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## *DIVERSITY OF MOSS SPECIES (BRYOPHYTA) IN REGION SENGGANI RAVINE*

### *TOURISM TULUNGAGUNG REGENCY*

#### **Abstract**

*Moss plants (Bryophyta) are found in every habitat, and their presence in an ecosystem is controlled by environmental circumstances. There is a beautiful pine forest and a camping place in the Senggani Gorge tourist region, which is a popular tourist attraction. This research aims to assess the diversity of mosses (Bryophyta) in the Senggani Gorge tourism region, Tulungagung Regency because the diversity of mosses in this tourist area has not been widely researched. June in 2022, exploratory descriptive research was undertaken. The researcher did a free wander by touring the Senggani Gorge tourism region directed by a preset position point (purposive sampling) using observation, documentation, literature study, and measurement of abiotic elements for data collection. According to the results, twenty species of mosses (Bryophyta) were identified and divided into four classes, namely the Bryopsida, Polytrichopsida, Jungermanniopsida, and Marchantiopsida classes. The number of species detected was Ceratodon purpureus, Fissidens sp., Leucobryum glaucum, Octoblepharum albidum, Rhizonium punctatum, Mnium stellare, Mnium hornum, Philonotis marchica, Fontinalis antipyretica, Hypnum cupressiform,*

*Polytrichastrum formosum*, *Lejeunea flava*, *Lejeunea cavifolia*, *Bazzania prareupta*, *Bazzania vittata*, *Conocephalum conicum*, *Marchantia emarginata*, *Marchantia polymorpha*, *Dumortiera hirsuta*, dan *Lunularia cruciate*. Abiotic factor measurements reveal that zone 3, which has a soil pH of 6, an air temperature of 24.1 C°, an 84% humidity level, and 200 Cd of light per square centimeter, is the most favorable region for the growth of moss. We can infer that the Senggani Gorge tourist area is still largely natural because the mosses (Bryophyta) are still quite diverse and varied. Moss plants are essential components of the environment because they absorb pollutants, give oxygen, slow down erosion, and serve as decorative plants and medicinal plants.

**Keywords:** Senggani Gorge, Diversity, Moss (Bryophyta), Tulungagung

## INTRODUCTION

Senggani Gorge is a tourist attraction in Tulungagung Regency's Nglurup Village, Sendang District. Known for its campgrounds and home to a magnificent pine forest, Senggani Gorge is a popular tourist attraction. It features a microclimate that is cool and humid and has rich soil. The predominance of dense and gloomy tree plants, as well as grass and other plants, indicates that these environmental circumstances continue to exist and enable the establishment of a variety of species, such as mosses (Effendi et al., 2018). Moss plants (Bryophyta) are a group of plants with 15,000 species, the second largest behind the tall plants that dominate the Indonesian mainland. The presence of moss plants in an ecosystem is influenced by environmental circumstances. moss grows in every habitat. Moss is capable of living and growing on a range of surfaces, including soil, rocks, sand, litter, tree trunks, and water. Numerous abiotic elements can influence the growth of mosses (Mulyani et al., 2015). According to Bawaihaty et al. (2014), environmental circumstances have a significant impact on the population and variety of mosses within an ecosystem (temperature, humidity, light, altitude, climate, and availability of nutrients).

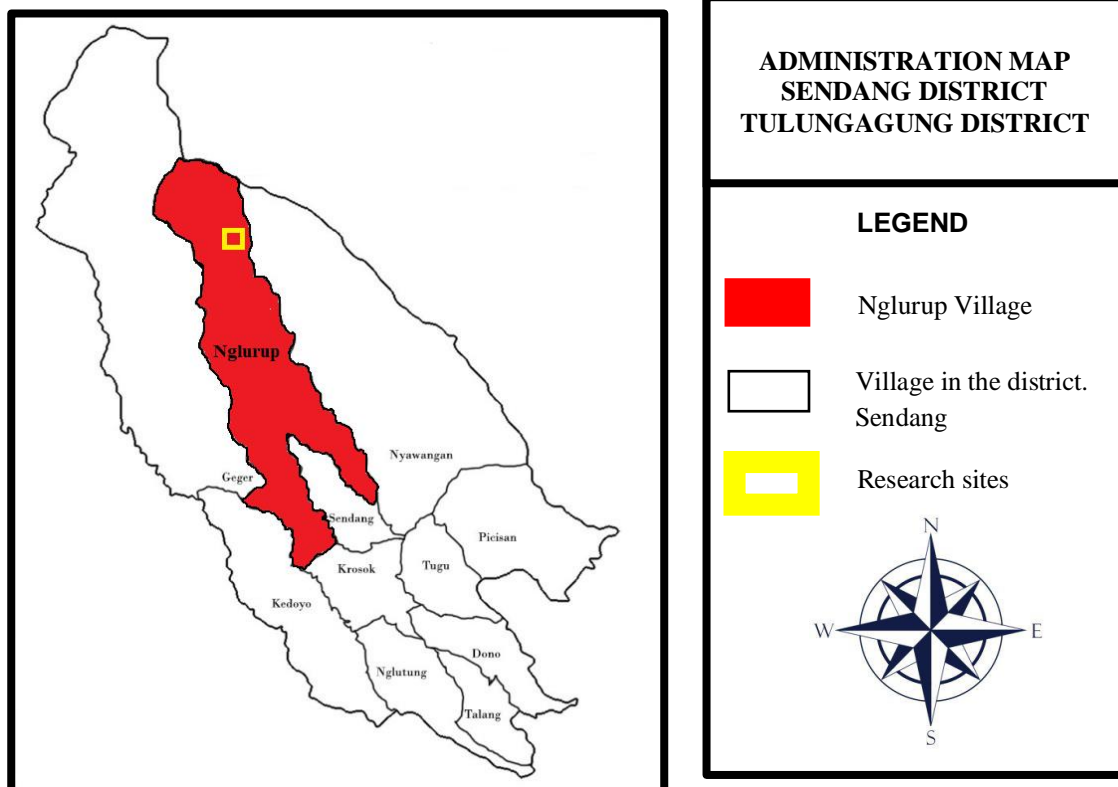
The growth of moss will have a good effect on the local ecosystem, particularly for other plants. Using rock mineralization, decomposition, and carbon fixation, moss (Bryophyta) has the

potential to balance the nutrient content of the soil (Lukitasari, 2018). According to Perwati et al. (2015), mosses play a significant role in tropical forest regions, particularly in highland regions. In addition to serving as a home for other organisms to reside in, moss plants also serve as groundwater balancers, oxygen suppliers, nutrient cycle inhibitors, ornamental plants, medication, and are capable of detecting pollution levels or environmental changes. Research on the variety of mosses (Bryophyta) in the Senggani Gorge tourism area, Tulungagung Regency, is required due to their significant ecological function and the lack of existing studies on moss plants in the region. By doing this research, it is anticipated to learn more about the variety of mosses (Bryophyta) and their ecological advantages.

## MATERIAL AND METHOD

### *Location and time of observation*

In June 2022, the research was carried out in the Senggani Gorge region, Nglurup Village, Sendang District, and Tulungagung Regency. Senggani Gorge is a region in the highlands that is about 800 meters above sea level, with an average temperature of 25.6 C° and is located at that altitude. 82.3% relative humidity *Sampling*. This kind of *in situ* research involves making firsthand observations by researchers



in their natural environments (Moelong, 2017). This research employed a descriptive exploratory

strategy with *cruising approaches* (Sundra, 2016). By using three specified observation spots (*purpose sampling*) as a reference for the observation area that can be shown on a map, researchers used free roaming (crushing method) to directly explore the Senggani Gorge tourism region (Figure 1).

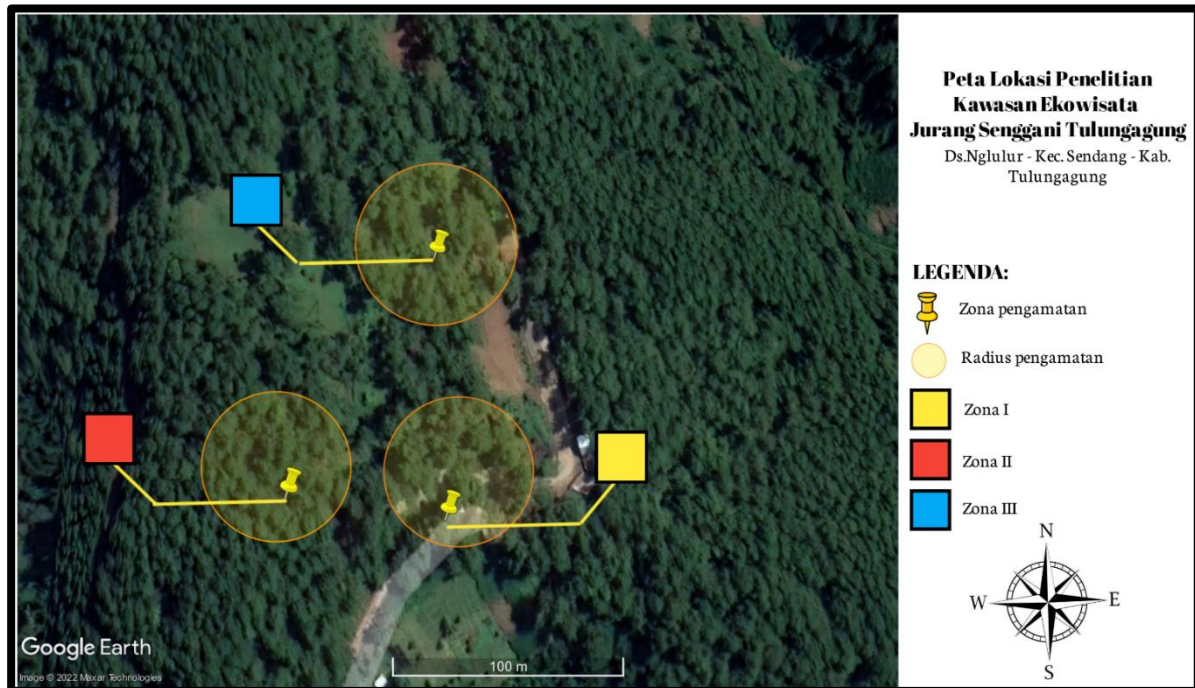


Figure 1. The Senggani Gorge tourism region, Nglurup Village, Sendang District, and Tulungagung Regency are all included on a map of the research locations.

Zone I is at the coordinate point (S 07°54'57.19" E 111°49'34.05"), Zone II is at the coordinate point (S 07°54'53.44" E 111°49'33.80"), and Zone III is at the coordinate point (S 07°54'57.00" E 111°49'31.88"). This research is not focused on establishing a particular hypothesis but is instead limited to describing the thing being observed through the use of tools for gathering observation data, documentation, and literature studies on the object being investigated (Arikunto, 2002). The Realme 3 Android camera and a Nikon 25 mm prosumer macro lens, as well as writing supplies and books for identifying mosses, were employed in the investigation. Understanding Moss Plants (Bryophyta) Description, Classification, Potential, and How to Learn It by Marheny Lukitasari (2016; 2018), as well as additional sources including articles, journals, and books. Instruments for measuring abiotic factors are employed (anemometer, GPS ETREX30X, AZ 885 Infrared Psychrometer, Three Way Soil Meter, and MA-30 Military Altimeter EX 284). Following collection, the specimens were identified and given a descriptive analysis based on their traits and abiotic components.

## RESULT AND DISCUSSION

### *Moss species diversity (Bryophyta)*

The research produced 20 species of moss plants (Bryophyta) that are native to Senggani Gorge's tourist region. A total of 20 species were present, with 15 moss plant families comprising 11 moss/leaf moss species (Bryophyta) and 9 liverwort/liverwort species (Marchantiophyta) (Table 1). According to field observations, zone III exhibits up to 13 more species than zones I or II combined, which is the highest level of species diversity. Moss plants can grow on a wide range of surfaces, including dirt, rocks, tree roots, tree trunks, worn wood, and the edge of cliffs.

