

Identification of Lichen Based on Substrate in Bale Village, Tanantovea District, Donggala Regency

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Abstract

Lichens are associations between fungi and photosynthetic symbionts, such as algae or cyanobacteria, that form stable and specialized thallus structures. The fungi that predominantly compose the lichen body belong to the Ascomycetes, while the algal partners contribute to the overall structure. This association enhances the ability of both fungi and algae to survive in suboptimal environmental conditions because the thallus structure, physiology, and chemical synthesis of lichens differ from those of the individual fungi or algae that constitute them. Lichens are lower plants that occur in various habitats worldwide and dominate terrestrial ecosystems, covering approximately 8% of the Earth's land surface. Globally, around 20,000 lichen species have been reported, whereas in Indonesia, 595 species or about 3% of the world's total have been documented. This study aimed to identify lichen species based on their substrates in the Bale Village area, Tanantovea District, Donggala Regency. The sampling method used was the exploration method. Lichen samples were collected from various substrates, followed by direct macroscopic observations to identify the species obtained. Research sites were determined using purposive sampling, selected based on the environmental conditions and the diversity of substrates where lichens grow. Three locations were designated as research stations: Station 1 (residential area), Station 2 (forest and river area, partly used as a tourist site), and Station 3 (forest area and local plantations). The results of this study identified 10 lichen species belonging to 5 families and found on 3 types of substrates. Environmental parameter measurements at the research sites showed an average temperature of 27.66°C, air humidity of 66%, and light intensity of 828.66 cd. These values indicate warm, humid conditions with moderate to high light intensity conditions generally optimal for the growth and development of lichens.

Keywords: Bale; identification; lichen; substrate; species.

INTRODUCTION

Lichens are associations between fungi and photosynthetic symbionts, such as algae or cyanobacteria, that form stable and specific thallus structures (Sanders & Masumoto, 2021). Most fungi that compose the lichen body belong to the Ascomycetes, while the algal partners also contribute to its structural formation. This symbiotic association enhances the ability of both fungi and algae to survive under suboptimal environmental conditions because the thallus structure, physiology, and chemical compound synthesis of lichens differ significantly from those of the individual fungal or algal partners (Slusarczyk et al., 2021). Lichens are organisms capable of inhabiting extreme environments on the Earth's surface. They can grow on soil, rocks, tree bark, and even artificial structures, indicating that research opportunities on lichen diversity in Indonesia remain widely open (Gao, 2025).

Lichen growth is influenced by several environmental factors, including air temperature, humidity, and light intensity. Lichens exhibit high tolerance to extreme

temperature and humidity conditions. However, environmental changes caused by air pollution can inhibit their growth and vitality. Microhabitat conditions also strongly determine their presence. In areas with high humidity and cooler temperatures, foliose (leaf-like) and fruticose (shrub-like) lichens such as *Usnea* and *Ramalina* tend to thrive. Meanwhile, in coastal environments, crustose lichens such as *Pertusaria* are more dominant due to their adaptation to strong winds and high salinity. Lichens are lower plants found in various habitats worldwide and dominate terrestrial ecosystems, covering approximately 8% of the Earth's land surface. Globally, around 20,000 lichen species have been reported (Das et al., 2024), whereas Indonesia has recorded 595 species (Atni et al., 2024), representing about 3% of the global total. This low number may be attributed to the limited number of researchers focusing on lichen taxonomy and ecology.

In-depth scientific studies on lichen diversity in Central Sulawesi remain significantly limited due to insufficient data. Field observations indicate that most

lichen research and exploration activities in Indonesia are concentrated in well-known and easily accessible regions, particularly the major islands of Java and Sumatra. This situation has resulted in a crucial information gap, especially considering the ecological role of lichens as highly sensitive bioindicators of air quality and habitat conditions (Hasairin et al., 2025). However, various literature sources and records from leading international lichenologists consistently indicate that the Sulawesi archipelago, including Central Sulawesi, represents a biodiversity hotspot with extraordinary lichen diversity (Wekke, 2024). This region is believed to harbor numerous rare species of high conservation value and potentially many undescribed taxa that have yet to be documented or classified taxonomically. These conditions highlight the urgent need to shift research attention toward this area. Consequently, Donggala Regency, particularly Bale Village, requires more systematic and comprehensive scientific investigation.

