort (in 2 genera). Even though this study exhibited only a few species of bryophytes, however this study is an example cases of bryophytes occurrence in small waterfall in East Java or very narrow habitat, which is one of the most destination for sightseeing. In the future, overall observation to study the impact of sightseeing or tourism activity on the diversity of bryophytes could be one of our interest to study.

In this study, the population of bryophytes was also calculated to determine the important value index (IVI) of each bryophyte species. IVI is somehow used as a value that influences the important role of a species in a particular region. In this study, *P. flexuosa* occupied the highest score with a value (78%) indicating that the species dominated in the Tumpak Sewu Waterfall Tourism Area Lumajang. The dominance of *P. flexuosa* in these locations shows a high level of adaptation to the environment and this statement is in accordance with the opinion of Hariyanto et al. (2008) which explains the dominance of a species influenced by the ability to optimally adapt to biotic and abiotic environmental factors.

It can be concluded that 7 species of bryophytes or mosses has been found in this study, in which 3 species belong to family Marcahntiaceae namely *Marchantia sp.1*, *Marchantia sp.2*, and *Marchantia polymorpha* L, 2 species belong to family Bryaceae namely *Pohlia flexuossa* W.J. Hooker and *Pohliia elongata* Hedw. In addition one species belongs to family Pottiaceae (*Barbula consanguiena* A.J) and family Anthocerotaceae (*Anthoceros sp*), respectively. The highest IVI value found in this study is *Pohlia flexuosa* W.J. Hooker (78.18 %), while the lowest is *Marchantia sp.* (4.5 %).

5. Acknowledgements

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