**Table 1.** List of the bryophytes (mosses) that can be found in Senggani Gorge.

| No.                          | Scientific Name                    | Family          | Substrate            | Location |         |          |
|------------------------------|------------------------------------|-----------------|----------------------|----------|---------|----------|
|                              |                                    |                 |                      | Zone I   | Zone II | Zone III |
| Leaf moss (Bryophyta)        |                                    |                 |                      |          |         |          |
| 1                            | <i>Ceratodon purpureus</i>         | Ditrichaceae    | Soil, rocks          | -        | +       | -        |
| 2                            | <i>Fissidens sp.</i> Hedw.         | Fissidentaceae  | Rocks                | +        | -       | -        |
| 3                            | <i>Leucobryum glaucum</i>          | Leucobryaceae   | Tree trunks          | -        | -       | +        |
| 4                            | <i>Octoblepharum albidum</i> Hedw. | Leucophanaceae  | Soil, tree trunk     | -        | +       | +        |
| 5                            | <i>Rhizonium punctatum</i>         | Mniaceae        | Soil, rocks          | -        | +       | +        |
| 6                            | <i>Mnium stellare</i>              | Mniaceae        | Soil                 | +        | +       | +        |
| 7                            | <i>Mnium hornum</i>                | Mniaceae        | Soil                 | -        | -       | +        |
| 8                            | <i>Philonotis marchica</i>         | Bartramiaceae   | Soil                 | +        | -       | +        |
| 9                            | <i>Fontinalis antipyretica</i>     | Fontinalaceae   | Soil                 | -        | +       | -        |
| 10                           | <i>Hypnum cupressiforme</i>        | Hypnaceae       | Soil, rocks          | +        | +       | +        |
| 11                           | <i>Polytrichastrum formosum</i>    | Polytrichaceae  | Soil                 | +        | -       | -        |
| Liver moss (Marchantiophyta) |                                    |                 |                      |          |         |          |
| 1                            | <i>Lejeunea flava</i>              | Lejeuneaceae    | Soil, roots, rocks   | -        | -       | +        |
| 2                            | <i>Lejeunea cavifolia</i>          | Lejeuneaceae    | Soil, roots, rocks   | -        | -       | +        |
| 3                            | <i>Bazzania praeupta</i>           | Lepidoziaceae   | Soil, weathered wood | -        | +       | -        |
| 4                            | <i>Bazzania vittata</i>            | Lepidoziaceae   | Soil, weathered wood | +        | +       | +        |
| 5                            | <i>Conocephalum conicum</i>        | Conocephalaceae | Soil                 | -        | +       | -        |
| 6                            | <i>Marchantia emarginata</i>       | Marchantiaceae  | Soil                 | -        | -       | +        |
| 7                            | <i>Marchantia polymorpha</i>       | Marchantiaceae  | Soil                 | +        | -       | +        |
| 8                            | <i>Dumortiera hirsuta</i>          | Dumortieraceae  | Soil, rocks          | +        | -       | +        |
| 9                            | <i>Lunularia cruciate</i>          | Lunulariaceae   | Rocks                | -        | +       | -        |

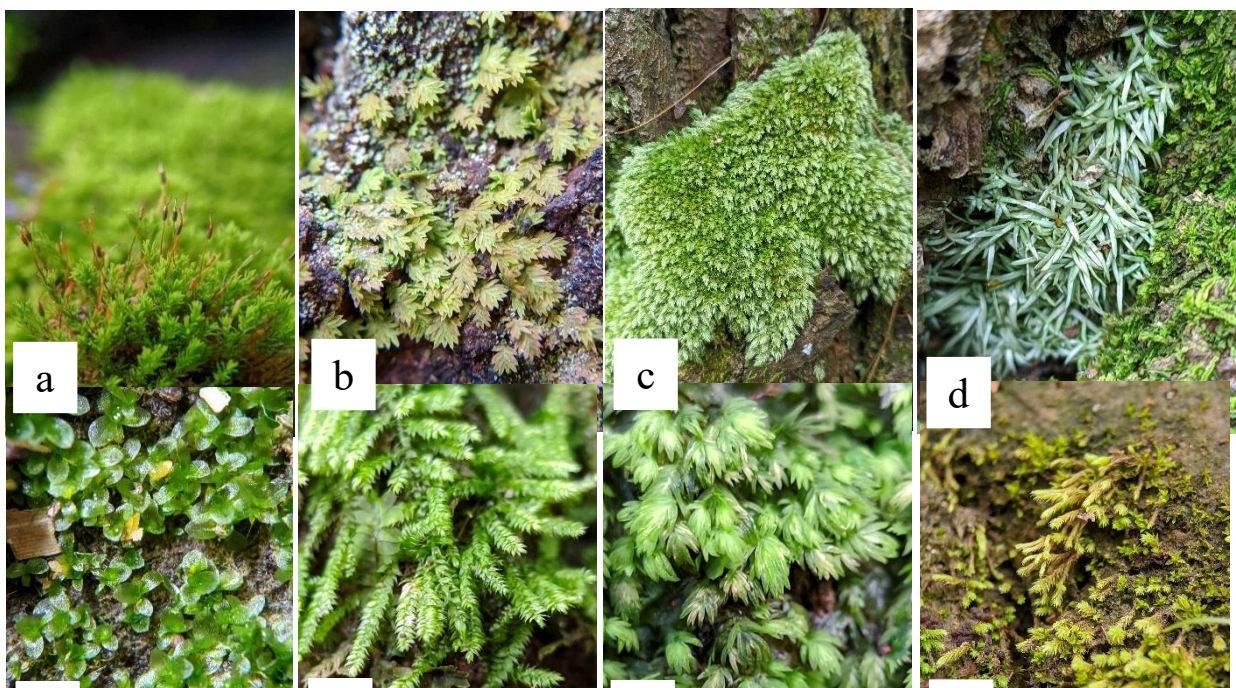
Table 1 shows that the mosses that dominate the Senggani Gorge tourism region are of the Bryophyta division (leaf/true mosses). This is because the fact that mosses (mosses) are a group of moss plants with the biggest number of species existing in the world when compared to other

moss groups, which have an estimated 12,000 species (Mulyani et al., 2015). According to research by Goffinet et al. (2008), the Bryopsida class, which encompasses 95% of the moss species globally, is the biggest group of mosses. True mosses with leaves (Bryophyta) are classified as having a greater level of development than other forms of mosses, which can already tell stems from leaves.

When compared to earlier studies on mosses, such as those carried out at Peucari Bueng Jantho Waterfall, Aceh Besar District by Raihan et al. (2018), A relatively high diversity of moss species was observed by Azwir et al. (2022) in the Forest of Mesjid Raya District, Aceh Besar District, and by Endang (2020) along the Kaburan-Burana River Basin, Batauga District, South Buton Regency, but further study is needed. undertaken in the vicinity of Mount Ungaran by Mulyani et al., 2015, and research performed on Mount Prau, Blumah, Central Java region by Linah et al. in 2021. Some of these variations in outcomes may be the consequence of various and unique environmental factors, which have an impact on the capacity of certain moss species to develop and adapt. Furthermore, human actions such as land clearing that results in increased light intensity in the habitat where the moss grows, as well as other environmental degradation, might alter the level a variety of moss species in certain regions (Liannah et al., 2021).

### *Description and possible use of mosses (Bryophyta)*

#### A. Leaf moss (Bryophyta)



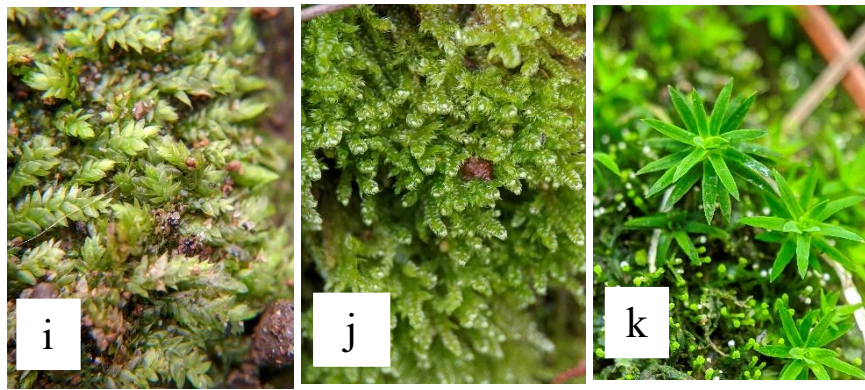


Figure 3. Leaf mosses (Bryophyta) found in the Senggani Gorge tourist area. a. *Ceratodon purpureus*, b. *Fissidens sp.*, c. *Leucobryum glaucum*, d. *Octoblepharum albidum*, e. *Rhizonium punctatum*, f. *Mnium stellare*, g. *Mnium hornum*, h. *Philonotis marchica*, i. *Fontinalis antipyretica*, j. *Hypnum cupressiform*, k. *Polytrichastrum formosum*

Figure 3 illustrates the variations between the properties of mosses belonging to the group Bryophyta (true/true mosses). Bryophyta, or real mosses, typically consist of entire plant-like structures (roots/rhizoids, leaves, and stems). On the stems of moss, which have upright, spirally arranged leaves, buds grow for reproduction. Leaf/true moss is capable of growing on soil, grass, rock, tree trunks, and roots. Andreaeales, Spagnales, and Bryales are the three orders that comprise the group of true/true mosses (mosses) (Lukitasari, 2018).

a. *Ceratodon purpureus*

The body structure of *Ceratodon purpureus* consists of a sporangium (capsule), stalk, stem, leaf, and rhizoids. The leaves are thin and green in color and contain chlorophyll. Its body size is about 1-2 cm. *Ceratodon purpureus* consists of a sporangium (capsule), stalk, stem, leaf, and rhizoids in its body structure. The leaves are slender, green, and composed of chlorophyll. Its body length is approximately 1-2 centimeters. The Sporophyte is capable of producing spores. *Ceratodon purpureus* can attach itself to shaded and moist rocks, trees, and walls (Nasuha et al., 2021).



b. *Fissidens sp.* Hedw

This plant has a flat form, shoots that grow vertically, varying body sizes, a yellowish-green hue, and a filoid fingered, pointy tip. (Risanto et al., 2021). The stems are so short and concealed by leaves that they appear to be nonexistent. The stems are short and completely covered by leaves. On the stem, the leaves are organized in two rows, are lanceolate, have flat, small-toothed margins, and are pointy at the tip/base. *Fissidens sp.* Hedw develops in clusters and spreads on moist and damp rock surfaces (Endang et al., 2020)

c. *Leucobryum glaucum*

The leaves have a sickle shape with a sharp tip and are erectly dispersed. Reproduce asexually specifically in small clusters, such as caducus at the stem's tip. Attachment to the substrate is facilitated by having roots (rhizoids) positioned beneath the reproductive organs (gametophytes). *Leucobryum glaucum* grows to a height of several meters, clustering and producing dense pads. This bearing structure features a dome with a height of several centimeters. Typically, this sort of moss adheres to the surface of a damp tree trunk (Sumiati et al., 2021).

d. *Octoblepharum albidum*

*Octoblepharum albidum* is a member of the Bryopsida phylum. The leaves range in color from pale green to white, have an elongated, pointed form, and are thick. The sporophyte of *Octoblepharum albidum* is readily discernible. The top of the sporangium is known as the spore box. *Octoblepharum albidum* forms colonies and adheres to the stem of pine trees. *Octoblepharum albidum* occurs in both wet and dry forests. Therefore, the Senggani Gorge tourist area is an ideal habitat for *Octoblepharum albidum* because it is shady and cool.

e. *Rhizonium punctatum*

The oval leaves of this plant, which frequently grow next to one another, will contract when dry. *Rhizonium punctatum* has dark red stems that eventually turn reddish-brown in maturity.

Green protonematous rhizoids specialize in asexual reproduction. This species inhabits dark, moist, and damp soil and rocks (Tomovic et al., 2021).

f. *Mnium stellare*

*Mnium stellare* has undifferentiated leaf edges, and tiny, green leaves with pointy leaf tips. **In central and southern Europe, a moss called *Mnium stellare* is frequently encountered. *Mnium stellare* was discovered to live and adhere to the surface of damp and wet soil based on the findings of the investigation. (Hugonnot & Celle, 2012)**

g. *Mnium hornum*

The genus *Mnium* of the family Bryaceae includes the species of moss known as *Mnium hornum*. The leaves of *Mnium hornum* are distinctively golden green in color, slightly elongated, and have a pointy leaf tip. It also grows parallel. This moss species thrives on moist, humid soil. (2017) Marom et al.

h. *Philonotis marchica*

The spores of *Philonotis marchica* are round. The leaves of *Philonotis marchica* are green, very tiny, serrated, and placed in rows along the stems. The cells of the leaf blades appear to be wider near the base. A particular kind of moss called *Philonotis marchica* can survive on moist and damp soil surfaces.

i. *Fontinalis antipyretic*

It can grow transversely branched and up to 60 cm in length. *Fontinalis antipyretic* leaves are oval, a little stiff, and arranged in an overlapping pattern. There are tiny spores on this moss plant. This huge moss can be seen growing on damp, wet rocks and dirt (Lukitasari, 2018).

j. *Hypnum cupressiforme*

Is a species of moss that may grow on damp surfaces of soil and rocks. The green leaves of *Hypnum cupressiforme* are long, curled, and tipped with a point. Because the leaves grow

densely on the stem's surface, the stem is covered in leaves. The branches are irregularly pinnate and the branches either spread or ascend.

k. *Polytrichastrum formosum*

*Polytrichastrum formosum* is a medium-sized plant with tall branches that are not branched. The leaves bloom like flowers and get dull when dry. On the leaf surface, tall lamellae cells can be detected. The stems are unbranched and grow erect. This species can be found on moist and damp soil surfaces as well as flooded soil surfaces (Asthana et al., 2012).