A detailed identification of lichen species is necessary, with particular emphasis on classifying them according to the substrates on which they grow (such as corticolous lichens on tree bark, saxicolous lichens on rocks, and foliicolous lichens on leaves). To date, no specialized scientific study has documented lichen diversity in this region based on substrate variation, even though substrate type greatly influences lichen distribution and survival. Substrate specificity is therefore key to uncovering the hidden biodiversity of

lichens in Central Sulawesi (Pasaribu et al., 2023). This study aims to identify lichen species based on the substrates on which they occur in Bale Village, Tanantovea District, Donggala Regency. This study aims to identify of lichen species based on substrates in Bale Village, Tanantovea District, Donggala Regency.

MATERIALS AND METHODS

Study area

The research was conducted in the Bale Village area, Tanantovea District, Donggala Regency (Figure 1). This research is descriptive in nature, intended to investigate conditions in the form of phenomena or events that are currently occurring (Benfield, 2025). The sampling technique used was the exploration method, based on the presence or absence of lichen species on the substrates to be observed. Lichen samples were collected from various substrates, followed by direct macroscopic observations to identify the species obtained (Mendili et al., 2023). The research sites were determined using purposive sampling, considering the environmental characteristics of Bale Village, Tanantovea District, Donggala Regency. The use of purposive sampling was also based on the conditions and diversity of substrates on which lichens grow. Three locations were designated as research stations: Station 1 (residential area), Station 2 (forest and river area, partly used as a tourist site), and Station 3 (forest area and local plantations).

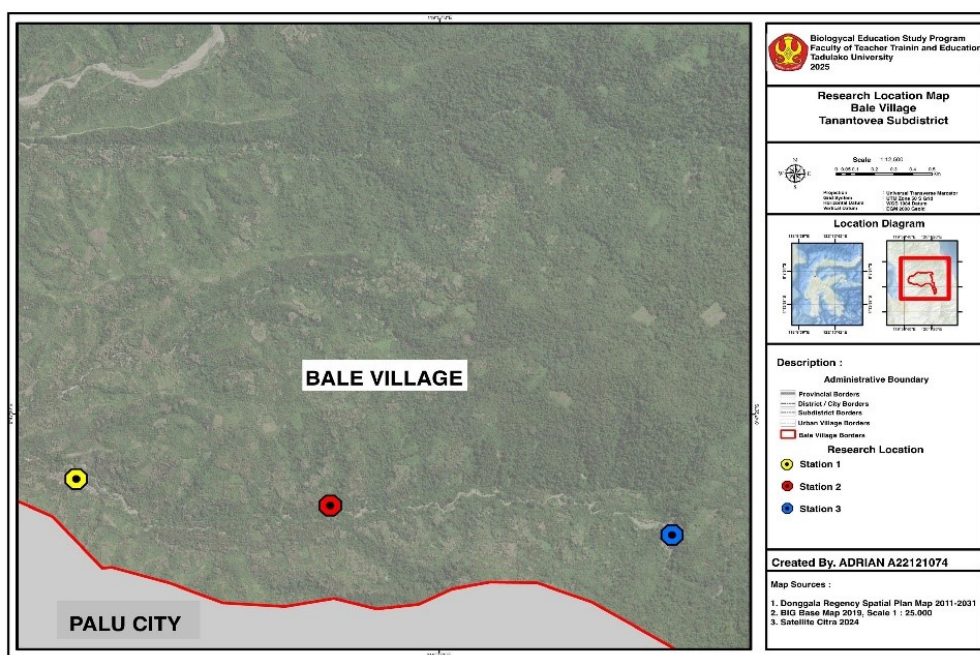


Figure 1. Map of the research location in the Bale Village, Donggala Regency.

Procedures

Tools and Materials

The tools used in this study included a thermometer, a hygrometer, a lux meter, a mobile phone camera, paper,

writing instruments, and an identification handbook. The materials used consisted of the lichen species collected along with their respective substrates.

Preparation Stage

The researcher conducted a field observation and preliminary survey of lichens found in the Bale Village area, Tanantovea District, Donggala Regency. Administrative preparations were also made, including obtaining a research permit letter from the Faculty of Teacher Training and Education (FKIP), Tadulako University, addressed to the Bale Village Office for conducting observation and research activities.

Sample Collection Stage

The sampling technique employed in this study was an exploratory method focusing on the presence of lichen species across different substrate types in Bale Village, Tanantovea District, Donggala Regency. Exploration was conducted by systematically surveying the study area and examining various natural substrates, including tree bark, rocks, soil surfaces, and decaying wood, which are commonly known to support lichen growth. Sampling locations were selected purposively to represent variations in substrate type, light exposure, and microhabitat conditions.