B. Liveworts (Marchantiophyta)



i h g

**Figure 4.** Liverworts (Marchantiophyta) were spotted in the Senggani Gorge's tourism zone. a. *Lejeunea flava*, b. *Lejeunea cavifolia*, c. *Bazzania prareupta*, d. *Bazzania vittata*, e. *Conocephalum conicum*, f. *Marchantia emarginata*, g. *Marchantia polymorpha*, h. *Dumortiera hirsuta*, dan i. *Lunularia cruciata*

Figure 4 depicts the species of liverworts (Marchantiophyta) discovered in several zones of the research region, with apparent variances in their characteristics. Liverworts are distinguished from other mosses by the presence of a thallus connected to the substrate and leaves made up of lined and thickened cells. The genital organs of liverworts are usually found on the surface and are protected by a unicellular root structure (Lukitasari, 2018).

a. *Lejeunea flava*

*Lejeunea flava* features a small circular thallus that is pale green, varied leaf sizes between large (lobes) and small (lobules), and flat and blunt edges. Small trunk, dense, creeping, and branching growth. The branching, however, is almost unnoticeable since it is covered with an incubous leaf arrangement (lower leaves cover the top leaves) or overlaps. *L. flava* colonizes soil, trees, and rock substrates (Angeles et al., 2020).

b. *Lejeunea cavifolia*

The trunk of *Lejeunea cavifolia* is dense, flat, and interwoven with soil, bark, roots, and pebbles. It has a little thallus that is spherical, smooth, and pale green. This moss' stem spreads across the substrate, usually with two uneven branches, the margins are flat and blunt, the lower leaves cover the higher leaves or overlap one other, and it is divided between large leaves (lobes) and little leaves (lobule). *L. Cavifolia* grows on rotting wood, roots, rocks, and dirt in shaded and moist areas (Putna and Mezaka, 2014).

c. *Bazzania prareupta*

The leaves of *Bazzania prareupta* are almost square in shape, green in color, flat at the base at the borders, and rounded at the ends with a slightly curved inward center. The leaves are *succubous* (the top two covers the lower leaf), have cilia (tapering at the tip of the leaf), and have amphigastria. It has a small stem that is covered with leaves, is of the Frullania branching type, and is linked to soil and worn wood surfaces (Lestari and Ariyanti, 2017).

d. *Bazzania vittata*

*Bazzania vittata* has a little green stem with a trunk branch that looks like a Frullania or is formed like a fork but is short and unusual. The leaves are closely packed, neighboring leaves overlap, the base of the leaf is flat, the ventral leaf is attached, the leaf edge is flat, and the top of the leaf is 2-3 serrated, blunt, and rough. The ventral leaves are closely spaced, circular to the square in form, and have thin walls. *B. Vittata* is frequently found clinging to soil substrates and worn wood (Lestari and Ariyanti, 2017).

e. *Conocephalum conicum*

*Conocephalum conicum* has a very large thallus, a thick, green, smooth surface, and a white pattern (air pores) that looks like scales with a dark green midrib (middle bone). The thallus tip is spherical with a little depression, while the base of the thallus has a flat edge. Rhizoids, which are roots found in the lower section of the thallus, aid in attachment to the soil substrate (Sopacua et al., 2020).

f. *Marchantia emarginata*

*Marchantia emarginata* has a branching and rigid thallus that is dark green and leafless. It has a smooth surface, no midrib/midrib spreads across the soil surface, and when dried, the edges turn brown. The ribbon-like leaves of *M. emarginata* are distinguished by forked, fleshy branches and the presence of brood buds, despite the absence of a petiole on the stem. A thallus and a root are the only components of the gametophyte structure. Roots (rhizoids) aid

in the attachment of the thallus to the substrate and are typically grouped in groups (Wen LU and Huang, 2017).

g. *Marchantia polymorpha*

*Marchantia polymorpha* has a green thallus, no leaves, and grows creeping above the ground. The top thallus has a hexagonal pattern, the tip and base of the thallus are blunt, porous, black striped, and has a thick stiff texture on the thallus (Febriansah et al. ., 2019). There is a gamma cup, which is used for vegetative reproduction, and spores are used for generative reproduction. The archegonium stem is brownish green, and the archegonium is green, lobe-shaped like an umbrella. It has many roots (rhizoids) that aid in adhering to the soil surface (Sholihat and Kurnia, 2021).

h. *Dumortiera hirsuta*

*Dumortiera hirsuta* is a dark green ribbon-shaped plant with dichotomous branches. The thallus has a blunt, rounded tip with an indentation like the letter V in the middle, a spore bowl, and flat margins. The surface is slick and striped in a white hexagonal pattern, and there a few downy hairs. Similar to other forms of mosses, mosses use rhizoid (roots) to adhere to the substrate. The substrate of *D. Hirsuta* consists of soil and rocks (Karomah et al., 2020).

i. *Lunularia cruciata*

The talus surface of *Lunularia cruciata* is glossy, pale green, sparsely bordered, and speckled; its branches are dichotomous. The top of the thallus is rounded, and its edges are wavy, with two to three waves and blunt edges. When dry, the thallus's thin scales turn yellow and the margins are somewhat curled. On the back are several rhizomes that anchor the plant to the rocky substrate (Kirschner et al., 2010).

## Environmental Element

The environmental parameters of mosses in the tourism area of Senggani Gorge differ significantly from those in the three observation zones. In general, however, the climate in the

Senggani Gorge is cool, humid, and chilly. Consequently, based on the measurements of environmental abiotic parameters, it has been determined that the environmental conditions in the Senggani Gorge tourism region are compatible with the features of the moss plant's habitat and conducive to its reproduction. Table 2 displays the abiotic environmental conditions of each zone's mosses.

**Table 2.** Each zone's moss plant abiotic environmental conditions

| Parameters                    | Location |         |          |
|-------------------------------|----------|---------|----------|
|                               | Zone I   | Zone II | Zone III |
| Air temperature (C°)          | 27,4     | 25,4    | 24,1     |
| Humidity (%)                  | 80       | 83      | 84       |
| Light intensity (Cd)          | 500      | 250     | 200      |
| Altitude of the place (m dpl) | 815      | 818     | 838      |
| Soil moisture (%)             | 6        | 7       | 7        |
| Soil pH                       | 7        | 7       | 6        |
| Wind speed (m/s)              | 1,7      | 1,2     | 2,0      |

Table 2 indicates that zone 3 has the highest altitude (838 m above sea level), is characterized by dense, shady trees, and has an air temperature of 24.1 C°. The air humidity is 84%, the light intensity is 200 Cd, the soil wetness is 7, the soil pH is 6, and the wind speed is 2.0 meters per second. This substantially supports the habitat of moss plants where humidity and light intensity greatly affect the number of moss creatures, as proven by the fact that zone 3 is home to as many as 13 kinds of mosses. The intensity of sunshine has a significant effect on the air's temperature and humidity, which in turn has a significant effect on the distribution of mosses. The less intense the sunshine, the greater the relative humidity and the lower the air temperature. The optimal air humidity for moss growth is between 70 and 98%, and soil pH has a significant impact on moss growth; moss thrives in the pH range of 4.9 to 8.3. (Wati, et al, 2016).

**CONCLUSION**

Based on the outcome of the research, it can be inferred that the diversity of mosses (Bryophyta) in the Senggani Gorge area is extremely diverse and varied, indicating that the area is still mostly undeveloped. There are 20 species of mosses (Bryophyta) divided into four classes:

Bryopsida, Polytrichopsida, Jungermanniopsida, and Marchantiopsida. Zone 3 is a region that strongly favors moss habitat due to its height (838 MASL ), air temperature 24.1 C°, air humidity 84%, light intensity 200 candelas per square meter, and soil pH 6. As an oxygen source, a water absorber, a pollutant absorber, an anti-erosion agent, an aesthetic plant, and a medicinal plant, moss plants play a vital function in the environment.

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## 2. Bukti Konfirmasi Revised atau direvisi (4 Februari 2024)

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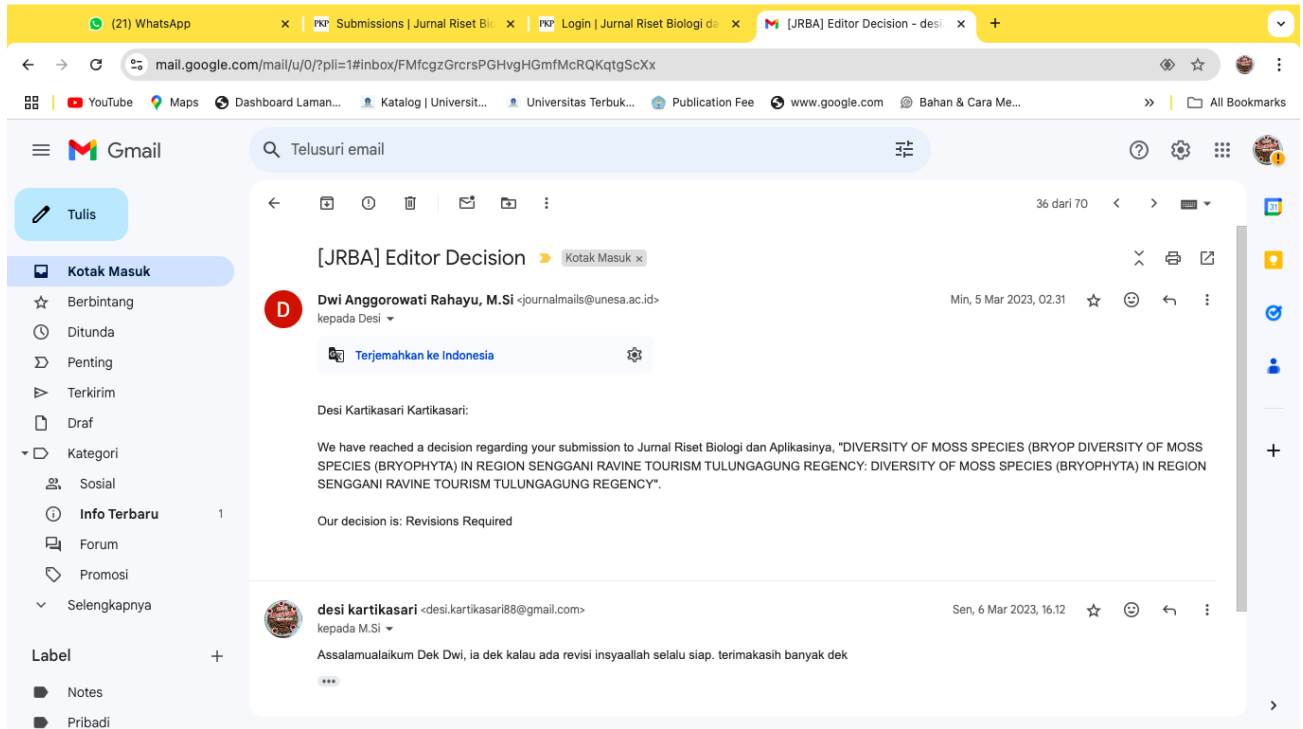
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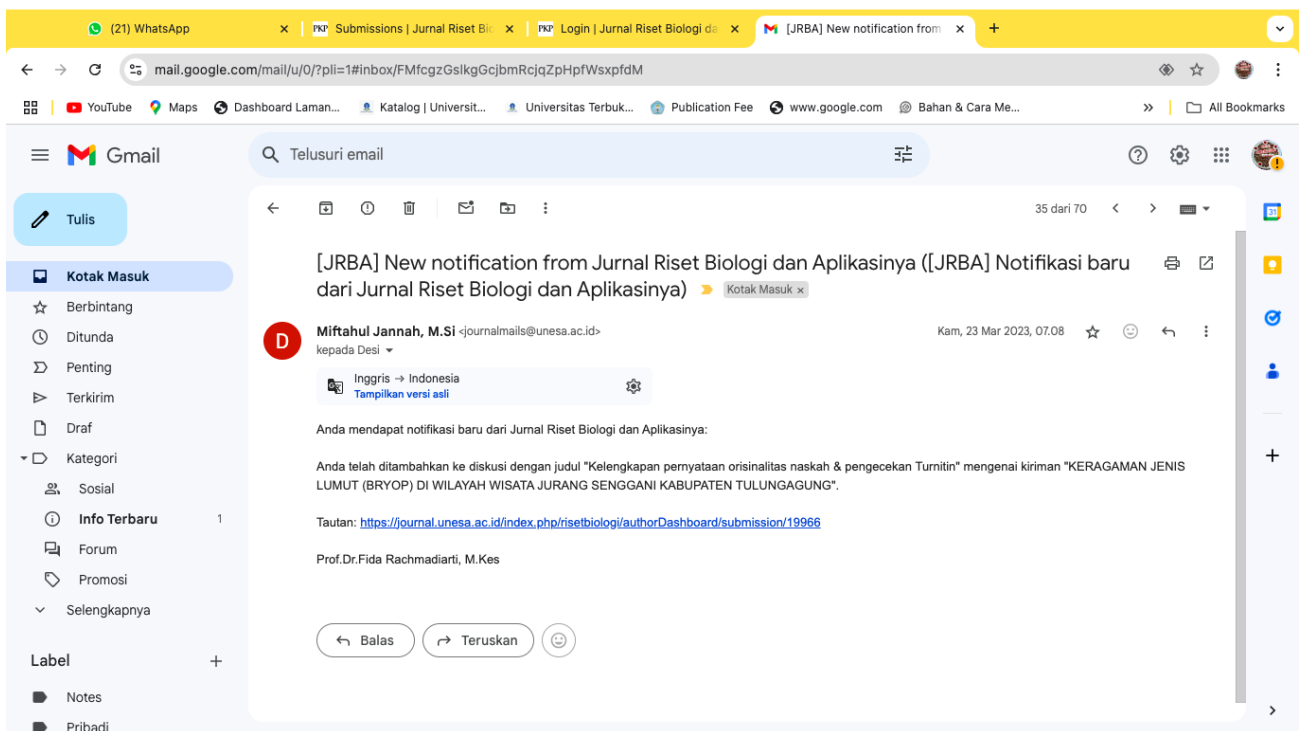
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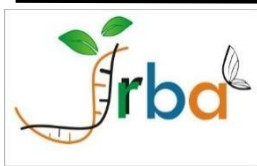
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## 4. Bukti Konfirmasi Revisi ulang (5 Maret 2024)



## 5. Bukti Konfirmasi dari Reviewer dan hasil review (23 Maret 2024)





***DIVERSITY OF MOSS SPECIES (BRYOPHYTA) IN REGION SENGGANI RAVINE  
TOURISM TULUNGAGUNG REGENCY***

***Abstract***

*Moss plants (Bryophyta) are found in every habitat, and their presence in an ecosystem is controlled by environmental circumstances. There is a beautiful pine forest and a camping place in the Senggani Gorge tourist region, which is a popular tourist attraction. This research aims to assess the diversity of mosses (Bryophyta) in the Senggani Gorge tourism region, Tulungagung Regency because the diversity of mosses in this tourist area has not been widely researched. June in 2022, exploratory descriptive research was undertaken. The researcher did a free wander by touring the Senggani Gorge tourism region directed by a preset position point (purposive sampling) using observation, documentation, literature study, and measurement of abiotic elements for data collection. According to the results, twenty species of mosses (Bryophyta) were identified and divided into four classes, namely the Bryopsida, Polytrichopsida, Jungermanniopsida, and Marchantiopsida classes. The number of species detected was Ceratodon purpureus, Fissidens sp., Leucobryum glaucum, Octoblepharum albidum, Rhizonium punctatum, Mnium stellare, Mnium hornum, Philonotis marchica, Fontinalis antipyretica, Hypnum cupressiform, Polytrichastrum formosum, Lejeunea flava, Lejeunea cavifolia, Bazzania praeupta, Bazzania vittata, Conocephalum conicum, Marchantia emarginata, Marchantia polymorpha, Dumortiera hirsuta, dan Lunularia cruciate. Abiotic factor measurements reveal that zone 3, which has a soil pH of 6, an air temperature of 24.1 C°, an 84% humidity level, and 200 Cd of light per square centimeter, is the most favorable region for the growth of moss. We can infer that the Senggani Gorge tourist area is still largely natural because the mosses (Bryophyta) are still quite diverse and varied. Moss plants are essential*

*components of the environment because they absorb pollutants, give oxygen, slow down erosion, and serve as decorative plants and medicinal plants.*

**Keywords:** *Senggani Gorge, Diversity, Moss (Bryophyta), Tulungagung*

## INTRODUCTION

Senggani Gorge is a tourist attraction in Tulungagung Regency's Nglurup Village, Sendang District. Known for its campgrounds and home to a magnificent pine forest, Senggani Gorge is a popular tourist attraction. It features a microclimate that is cool and humid and has rich soil. The predominance of dense and gloomy tree plants, as well as grass and other plants, indicates that these environmental circumstances continue to exist and enable the establishment of a variety of species, such as mosses (Effendi et al., 2018). Moss plants (Bryophyta) are a group of plants with 15,000 species, the second largest behind the tall plants that dominate the Indonesian mainland. The presence of moss plants in an ecosystem is influenced by environmental circumstances. moss grows in every habitat. Moss is capable of living and growing on a range of surfaces, including soil, rocks, sand, litter, tree trunks, and water. Numerous abiotic elements can influence the growth of mosses (Mulyani et al., 2015). According to Bawaihaty et al. (2014), environmental circumstances have a significant impact on the population and variety of mosses within an ecosystem (temperature, humidity, light, altitude, climate, and availability of nutrients).

The growth of moss will have a good effect on the local ecosystem, particularly for other plants. Using rock mineralization, decomposition, and carbon fixation, moss (Bryophyta) has the potential to balance the nutrient content of the soil (Lukitasari, 2018). According to Perwati et al. (2015), mosses play a significant role in tropical forest regions, particularly in highland regions. In addition to serving as a home for other organisms to reside in, moss plants also serve as groundwater balancers, oxygen suppliers, nutrient cycle inhibitors, ornamental plants, medication, and are capable of detecting pollution levels or environmental changes. Research on the variety of mosses (Bryophyta) in the Senggani Gorge tourism area, Tulungagung Regency,

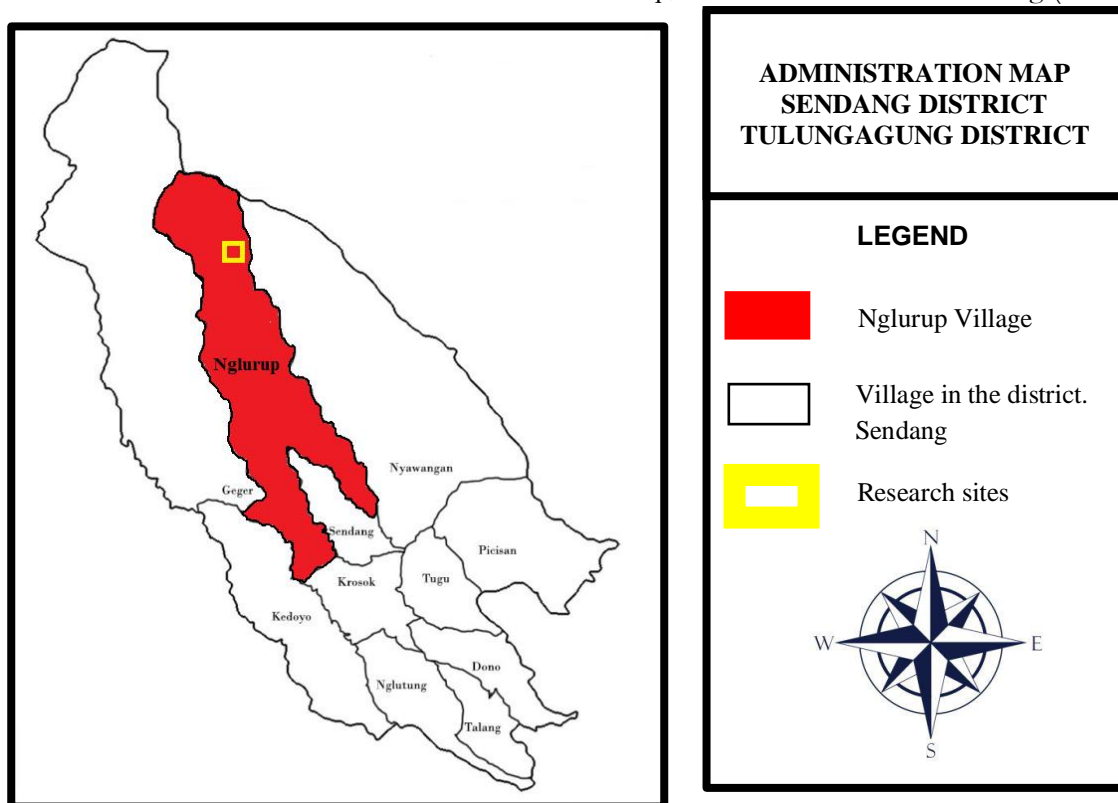
is required due to their significant ecological function and the lack of existing studies on moss plants in the region. By doing this research, it is anticipated to learn more about the variety of mosses (Bryophyta) and their ecological advantages.

## MATERIAL AND METHOD

### *Location and time of observation*

In June 2022, the research was carried out in the Senggani Gorge region, Nglurup Village, Sendang District, and Tulungagung Regency. Senggani Gorge is a region in the highlands that is about 800 meters above sea level, with an average temperature of 25.6 C° and is located at that altitude. 82.3% relative humidity

*Sampling*. This kind of *in situ* research involves making firsthand observations by researchers in their natural environments (Moelong, 2017). This research employed a descriptive exploratory strategy with *cruising approaches* (Sundra, 2016). By using three specified observation spots (*purpose sampling*) as a reference for the observation area that can be shown on a map, researchers used free roaming (crushing



method) to directly explore the Senggani Gorge tourism region (Figure 1).



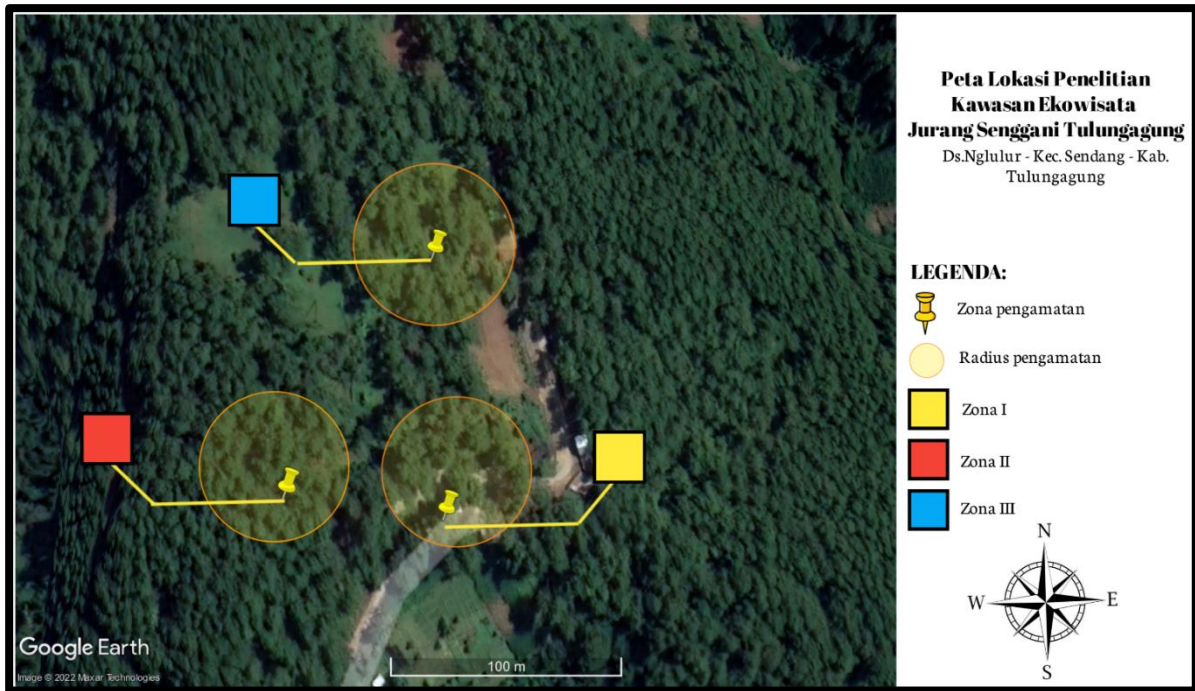


Figure 1. The Senggani Gorge tourism region, Nglurup Village, Sendang District, and Tulungagung Regency are all included on a map of the research locations.

Zone I is at the coordinate point (S 07°54'57.19" E 111°49'34.05"), Zone II is at the coordinate point (S 07°54'53.44" E 111°49'33.80"), and Zone III is at the coordinate point (S 07°54'57.00" E 111°49'31.88"). This research is not focused on establishing a particular hypothesis but is instead limited to describing the thing being observed through the use of tools for gathering observation data, documentation, and literature studies on the object being investigated (Arikunto, 2002). The Realme 3 Android camera and a Nikon 25 mm prosumer macro lens, as well as writing supplies and books for identifying mosses, were employed in the investigation. *Understanding Moss Plants (Bryophyta) Description, Classification, Potential, and How to Learn It* by Marheny Lukitasari (2016; 2018), as well as additional sources including articles, journals, and books. Instruments for measuring abiotic factors are employed (anemometer, GPS ETREX30X, AZ 885 Infrared Psychrometer, Three Way Soil Meter, and MA-30 Military Altimeter EX 284). Following collection, the specimens were identified and given a descriptive analysis based on their traits and abiotic components.

## RESULT AND DISCUSSION

### *Moss species diversity (Bryophyta)*

The research produced 20 species of moss plants (Bryophyta) that are native to Senggani Gorge's tourist region. A total of 20 species were present, with 15 moss plant families comprising 11 moss/leaf moss species (Bryophyta) and 9 liverwort/liverwort species (Marchantiophyta) (Table 1). According to field observations, zone III exhibits up to 13 more species than zones I or II combined, which is the highest level of species diversity. Moss plants can grow on a wide range of surfaces, including dirt, rocks, tree roots, tree trunks, worn wood, and the edge of cliffs.