Lichen samples were collected by carefully removing thalli from their substrates using appropriate tools to avoid damaging morphological structures. Each sample was labeled according to substrate type, location, and environmental characteristics. Direct macroscopic observations were carried out in the field to record thallus form, color, texture, and attachment type, which are key characteristics in lichen identification (Lohmus, 2023). This substrate-based exploration approach allowed for the documentation of lichen species distribution patterns and their substrate preferences within the study area.

Measurement of Environmental Physical Conditions

Environmental physical conditions were measured to support the identification and distribution analysis of lichen species in Bale Village. The parameters recorded included air temperature, relative humidity, and light intensity at each sampling point. These measurements were conducted simultaneously with lichen sampling to ensure that the environmental data accurately reflected the microhabitat conditions in which the lichens were found.

Temperature and humidity are critical factors influencing physiological processes such as photosynthesis and water absorption in lichens, while light intensity affects photobiont activity and thallus development. Lichens are known to be highly sensitive to microclimatic variations, making them reliable bioindicators of environmental conditions. By measuring these environmental variables, this study aimed to examine the relationship between substrate characteristics, microclimate, and lichen species diversity (Stanton et al., 2023). The collected data provide an ecological context for understanding lichen distribution patterns across different substrates in the study area.

Sample Identification Stage

Sample identification was conducted directly at the research site through macroscopic examination of lichen thalli. Identification was based on morphological characteristics such as thallus type (crustose, foliose, or fruticose), color, surface texture, presence of reproductive structures (apothecia or soredia), and attachment to the substrate. These characteristics were compared with descriptions provided in lichen identification manuals, relevant scientific articles, and peer-reviewed journals. When field identification was uncertain, samples were documented photographically and further examined using available reference materials to ensure accurate species determination. The identification process emphasized substrate association to classify lichen species according to their preferred growth surfaces. This approach supports the main objective of the study, which is to identify lichen species based on substrate type in Bale Village, Tanantovea District, Donggala Regency, and to provide baseline data for future ecological and environmental monitoring studies.

Data Analysis

Data analysis in this study was carried out using a digital book published by CV. Global Aksara Pers entitled “Keanekaragaman Jenis Lichen (Lumut Kerak) di Kawasan Tahura Bukit Barisan Berbasis Riset, Surabaya” (Hasairin et al., 2021).

RESULTS AND DISCUSSION

Result

General Description of the Research Location

Bale Village is located between Donggala Regency and Palu City. Administratively, it falls within the Tanantovea District of Donggala Regency and covers an area of 1,050 hectares (Ha), equivalent to 10.5 km². Based on its topographic classification, Bale Village is categorized as a lowland area. Although Donggala Regency is generally known for its mountainous and hilly regions, Bale Village itself lies within a relatively flat zone. The village has an elevation of 125 meters above sea level, indicating that it is situated in a lowland area. The research was conducted in the Bale Village area, Tanantovea District, Donggala Regency. The process of data collection involved determining research locations using purposive sampling, which was selected based on environmental conditions and the diversity of substrates where lichens grow. Three locations were designated as research stations: Station 1: residential area, Station 2: forest and river area, partly functioning as a tourist site, and Station 3: forest area and local plantations.

Results of Environmental Physical Condition Measurements

The measurements of environmental physical conditions included temperature, humidity, and light intensity. The results of these measurements are presented in Table 1.

Table 1. Results of environmental physical condition measurements in Bale Village, Tanantovea District, Donggala Regency.

No	Parameter	Environmental Physical Conditions			Average
		Stasiun 1	Stasiun 2	Stasiun 3	
1	Temperature	30°C	27°C	26°C	27,66°C
2	Humidity	59%	68%	71%	66%
3	Light Intensity	989	785	712	828,66

Observation Results of Lichens Based on Substrates

The observations conducted at three stations in the Bale Village area, Tanantovea District, Donggala Regency,

identified a total of 10 species belonging to 5 families, 2 thallus types, and 3 substrate types (Table 2).

Table 2. Types of lichens in the Bale Village Area, Tanantovea District, Donggala Regency.