**Table 1.** List of the bryophytes (mosses) that can be found in Senggani Gorge.

| No.                          | Scientific Name                    | Family          | Substrate            | Location |         |          |
|------------------------------|------------------------------------|-----------------|----------------------|----------|---------|----------|
|                              |                                    |                 |                      | Zone I   | Zone II | Zone III |
| Leaf moss (Bryophyta)        |                                    |                 |                      |          |         |          |
| 1                            | <i>Ceratodon purpureus</i>         | Ditrichaceae    | Soil, rocks          | -        | +       | -        |
| 2                            | <i>Fissidens sp.</i> Hedw.         | Fissidentaceae  | Rocks                | +        | -       | -        |
| 3                            | <i>Leucobryum glaucum</i>          | Leucobryaceae   | Tree trunks          | -        | -       | +        |
| 4                            | <i>Octoblepharum albidum</i> Hedw. | Leucophanaceae  | Soil, tree trunk     | -        | +       | +        |
| 5                            | <i>Rhizonium punctatum</i>         | Mniaceae        | Soil, rocks          | -        | +       | +        |
| 6                            | <i>Mnium stellare</i>              | Mniaceae        | Soil                 | +        | +       | +        |
| 7                            | <i>Mnium hornum</i>                | Mniaceae        | Soil                 | -        | -       | +        |
| 8                            | <i>Philonotis marchica</i>         | Bartramiaceae   | Soil                 | +        | -       | +        |
| 9                            | <i>Fontinalis antipyretica</i>     | Fontinalaceae   | Soil                 | -        | +       | -        |
| 10                           | <i>Hypnum cupressiforme</i>        | Hypnaceae       | Soil, rocks          | +        | +       | +        |
| 11                           | <i>Polytrichastrum formosum</i>    | Polytrichaceae  | Soil                 | +        | -       | -        |
| Liver moss (Marchantiophyta) |                                    |                 |                      |          |         |          |
| 1                            | <i>Lejeunea flava</i>              | Lejeuneaceae    | Soil, roots, rocks   | -        | -       | +        |
| 2                            | <i>Lejeunea cavifolia</i>          | Lejeuneaceae    | Soil, roots, rocks   | -        | -       | +        |
| 3                            | <i>Bazzania prareupta</i>          | Lepidoziaceae   | Soil, weathered wood | -        | +       | -        |
| 4                            | <i>Bazzania vittata</i>            | Lepidoziaceae   | Soil, weathered wood | +        | +       | +        |
| 5                            | <i>Conocephalum conicum</i>        | Conocephalaceae | Soil                 | -        | +       | -        |
| 6                            | <i>Marchantia emarginata</i>       | Marchantiaceae  | Soil                 | -        | -       | +        |
| 7                            | <i>Marchantia polymorpha</i>       | Marchantiaceae  | Soil                 | +        | -       | +        |
| 8                            | <i>Dumortiera hirsuta</i>          | Dumortieraceae  | Soil, rocks          | +        | -       | +        |
| 9                            | <i>Lunularia cruciata</i>          | Lunulariaceae   | Rocks                | -        | +       | -        |

Table 1 shows that the mosses that dominate the Senggani Gorge tourism region are of the Bryophyta division (leaf/true mosses). This is because the fact that mosses (mosses) are a group of moss plants with the biggest number of species existing in the world when compared to other moss groups, which have an estimated 12,000 species (Mulyani et al., 2015). According to research by Goffinet et al. (2008), the Bryopsida class, which encompasses 95% of the moss

species globally, is the biggest group of mosses. True mosses with leaves (Bryophyta) are classified as having a greater level of development than other forms of mosses, which can already tell stems from leaves.

When compared to earlier studies on mosses, such as those carried out at Peucari Bueng Jantho Waterfall, Aceh Besar District by Raihan et al. (2018), A relatively high diversity of moss species was observed by Azwir et al. (2022) in the Forest of Mesjid Raya District, Aceh Besar District, and by Endang (2020) along the Kaburan-Burana River Basin, Batauga District, South Buton Regency, but further study is needed. undertaken in the vicinity of Mount Ungaran by Mulyani et al., 2015, and research performed on Mount Prau, Blumah, Central Java region by Linah et al. in 2021. Some of these variations in outcomes may be the consequence of various and unique environmental factors, which have an impact on the capacity of certain moss species to develop and adapt. Furthermore, human actions such as land clearing that results in increased light intensity in the habitat where the moss grows, as well as other environmental degradation, might alter the level a variety of moss species in certain regions (Liannah et al., 2021).

*Description and possible use of mosses (Bryophyta)*

C. Leaf moss (Bryophyta)

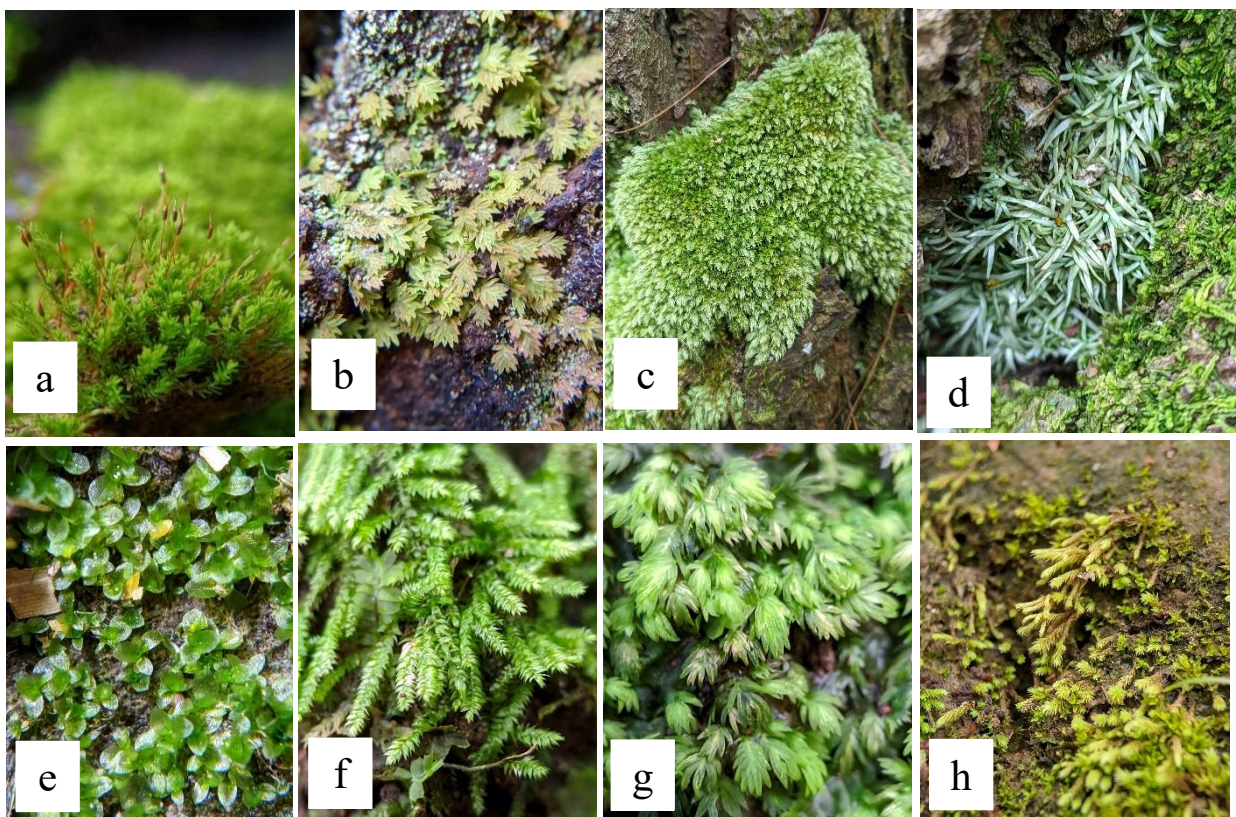




Figure 3. Leaf mosses (Bryophyta) found in the Senggani Gorge tourist area. a. *Ceratodon purpureus*, b. *Fissidens sp.*, c. *Leucobryum glaucum*, d. *Octoblepharum albidum*, e. *Rhizonium punctatum*, f. *Mnium stellare*, g. *Mnium hornum*, h. *Philonotis marchica*, i. *Fontinalis antipyretica*, j. *Hypnum cupressiform*, k. *Polytrichastrum formosum*

Figure 3 illustrates the variations between the properties of mosses belonging to the group Bryophyta (true/true mosses). Bryophyta, or real mosses, typically consist of entire plant-like structures (roots/rhizoids, leaves, and stems). On the stems of moss, which have upright, spirally arranged leaves, buds grow for reproduction. Leaf/true moss is capable of growing on soil, grass, rock, tree trunks, and roots. Andreaeales, Spagnales, and Bryales are the three orders that comprise the group of true/true mosses (mosses) (Lukitasari, 2018).

#### 1. *Ceratodon purpureus*

The body structure of *Ceratodon purpureus* consists of a sporangium (capsule), stalk, stem, leaf, and rhizoids. The leaves are thin and green in color and contain chlorophyll. Its body size is about 1-2 cm. *Ceratodon purpureus* consists of a sporangium (capsule), stalk, stem, leaf, and rhizoids in its body structure. The leaves are slender, green, and composed of chlorophyll. Its body length is approximately 1-2 centimeters. The Sporophyte is capable of producing spores. *Ceratodon purpureus* can attach itself to shaded and moist rocks, trees, and walls (Nasuha et al., 2021).

m. *Fissidens sp.* Hedw

This plant has a flat form, shoots that grow vertically, varying body sizes, a yellowish-green hue, and a filoid fingered, pointy tip. (Risanto et al., 2021). The stems are so short and concealed by leaves that they appear to be nonexistent. The stems are short and completely covered by leaves. On the stem, the leaves are organized in two rows, are lanceolate, have flat, small-toothed margins, and are pointy at the tip/base. *Fissidens sp.* Hedw develops in clusters and spreads on moist and damp rock surfaces (Endang et al., 2020)

n. *Leucobryum glaucum*

The leaves have a sickle shape with a sharp tip and are erectly dispersed. Reproduce asexually specifically in small clusters, such as caducus at the stem's tip. Attachment to the substrate is facilitated by having roots (rhizoids) positioned beneath the reproductive organs (gametophytes). *Leucobryum glaucum* grows to a height of several meters, clustering and producing dense pads. This bearing structure features a dome with a height of several centimeters. Typically, this sort of moss adheres to the surface of a damp tree trunk (Sumiati et al., 2021).

o. *Octoblepharum albidum*

*Octoblepharum albidum* is a member of the Bryopsida phylum. The leaves range in color from pale green to white, have an elongated, pointed form, and are thick. The sporophyte of *Octoblepharum albidum* is readily discernible. The top of the sporangium is known as the spore box. *Octoblepharum albidum* forms colonies and adheres to the stem of pine trees. *Octoblepharum albidum* occurs in both wet and dry forests. Therefore, the Senggani Gorge tourist area is an ideal habitat for *Octoblepharum albidum* because it is shady and cool.

p. *Rhizonium punctatum*

The oval leaves of this plant, which frequently grow next to one another, will contract when dry. *Rhizonium punctatum* has dark red stems that eventually turn reddish-brown in maturity.

Green protonematous rhizoids specialize in asexual reproduction. This species inhabits dark, moist, and damp soil and rocks (Tomovic et al., 2021).

q. *Mnium stellare*

*Mnium stellare* has undifferentiated leaf edges, and tiny, green leaves with pointy leaf tips. **In central and southern Europe, a moss called *Mnium stellare* is frequently encountered. *Mnium stellare* was discovered to live and adhere to the surface of damp and wet soil based on the findings of the investigation. (Hugonnot & Celle, 2012)**

r. *Mnium hornum*

The genus *Mnium* of the family Bryaceae includes the species of moss known as *Mnium hornum*. The leaves of *Mnium hornum* are distinctively golden green in color, slightly elongated, and have a pointy leaf tip. It also grows parallel. This moss species thrives on moist, humid soil. (2017) Marom et al.

s. *Philonotis marchica*

The spores of *Philonotis marchica* are round. The leaves of *Philonotis marchica* are green, very tiny, serrated, and placed in rows along the stems. The cells of the leaf blades appear to be wider near the base. A particular kind of moss called *Philonotis marchica* can survive on moist and damp soil surfaces.

t. *Fontinalis antipyretic*

It can grow transversely branched and up to 60 cm in length. *Fontinalis antipyretic* leaves are oval, a little stiff, and arranged in an overlapping pattern. There are tiny spores on this moss plant. This huge moss can be seen growing on damp, wet rocks and dirt (Lukitasari, 2018).

u. *Hypnum cupressiforme*

Is a species of moss that may grow on damp surfaces of soil and rocks. The green leaves of *Hypnum cupressiforme* are long, curled, and tipped with a point. Because the leaves grow

densely on the stem's surface, the stem is covered in leaves. The branches are irregularly pinnate and the branches either spread or ascend.

v. *Polytrichastrum formosum*

*Polytrichastrum formosum* is a medium-sized plant with tall branches that are not branched. The leaves bloom like flowers and get dull when dry. On the leaf surface, tall lamellae cells can be detected. The stems are unbranched and grow erect. This species can be found on moist and damp soil surfaces as well as flooded soil surfaces (Asthana et al., 2012).

D. Liveworts (Marchantiophyta)



**Figure 4.** Liverworts (Marchantiophyta) were spotted in the Senggani Gorge's tourism zone. a. *Lejeunea flava*, b. *Lejeunea cavifolia*, c. *Bazzania prareupta*, d. *Bazzania vittata*, e. *Conocephalum conicum*, f. *Marchantia emarginata*, g. *Marchantia polymorpha*, h. *Dumortiera hirsuta*, dan i. *Lunularia cruciate*

Figure 4 depicts the species of liverworts (Marchantiophyta) discovered in several zones of the research region, with apparent variances in their characteristics. Liverworts are distinguished from other mosses by the presence of a thallus connected to the substrate and leaves made up of lined and thickened cells. The genital organs of liverworts are usually found on the surface and are protected by a unicellular root structure (Lukitasari, 2018).

j. *Lejeunea flava*

*Lejeunea flava* features a small circular thallus that is pale green, varied leaf sizes between large (lobes) and small (lobules), and flat and blunt edges. Small trunk, dense, creeping, and branching growth. The branching, however, is almost unnoticeable since it is covered with an incubous leaf arrangement (lower leaves cover the top leaves) or overlaps. *L. flava* colonizes soil, trees, and rock substrates (Angeles et al., 2020).

k. *Lejeunea cavifolia*

The trunk of *Lejeunea cavifolia* is dense, flat, and interwoven with soil, bark, roots, and pebbles. It has a little thallus that is spherical, smooth, and pale green. This moss' stem spreads across the substrate, usually with two uneven branches, the margins are flat and blunt, the lower leaves cover the higher leaves or overlap one other, and it is divided between large leaves (lobes) and little leaves (lobule). *L. Cavifolia* grows on rotting wood, roots, rocks, and dirt in shaded and moist areas (Putna and Mezaka, 2014).

l. *Bazzania prareupta*



The leaves of *Bazzania prareupta* are almost square in shape, green in color, flat at the base at the borders, and rounded at the ends with a slightly curved inward center. The leaves are *succubous* (the top two covers the lower leaf), have cilia (tapering at the tip of the leaf), and have amphigastria. It has a small stem that is covered with leaves, is of the Frullania branching type, and is linked to soil and worn wood surfaces (Lestari and Ariyanti, 2017).

*m. Bazzania vittata*

*Bazzania vittata* has a little green stem with a trunk branch that looks like a Frullania or is formed like a fork but is short and unusual. The leaves are closely packed, neighboring leaves overlap, the base of the leaf is flat, the ventral leaf is attached, the leaf edge is flat, and the top of the leaf is 2-3 serrated, blunt, and rough. The ventral leaves are closely spaced, circular to the square in form, and have thin walls. *B. Vittata* is frequently found clinging to soil substrates and worn wood (Lestari and Ariyanti, 2017).

*n. Conocephalum conicum*

*Conocephalum conicum* has a very large thallus, a thick, green, smooth surface, and a white pattern (air pores) that looks like scales with a dark green midrib (middle bone). The thallus tip is spherical with a little depression, while the base of the thallus has a flat edge. Rhizoids, which are roots found in the lower section of the thallus, aid in attachment to the soil substrate (Sopacua et al., 2020).

*o. Marchantia emarginata*

*Marchantia emarginata* has a branching and rigid thallus that is dark green and leafless. It has a smooth surface, no midrib/midrib spreads across the soil surface, and when dried, the edges turn brown. The ribbon-like leaves of *M. emarginata* are distinguished by forked, fleshy branches and the presence of brood buds, despite the absence of a petiole on the stem. A thallus and a root are the only components of the gametophyte structure. Roots (rhizoids) aid

in the attachment of the thallus to the substrate and are typically grouped in groups (Wen LU and Huang, 2017).

*p. Marchantia polymorpha*

*Marchantia polymorpha* has a green thallus, no leaves, and grows creeping above the ground. The top thallus has a hexagonal pattern, the tip and base of the thallus are blunt, porous, black striped, and has a thick stiff texture on the thallus (Febriansah et al. ., 2019). There is a gamma cup, which is used for vegetative reproduction, and spores are used for generative reproduction. The archegonium stem is brownish green, and the archegonium is green, lobe-shaped like an umbrella. It has many roots (rhizoids) that aid in adhering to the soil surface (Sholihat and Kurnia, 2021).

*q. Dumortiera hirsuta*

*Dumortiera hirsuta* is a dark green ribbon-shaped plant with dichotomous branches. The thallus has a blunt, rounded tip with an indentation like the letter V in the middle, a spore bowl, and flat margins. The surface is slick and striped in a white hexagonal pattern, and there a few downy hairs. Similar to other forms of mosses, mosses use rhizoid (roots) to adhere to the substrate. The substrate of *D. Hirsuta* consists of soil and rocks (Karomah et al., 2020).

*r. Lunularia cruciata*

The talus surface of *Lunularia cruciata* is glossy, pale green, sparsely bordered, and speckled; its branches are dichotomous. The top of the thallus is rounded, and its edges are wavy, with two to three waves and blunt edges. When dry, the thallus's thin scales turn yellow and the margins are somewhat curled. On the back are several rhizomes that anchor the plant to the rocky substrate (Kirschner et al., 2010).

## Environmental Element

The environmental parameters of mosses in the tourism area of Senggani Gorge differ significantly from those in the three observation zones. In general, however, the climate in the

Senggani Gorge is cool, humid, and chilly. Consequently, based on the measurements of environmental abiotic parameters, it has been determined that the environmental conditions in the Senggani Gorge tourism region are compatible with the features of the moss plant's habitat and conducive to its reproduction. Table 2 displays the abiotic environmental conditions of each zone's mosses.

**Table 2.** Each zone's moss plant abiotic environmental conditions

| Parameters                    | Location |         |          |
|-------------------------------|----------|---------|----------|
|                               | Zone I   | Zone II | Zone III |
| Air temperature (C°)          | 27,4     | 25,4    | 24,1     |
| Humidity (%)                  | 80       | 83      | 84       |
| Light intensity (Cd)          | 500      | 250     | 200      |
| Altitude of the place (m dpl) | 815      | 818     | 838      |
| Soil moisture (%)             | 6        | 7       | 7        |
| Soil pH                       | 7        | 7       | 6        |
| Wind speed (m/s)              | 1,7      | 1,2     | 2,0      |

Table 2 indicates that zone 3 has the highest altitude (838 m above sea level), is characterized by dense, shady trees, and has an air temperature of 24.1 C°. The air humidity is 84%, the light intensity is 200 Cd, the soil wetness is 7, the soil pH is 6, and the wind speed is 2.0 meters per second. This substantially supports the habitat of moss plants where humidity and light intensity greatly affect the number of moss creatures, as proven by the fact that zone 3 is home to as many as 13 kinds of mosses. The intensity of sunshine has a significant effect on the air's temperature and humidity, which in turn has a significant effect on the distribution of mosses. The less intense the sunshine, the greater the relative humidity and the lower the air temperature. The optimal air humidity for moss growth is between 70 and 98%, and soil pH has a significant impact on moss growth; moss thrives in the pH range of 4.9 to 8.3. (Wati, et al, 2016).

**CONCLUSION**

Based on the outcome of the research, it can be inferred that the diversity of mosses (Bryophyta) in the Senggani Gorge area is extremely diverse and varied, indicating that the area is still mostly undeveloped. There are 20 species of mosses (Bryophyta) divided into four classes:

Bryopsida, Polytrichopsida, Jungermanniopsida, and Marchantiopsida. Zone 3 is a region that strongly favors moss habitat due to its height (838 MASL ), air temperature 24.1 C°, air humidity 84%, light intensity 200 candelas per square meter, and soil pH 6. As an oxygen source, a water absorber, a pollutant absorber, an anti-erosion agent, an aesthetic plant, and a medicinal plant, moss plants play a vital function in the environment.

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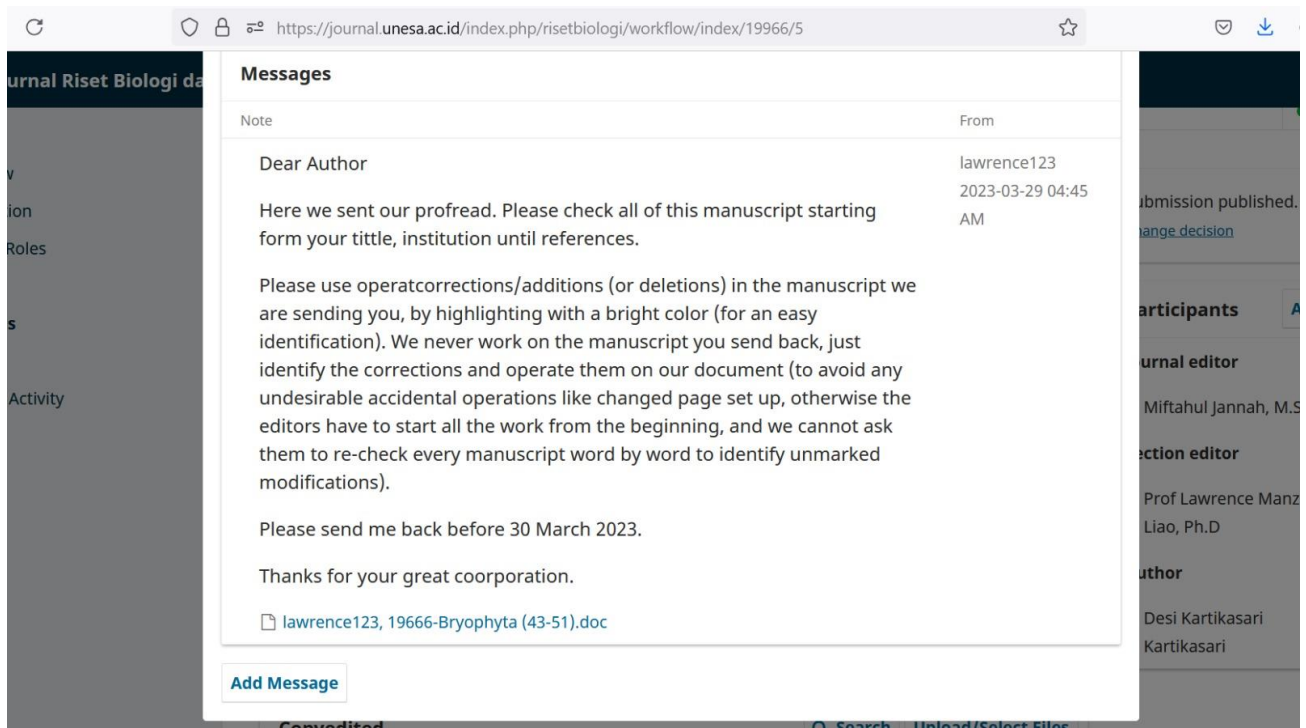
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## 6. Bukti Konfirmasi dari Reviewer Luar Negeri dan hasil review terakhir (29 Maret 2024)



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### Diversity of Moss Species (Bryophyta) In Senggani Ravine Tourism Area, Tulungagung Regency

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#### ABSTRACT

Moss plants (Bryophyta) are found in every habitat, and their presence in an ecosystem is controlled by environmental circumstances. The Senggani Ravine tourism area is a popular tourist attraction comprising a pine forest with extensive moss communities. This work aimed to assess the diversity of mosses (Bryophyta) in the Senggani Ravine tourism area for the first time. In June 2022, exploratory descriptive research of moss diversity was undertaken by a free walk around the Senggani Ravine tourism area from a predetermined position point (purposive sampling) using observation, documentation, literature study, and measurement of abiotic elements for data collection. Based on the results, twenty species of mosses were identified and can be divided into four classes, namely the Bryopsida, Polytrichopsida, Jungermanniopsida, and Marchantiopsida. The species identified



were *Barbulla indica*, *Fissidens purpusillus*, *Fissidens bififormis*, *Fissidens bififormis*, *Octoblepharum albidum*, *Rhizonium punctatum*, *Mnium hornum*, *Philonotis marchica*, *Fontinalis antipyretica*, *Hypnum cupressiform*, *Polytrichastrum formosum*, *Lejeunea flava*, *Lejeunea cavifolia*, *Bazzania praeupta*, *Bazzania vittata*, *Riccia junghuhniana*, *Marchantia emarginata*, *Marchantia polymorpha*, *Dumortiera hirsuta*, and *Lumularia cruciate*. Abiotic factor measurements revealed that zone 3, which has a soil pH of 6, an air temperature of 24.1 C°, an 84% humidity level, and 200 Cd of light cm<sup>-1</sup>, is the most favorable area for moss growth. We can infer that the Senggani Ravine tourism area is still primarily undisturbed because the moss flora is still quite diverse and varied.

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## INTRODUCTION

Senggani Ravine is a tourist destination in Nglurup Village, Sendang District, Tulungagung Regency. Known for its campgrounds and home to a magnificent pine forest, it is a popular tourist attraction. It features a cool and humid microclimate and has fertile soil. The predominance of dense and gloomy trees, as well as grass and other vegetation indicates that these environmental circumstances enable the establishment of various species like mosses (Effendi et al., 2018). Mosses (Bryophyta) are a group of plants with 15,000 species, the second largest after the flowering plants that dominate the Indonesian mainland. The presence of mosses in an ecosystem is influenced by environmental circumstances. Mosses grow in every habitat. They are able to live and grow on a variety of surfaces, including soil, rocks, sand, litter, tree trunks, and even water. Numerous abiotic elements can affect the growth of mosses (Mulyani et al., 2015). According to Bawaihaty et al. (2014), environmental circumstances such as temperature, humidity, light, altitude, climate, and availability of nutrients have a significant impact on the population and variety of mosses within an ecosystem.

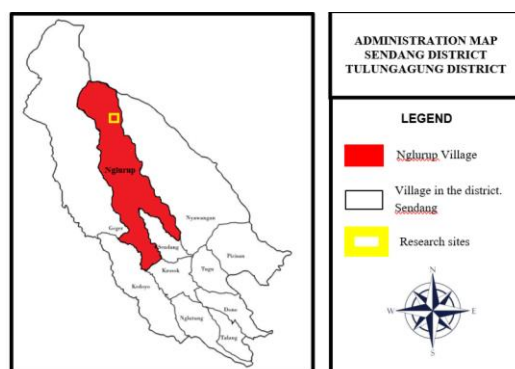
The growth of mosses exerts positive effects on the local ecosystem, particularly for other plants. Using rock mineralization, decomposition, and carbon fixation, mosses have the potential to balance the nutrient content of the soil (Lukitasari, 2018). According to Perwati et al. (2015), mosses play a significant role in tropical forest areas, particularly in highland regions. In addition to serving as a home

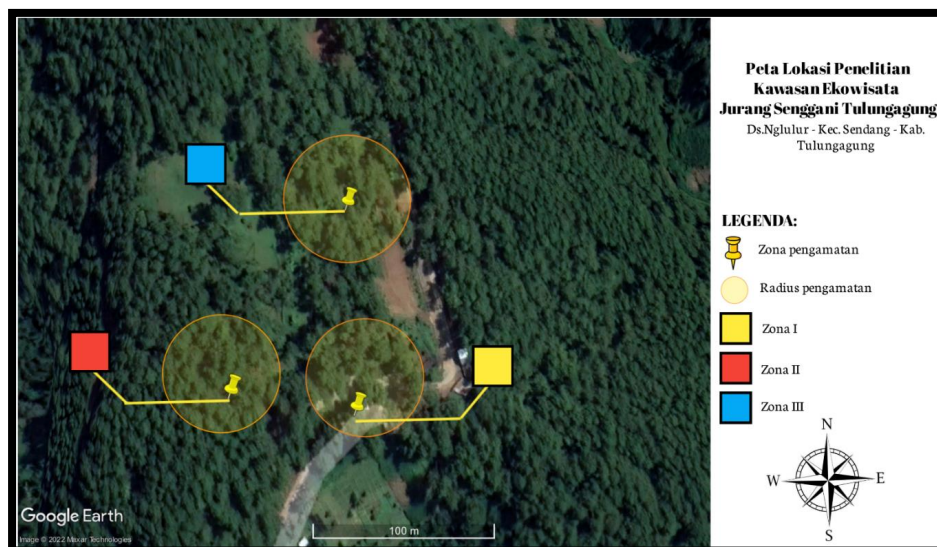
for other organisms, moss plants also serve as groundwater balancers, oxygen suppliers, nutrient cycle inhibitors, ornamental plants, medicinals, and are able to detect pollution levels or environmental changes. Research on the variety of mosses in the Senggani Ravine tourism area, is conducted due to their significant ecological function and to address the lack of existing studies on mosses in the region. This research aimed to assess the diversity of mosses (Bryophyta) in the Senggani Ravine tourism area. By doing this research, it is anticipated to reveal more about the variety of mosses there and their ecological advantages.