No	Substrate	Thallus	Family	Species
1	Kortikolus	Crustose	<i>Physciaceae</i>	<i>Dirinaria</i> sp1.
2		Crustose	<i>Physciaceae</i>	<i>Dirinaria</i> sp2.
3		Foliose	<i>Physciaceae</i>	<i>Dirinaria frosti</i>
4		Crustose	<i>Graphidaceae</i>	<i>Graphis scripta</i> .
5		Crustose	<i>Graphidaceae</i>	<i>Graphis</i> sp.
6		Crustose	<i>Lecanoraceae</i>	<i>Lecanora</i> sp.
7		Foliose	<i>Lecanoraceae</i>	<i>Leptogium cyanescens</i>
8		Crustose	<i>Steriocaulaceae</i>	<i>Lepraria incana</i>
9		Crustose	<i>Steriocaulaceae</i>	<i>Lepraria</i> sp.
10		Foliose	<i>Parmeliaceae</i>	<i>Parmoterma perlatum</i>
11	Saksikolus	Crustose	<i>Physciaceae</i>	<i>Dirinaria</i> sp1.
12		Crustose	<i>Physciaceae</i>	<i>Dirinaria</i> sp2.
13		Foliose	<i>Lecanoraceae</i>	<i>Leptogium cyanescens</i>
14	Folikolus	Crustose	<i>Physciaceae</i>	<i>Dirinaria</i> sp1.

Classification and Identification Results

The identification of lichens based on substrates in the Bale Village area, Tanantovea District, Donggala Regency, resulted in a total of 10 species categorized into

three substrate types: corticolous (tree-dwelling), saxicolous (rock-dwelling), and folicolous (leaf-dwelling) (Figure 2).



Figure 2. A. Kortikolus/Pepohonan: A1. *Dirinaria* sp1, A2. *Dirinaria* sp2, A3. *Dirinaria frosti*, A4. *Graphis scripta*, A5. *Graphis* sp, A6. *Lecanora* sp, A7. *Leptogium cyanescens*, A8. *Lepraria* sp, A9. *Lepraria incana*, A10. *Parmelia perlatum*, B. Saksikolus/Bebatuan: B1. *Dirinaria* sp1, B2. *Dirinaria* sp2., B3. *Leptogium cyanescens*. C. Folikolus/Dedaunan: C1. *Dirinaria* sp1.

Discussion

The results of the study and the identification of lichens based on substrate types conducted in Bale Village, Tanantovea District, Donggala Regency, recorded 10 lichen species belonging to 5 families and three substrate types. Observations revealed three species from the family Physciaceae, namely *Dirinaria* sp. 1, *Dirinaria* sp. 2, and *Dirinaria frosti*. Two species were identified from the family Graphidaceae, namely *Graphis scripta* and *Graphis* sp. Two species belonged to the family Lecanoraceae, specifically *Lecanora* sp. and *Leptogium cyanescens*. Two species were recorded from the family Stereocaulaceae, namely *Lepraria* sp. and *Lepraria incana*. Finally, one species from the family Parmeliaceae, *Parmelia perlatum*, was identified. The study also identified three substrate types: corticolous (tree bark), saxicolous (rock surfaces), and foliicolous (leaves). On corticolous substrates, all 10 species were recorded, including *Dirinaria* sp1, *Dirinaria* sp2, *Dirinaria frosti*, *Graphis* sp., *Graphis scripta*, *Lecanora* sp., *Leptogium cyanescens*, *Lepraria* sp., *Lepraria incana*, and *Parmelia perlatum*. Saxicolous substrates hosted three species *Dirinaria* sp1, *Dirinaria* sp2, and *Leptogium cyanescens* while foliicolous substrates contained only one species, *Dirinaria* sp1. Furthermore, the 10 species identified in this study exhibited two thallus types: crustose and foliose. Seven species were crustose (*Dirinaria* sp1, *Dirinaria* sp2, *Graphis* sp., *Graphis scripta*, *Lecanora* sp., *Lepraria* sp., and *Lepraria incana*), while three species *Dirinaria frosti*, *Leptogium cyanescens*, and *Parmelia perlatum* were foliose.