## MATERIALS AND METHODS

### *Location and time of observation*

The research was carried out in the Senggani Gorge region, Nglurup Village, Sendang District, Tulungagung Regency in June 2022. Senggani Ravine is a region in the highlands that is about 800 m above sea level, has an average temperature of 25.6 C°, and 82.3% relative humidity. Sampling involved *in situ* research through direct observations by researchers in their natural environments (Moelong, 2017). This research employed a descriptive exploratory strategy with *cruising* approaches (Sundra, 2016). By using three specified observation points (purposive sampling) as a reference for the observation area that can be shown on a map, researchers used free roaming (cruising method) to directly explore the Senggani Ravine tourism area (Figure 1).





**Figure 1.** The Senggani Ravine tourism Area, Nglurup Village, Sendang District, Tulungagung Regency are all included on a map of the research locations

Zone I is at the coordinate point (S 07°54'57.19" E 111°49'34.05"), Zone II is at the coordinate point (S 07°54'53.44" E 111°49'33.80"), and Zone III is at the coordinate point (S 07°54'57.00" E 111°49'31.88"). This research was not focused on establishing a particular hypothesis but limited to descriptions being observed using tools for gathering observation data, documentation, and literature studies (Arikunto, 2002). A Realme 3 Android camera and a Nikon 25 mm prosumer macro lens, as well as writing supplies and books for identifying mosses, were used in the investigation. References such as Lukitasari (2016; 2018) and additional sources including articles, journals, and books were consulted. Instruments for measuring abiotic factors were employed (anemometer, GPS ETREX30X, AZ 885 Infrared Psychrometer, Three Way Soil Meter, and MA-30 Military Altimeter EX 284). Following collection, the specimens were identified and given a descriptive analysis based on their traits and abiotic components.

## RESULTS AND DISCUSSION

### *Moss species diversity (Bryophyta)*

The research identified 20 species of mosses (Bryophyta) that are native of Senggani Ravine tourist area. A total of 20 species were collected, classified into 15 moss plant families comprising 11 moss/leaf moss species (Bryophyta) and 9 liverwort species (Marchantiophyta) (Table 1). According to field observations, zone III exhibited up to 13 more species than zones I or II combined, which is the highest level of species diversity. Moss plants can grow on a wide

range of surfaces, including soil, rocks, tree roots, tree trunks, weathered logs, and cliffs edge.

The mosses that dominated the Senggani Ravine tourism area belonged to the Bryophyta division (leaf/true mosses) (Table 1) which is the group of moss plants with the highest number of species in the world when compared to other moss groups, which is estimated at 12,000 species (Mulyani et al., 2015). According to research by Goffinet et al. (2008), the Bryopsida class, which encompasses 95% of the moss species globally, is the biggest group of mosses. True mosses with leaves (Bryophyta) are classified as having a greater level of development than other forms of mosses, in which stems can already be distinguished from leaves.

When compared to earlier studies on mosses, such as those carried out at Peucari Bueng Jantho Waterfall, Aceh Besar District by Raihan et al. (2018), a relatively high diversity of moss species was observed by Azwir et al. (2022) in the forest of Mesjid Raya District, Aceh Besar District, and by Endang (2020) along the Kaburan-Burana River Basin, Batauga District, South Buton Regency, but further study is needed. Other studies were also undertaken in the vicinity of Mount Ungaran by Mulyani et al. (2015), and on Mount Prau, Blumah, Central Java region by Linah et al. (2021). Some of these variations in yield may be the consequence of various and unique environmental factors impacting upon the capacity of certain moss species to develop and adapt. Furthermore, human actions such as land clearing those results in increased light intensity in the moss habitat, as well as other

environmental degradation, might alter the variety of moss species in certain areas (Liannah et al., 2021).

Figure 3 illustrates the variations between the properties of mosses belonging to the Bryophyta (true mosses) group. Bryophyta, or true mosses, typically consist of entire plant-like structures (roots/rhizoids, leaves, and stems). On the stems of moss, which have upright, spirally arranged leaves, buds grow for reproduction. Leaf/true mosses are able to grow on soil, grass, rock, tree trunks, and roots. Andreaeales, Sphagnales, and Bryales are the three orders that comprise the group of true mosses (mosses) (Lukitasari, 2018).

#### ***Barbula indica***

*Barbula indica* has a height of 5-15 mm, smooth brown rhizomes, stems erect and occasionally branched, dark brown to reddish brown. Lanceolate leaves, grow upright on the stem, when dry the leaves will turn brown. The arrangement of the leaves is alternate, dense so that it looks stacked on top of each other, with small toothed leaf margins, leaf tips rounded, large costa ending at the leaf tip. Setae erect, occasionally bent, measuring 1 cm or more, capsules are round, cylindrical, measuring 1.5 mm and have an elongated capsule cover. This type of moss is found growing in groups, dense and growing upright on calcareous soil with open environmental conditions. Eddy (1998) argues that *Barbula indica* is a small, green or yellowish plant with a height of more than 1 cm. Stem simple or branched. Leaves narrow, apex (leaf tip) rounded, often emarginated (heart-shaped). Setae short, spherical cylindrical capsule, up to 1.5 mm long, narrowly conical capsule cover. It grows on rocks, soil and walls, especially in damp and calcareous places.

#### ***Fissidens perpusillus***

This plant has a flat form, shoots that grow vertically, varying body sizes, a yellowish-green hue, and a filoid fingered, pointy tip (Ristanto et al., 2021). The stems are so short and concealed by leaves that they appear to be nonexistent. The stems are short and completely covered by leaves. On the stem, the leaves are organized in two rows, are lanceolate, have flat, small-toothed margins, and are pointy at the tip/base. *Fissidens perpusillus* develops in clusters and spreads on moist and damp rock surfaces (Endang et al., 2020).

#### ***Fessidens biformis***

Belongs to the Fissidentaceae group. Almost often found growing on rock substrate. It has a leaf morphology that is wide, upright and clustered, the tips are pointed, finger-like and stacked in a row, has a short stalk that is not visible, capsules and setae are about 1 cm long (Febrianti, 2015).

#### ***Fessidens astroviridis***

*Fissidens astroviridis* is commonly found in soil substrates but is also found in rocks. This moss has a dull green color and looks comb-shaped when viewed from above (Febrianti, 2015). The individual size of *F. atroviridis* reaches 5 mm. The leaves are lanceolate with a pointed tip (Raihan et al., 2018). Leaf anatomy has a size of 1  $\mu$ m with an irregular rectangular shape. The stem is almost invisible because it is covered with a collection of thread-like leaves and rhizoids. Environmental conditions have a significant influence on moss. Differences of each species of mosses to environmental factors will affect the level of adaptation, species composition, and distribution of mosses (Pasaribu, 2013).

#### ***Octoblepharum albidum***

The leaves ranged in color from pale green to white, have an elongated, pointed form, and are thick. The sporophyte of *O. albidum* is readily discernible. The top of the sporangium is known as the spore box. It forms colonies and adheres to the stem of pine trees and is found in both wet and dry forests. Therefore, the Senggani Ravine tourism area is an ideal habitat for *O. albidum* because it is shady and cool.

#### ***Rhizonium punctatum***

The oval leaves of this plant, which frequently grow next to one another, shrink when dry. *R. punctatum* has dark red stems that eventually turn reddish-brown as they mature. Green protonematous rhizoids specialize in asexual reproduction. This species inhabits dark, moist, and damp soil and rocks (Tomovic et al., 2021).

#### ***Mnium hornum***

The leaves of *Mnium hornum* are distinctively golden green in color, slightly elongated, and have a pointed leaf tip. This moss species thrives on moist and humid soil (Marom et al., 2017).

#### ***Philonotis marchica***

The spores of *Philonotis marchica* are round. The leaves are green, weeny, serrated, and arranged

**Table 1.** List of the bryophytes (mosses) that can be found in Senggani Gorge

| No.                                 | Scientific Name                 | Family         | Substrate            | Location |         |          |
|-------------------------------------|---------------------------------|----------------|----------------------|----------|---------|----------|
|                                     |                                 |                |                      | Zone I   | Zone II | Zone III |
| <b>Leaf moss (Bryophyta)</b>        |                                 |                |                      |          |         |          |
| 1                                   | <i>Barbulla indica</i>          | Pottiaceae     | Soil, rocks          | -        | +       | -        |
| 2                                   | <i>Fissidens purpusillus</i>    | Fissidentaceae | Rocks                | +        | -       | -        |
| 3                                   | <i>Fissidens bififormis</i>     | Fissidentaceae | Tree trunks          | -        | -       | +        |
| 4                                   | <i>Fissidens astroviridis</i>   | Fissidentaceae | Soil                 | +        | +       | +        |
| 5                                   | <i>Octoblepharum albidum</i>    | Leucophanaceae | Soil, tree trunk     | -        | +       | +        |
| 6                                   | <i>Rhizonium punctatum</i>      | Mniaceae       | Soil, rocks          | -        | +       | +        |
| 7                                   | <i>Mnium hornum</i>             | Mniaceae       | Soil                 | -        | -       | +        |
| 8                                   | <i>Philonotis marchica</i>      | Bartramiaceae  | Soil                 | +        | -       | +        |
| 9                                   | <i>Fontinalis antipyretica</i>  | Fontinalaceae  | Soil                 | -        | +       | -        |
| 10                                  | <i>Hypnum cupressiforme</i>     | Hypnaceae      | Soil, rocks          | +        | +       | +        |
| 11                                  | <i>Polytrichastrum formosum</i> | Polytrichaceae | Soil                 | +        | -       | -        |
| <b>Liver moss (Marchantiophyta)</b> |                                 |                |                      |          |         |          |
| 1                                   | <i>Lejeunea flava</i>           | Lejeuneaceae   | Soil, roots, rocks   | -        | -       | +        |
| 2                                   | <i>Lejeunea cavifolia</i>       | Lejeuneaceae   | Soil, roots, rocks   | -        | -       | +        |
| 3                                   | <i>Bazzania prareupta</i>       | Lepidoziaceae  | Soil, weathered wood | -        | +       | -        |
| 4                                   | <i>Bazzania vittata</i>         | Lepidoziaceae  | Soil, weathered wood | +        | +       | +        |
| 5                                   | <i>Riccia junghuhniana</i>      | Ricciaceae     | Soil                 | -        | +       | -        |
| 6                                   | <i>Marchantia emarginata</i>    | Marchantiaceae | Soil                 | -        | -       | +        |
| 7                                   | <i>Marchantia polymorpha</i>    | Marchantiaceae | Soil                 | +        | -       | +        |
| 8                                   | <i>Dumortiera hirsuta</i>       | Dumortieraceae | Soil, rocks          | +        | -       | +        |
| 9                                   | <i>Lunularia cruciata</i>       | Lunulariaceae  | Rocks                | -        | +       | -        |



**Figure 3.** Leaf mosses (Bryophyta) were found in the Senggani Ravine tourism area. a. *Barbulla indica* b. *Fissidens purpusillus* c. *Fissidens biformis*, d. *Octoblepharum albidum*, e. *Rhizonium punctatum*, f. *Mnium stellare*, g. *Mnium hornum*, h. *Philonotis marchica*, i. *Fontinalis antipyretica*, j. *Hypnum cupressiforme*, k. *Polytrichastrum formosum*

along the stems. The cells of the leaf blades appear to be wider near the base. It can survive on moist and damp soil surfaces.

#### ***Fontinalis antipyretica***

It can grow transversely branched and reach up to 60 cm in length. Its leaves are oval, slightly stiff, and arranged in an overlapping pattern. There are tiny spores on this moss plant at the time of collection. This huge moss can be seen growing on damp, wet rocks and soil (Lukitasari, 2018).

#### ***Hypnum cupressiforme***

*Hypnum cupressiforme* is a species of moss that may grow on damp surfaces of soil and rocks. Its green leaves are long, curled, and have pointed tips. Because the leaves grow densely on the stem's surface, the stem is almost completely covered by the leaves. The branches are irregularly pinnate and the branches either spread or ascendant.

#### ***Polytrichastrum formosum***

*Polytrichastrum formosum* is a medium-sized plant with tall and unbranched main stems. The leaves bloom like flowers and become dull when dry. On the leaf surface, tall lamellae cells can be detected. This species can be found on moist and damp soil surfaces as well as flooded soil surfaces (Asthana et al., 2012).

#### **Liverworts (Marchantiophyta)**

Figure 4 depicts the species of liverworts (Marchantiophyta) discovered in several zones of the research area, with apparent variances in their characteristics. Liverworts are distinguished from other mosses by the presence of a thallus connected to the substrate and leaves made up of lined and thickened cells. The genital organs of liverworts are usually found on the surface and are protected by a unicellular root structure (Lukitasari, 2018).

#### ***Lejeunea flava***

*Lejeunea flava* features a small and pale green circular thallus, varied leaf sizes between large (lobes) and small (lobules), and flat and blunt edges. Small trunk, dense, creeping, and branching growth.

The branching, however, is almost unnoticeable since it is covered with an incubous leaf arrangement (lower leaves covering the top leaves) or overlaps. *L. flava* colonizes soil, trees, and rock substrates (Angeles et al., 2020).

#### ***Lejeunea cavifolia***

The trunk of *Lejeunea cavifolia* is dense, flat, and intertwined with soil, bark, roots, and pebbles. It has a small thallus that is spherical, smooth, and pale green. This moss's stem spreads over the substrate, usually with two uneven branches, the edges are flat and blunt, the lower leaves covering the higher leaves or overlap each other, and it is divided between large leaves (lobes) and little leaves (lobule). *L. cavifolia* grows on rotten wood, roots, rocks, and soil in shaded and moist areas (Putna and Mezaka, 2014).

#### ***Bazzania praeupta***

The leaves of *Bazzania praeupta* are almost square in shape, green in color, flat at the basal borders, and rounded at the ends with a slightly curved inward center. The leaves are *succubous* (two upper covering the lower leaf), have cilia (tapering at the tip of the leaf), and have amphigastria. It has a small stem that is covered with leaves, of the *Frullania* branching type, and is linked to soil and worn wood surfaces (Lestari and Ariyanti, 2017).

#### ***Bazzania vittata***

*Bazzania vittata* has a little green stem with a trunk branch that looks like a *Frullania* or is formed like a fork but is short and unusual. The leaves are closely packed, neighboring leaves overlap, the base of the leaf is flat, the ventral leaf is attached, the leaf edge is flat, and the top of the leaf is 2-3 serrated, blunt, and rough. The ventral leaves are closely spaced, circular to the square in form, and have thin walls. *B. Vittata* is frequently found clinging to soil substrates and worn wood (Lestari and Ariyanti, 2017).

#### ***Riccia junghuhniana***

*Riccia junghuhniana* Nees & Lindenb belongs to the Ricciaceae family. *Riccia junghuhniana* is a liverwort that grows on the surface of the substrate like on the ground. *R. junghuhniana* has a thallus that is flush with the substrate, has midribs on the dorsal side of the thallus. Thallus branched dichotomous, light green and shiny. Live in groups by forming floral or circular patterns. When it has dried the thallus is yellowish in color (Lianah, et al., 2021).

#### ***Marchantia emarginata***

*Marchantia emarginata* has a branched and stiff thallus that is dark green and leafless. It has a smooth surface, no midrib/midrib spreads across the soil

surface, and when it is dried, the edges turn brown. The ribbon-like leaves of *M. emarginata* are distinguished by forked, fleshy branches and the presence of brood buds, despite the absence of a petiole on the stem. The thallus and the root are the only components of the gametophyte structure. Roots (rhizoids) aid in the attachment of the thallus to the substrate and are typically grouped in clusters (Wen and Huang, 2017).

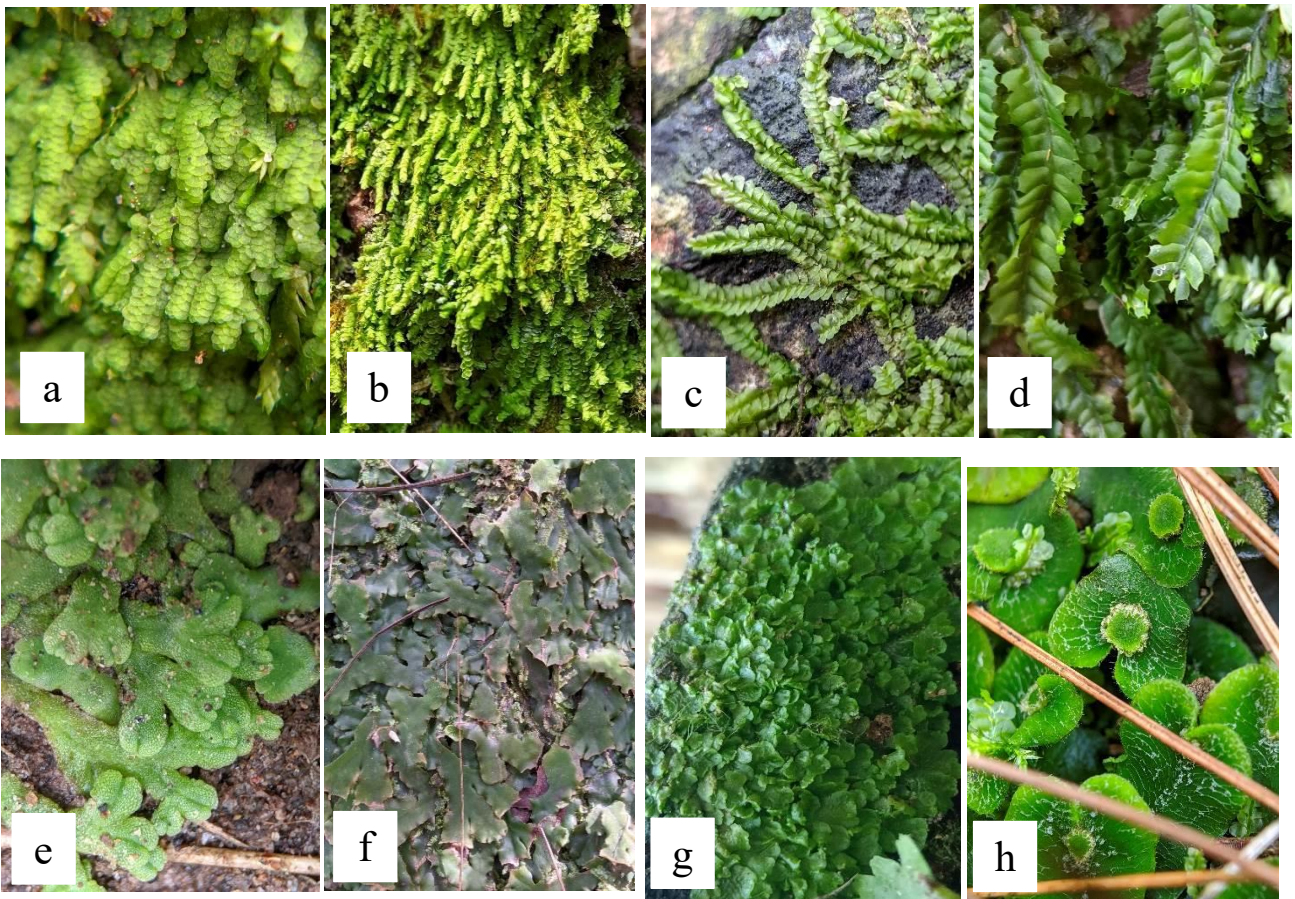
**Marchantia polymorpha**

*Marchantia polymorpha* has a green thallus, no leaves, and grows creeping on the ground. The upper thallus has a hexagonal pattern, the tip and base of the thallus are blunt, porous, black striped, and has a thick stiff texture on the thallus (Febriansah et al., 2019). There is a *gemmae* cup, which is used for

vegetative reproduction, and spores are used for generative reproduction. The archegonial stem is brownish green, and the archegoniophore is green, lobe-shaped like an umbrella. It has many roots (rhizoids) that aid in adhering to the soil surface (Sholihat and Kurnia, 2021).

**Dumortiera hirsuta**

*Dumortiera hirsuta* is a dark green ribbon-shaped plant with dichotomous branches. The thallus has a blunt, rounded tip with a V-shaped indentation in the middle, a spore cup, and flat margins. The surface is slick and striped in a white hexagonal pattern, and there a few downy hairs. Similar to other forms of mosses, it uses rhizoid (roots) to adhere to the substrate. The substrate of *D. hirsuta* consists of soil and rocks (Karomah et al., 2020).



**Figure 4.** Liverworts (Marchantiophyta) spotted in the Senggani Gorge's tourism zone. a. *Lejeunea flava*, b. *Lejeunea cavifolia*, c. *Bazzania praeupta*, d. *Bazzania vittata*, e. *Riccia junghuhniana*, f. *Marchantia emarginata*, g. *Marchantia polymorpha*, h. *Dumortiera hirsuta*, and i. *Lunularia cruciata*

**Table 2.** Each zone's moss plant abiotic environmental conditions

| Parameters           | Location |         |          |
|----------------------|----------|---------|----------|
|                      | Zone I   | Zone II | Zone III |
| Air temperature (C°) | 27.4     | 25.4    | 24.1     |

|                                 |     |     |     |
|---------------------------------|-----|-----|-----|
| Humidity (%)                    | 80  | 83  | 84  |
| Light intensity (Cd)            | 500 | 250 | 200 |
| Altitude of the place (m a.s.l) | 815 | 818 | 838 |
| Soil moisture (%)               | 6   | 7   | 7   |
| Soil pH                         | 7   | 7   | 6   |
| Wind speed (m/s)                | 1.7 | 1.2 | 2.0 |

### Environmental Factors

The environmental parameters affecting mosses in the tourism area of Senggani Ravine differ significantly in the three observation zones. However, in general, the climate in the Senggani Ravine is cold, humid, and chilly. Consequently, based on the measurements of environmental abiotic parameters, it has been determined that the environmental conditions in the Senggani Gorge tourism area are compatible with the features of the moss plant's habitat and conducive to its reproduction. Table 2 displays the abiotic environmental conditions of each moss zone.

Table 2 indicates that zone 3 has the highest altitude (838 m above sea level), is characterized by dense, shady trees, and has an air temperature of 24.1 C°. The air humidity is 84%, the light intensity is 200 Cd, the soil wetness is 7, the soil pH is 6, and the wind speed is 2.0 m s<sup>-1</sup>. This substantially supports the habitat of moss plants where humidity and light intensity greatly affect the number of moss species, as proven by the fact that zone 3 is home to as many as 13 kinds of mosses. The intensity of sunlight has a significant effect on the air temperature and humidity, which in turn has a significant effect on the distribution of mosses. The less intense the sunshine, the greater the relative humidity and the lower the air temperature. The optimal air humidity for moss growth is between 70 and 98%, and soil pH has a significant impact on moss growth; moss thrives in the pH range of 4.9 to 8.3. (Wati, et al., 2016).

### CONCLUSION

Based on the outcome of the research, it can be inferred that the diversity of mosses (Bryophyta) in the Senggani Ravine area is extremely diverse and varied, indicating that the area is still mostly undeveloped. There are 20 species of mosses (Bryophyta) divided into four classes: Bryopsida, Polytrichopsida, Jungermanniopsida, and Marchantiopsida. Zone 3 is a region that strongly favors moss habitat due to its height (838 MASL), air temperature 24.1 C°, air humidity 84%, light intensity 200 candelas per square meter, and soil pH 6. As oxygen sources, water absorbers, pollutant absorbers, anti-erosion agents, aesthetic and medicinal plants, moss plants play a vital function in the environment.

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## 7. Bukti Konfirmasi mulai dari proses accepted dan copyediting untuk siap terbit (29 Maret 2024)

The screenshot shows a journal submission system interface for 'Jurnal Riset Biologi dan Aplikasinya'. The submission is titled 'Diversity of Moss Species (Bryophyta) In Senggani Ravine Tourism Area' by Kartikasari et al. The submission is in the 'Production' stage, with tabs for 'Submission', 'Review', 'Copyediting', and 'Production'. The 'Production' tab is active, showing a 'Draft Files' section with one file: 'mifta2022, RL19666-Bryophyta.doc' (March 29, 2023). A 'Participants' section is also visible with an 'Assign' button. A notification on the right states 'Submission published. Change decision'.

This screenshot provides a detailed view of the 'Copyediting Discussions' section. It features a table with the following data:


| Name   | From                                  | Last Reply | Replies | Closed                   |
|--|---------------------------------------|------------|---------|--------------------------|
| <a href="#">Checking article Profreading</a> | lawrence123<br>2023-03-29<br>04:45 AM | -          | 0       | <input type="checkbox"/> |


Buttons for 'Order' and 'Add discussion' are located above the table. The 'Draft Files' section above shows the file 'mifta2022, RL19666-Bryophyta.doc' with a 'Search' and 'Upload/Select Files' button.



## 8. Bukti Konfirmasi penerbitan artikel pada jurnal atau published (31 Maret 2024)

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|   |   |  |                |              |
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Home / Archives / Vol. 5 No. 1 (2023)

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Genetic Profile of Local Buffalo (*Bubalus bubalis*) Populations in Pacitan and Tuban, East Java, Indonesia Measured by the Molecular Marker of INRA032 Locus

37-42

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43-51

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