The presence of these five families reflects their differing ecological adaptations to environmental conditions (Boruah et al., 2024). Members of the family Physciaceae, such as *Dirinaria* spp., are known for their high tolerance to sunlight and open habitats. In contrast, species from Graphidaceae, including *Graphis scripta* and *Graphis* sp., are more commonly found in humid and shaded areas typical of tropical forests. Families Lecanoraceae and Stereocaulaceae generally exhibit broad substrate adaptability, whereas Parmeliaceae, represented by *Parmelia perlatum*, are often used as indicators of good air quality due to their sensitivity to pollutants such as sulfur dioxide (SO₂) (Roziaty et al., 2023). This study also confirmed the distribution of lichens across the three substrate types. Among them, corticolous substrates were the most frequently colonized, with all 10 species recorded. This finding aligns with Larsen & Rasmussen (2021), who note that tree bark is an ideal substrate for lichens due to its moisture content and nutrient availability. Saxicolous substrates were inhabited by only three species, likely due to the hard surface and fluctuating pH levels of rocks, which limit lichen attachment and growth (Peksa et al., 2022). Foliicolous substrates contained only one species, consistent with Thakur (2024), who explains that foliicolous lichens are rare because leaves have short life

spans and are more susceptible to environmental fluctuations. In addition to substrate variation, two thallus types, crustose and foliose, were recorded. Seven crustose species and three foliose species were identified. The dominance of crustose lichens indicates a high level of adaptation to fluctuating environmental conditions (De Jonge et al., 2025). According to Untari (2024), crustose lichens adhere strongly to substrates, enabling them to withstand harsher environments. Conversely, the presence of foliose species such as *Dirinaria frosti*, *Leptogium cyanescens*, and *Parmelia perlatum* suggests that the study area maintains adequate humidity and good air quality (Pradhan et al., 2025). Ecologically, the results indicate that lichen diversity in Bale Village is influenced by substrate heterogeneity and local microclimatic conditions. The availability of multiple substrate types allows various lichen species to grow, while the dominance of crustose thalli and the presence of several foliose species reflect that the area remains relatively undisturbed and low in pollution (Bousbih et al., 2025). Thus, the findings support the use of lichens as effective bioecological indicators and bioindicators for assessing ecosystem stability and environmental quality (Matusyak, 2025).

Environmental measurements at the study site recorded an average temperature of 27.66°C, relative humidity of 66%, and light intensity of 828.66 cd. These values represent warm, humid, and moderately high light conditions optimal for lichen growth (Jia et al., 2025). Bhagarathi et al. (2022) emphasize that temperature and humidity are key factors influencing lichen distribution and abundance. Temperatures between 25–30°C fall within the ideal range for photosynthesis by algal or cyanobacterial symbionts within lichens (Veres et al., 2022). At these temperatures, metabolic processes between fungi and algae remain balanced, supporting healthy thallus formation. Humidity levels around 66% are also favorable, as most lichens absorb moisture and nutrients directly from the atmosphere (Stanton et al., 2023). Borge & Ellis (2024) state that relative humidity between 60–80% is suitable for many tropical lichen species. The recorded light intensity of 828.66 cd indicates moderate to high illumination. According to Gasulla et al. (2021), adequate light is essential for photosynthetic activity in lichen photobionts, although excessive light combined with high temperatures may cause dehydration and reduced photosynthesis. The measured intensity suggests that the site provides conditions favorable for both crustose lichens which are typically light-tolerant and foliose lichens, which require higher humidity (Kidron & Kronenfeld, 2022). Overall, the combination of these parameters supports high lichen diversity in Bale Village and aligns with ecological principles showing that stable temperatures, moderate humidity, and sufficient illumination foster diverse lichen communities (Lohmus, 2023).

Across the three study stations, a total of 10 lichen species were recorded. Station 1, located in a residential

area, contained one species: *Dirinaria frosti*. Station 2, characterized by forest and river habitats and partially used as a tourist site, contained three species: *Dirinaria* sp1, *Dirinaria* sp2, and *Graphis* sp. Station 3, consisting of forested areas and community plantations, contained six species: *Graphis scripta*, *Lecanora* sp., *Leptogium cyanescens*, *Lepraria* sp., *Lepraria incana*, and *Parmelia perlatum*. The differences in species composition among the three stations are influenced by variations in physical environmental conditions, as well as biotic and abiotic factors that shape habitat suitability (Zhang, 2021). Lichen research also faced several challenges. One major issue is the difficulty of identifying species, as many lichens have similar thallus morphologies despite differing genetic characteristics and types of photobionts (Simon et al., 2024). Additionally, studies on the functional roles and ecological characteristics of lichens remain limited due to insufficient data and understanding of lichen environment interactions (Ellin et al., 2021). The use of online databases such as iNaturalist can also lead to misidentifications, as many records are contributed by non-experts (Fonturbel et al., 2023). Moreover, the limited availability of lichen literature and reference collections in Indonesia complicates specimen comparison and species verification.

CONCLUSIONS

Based on the research conducted in the Bale Village area, Tanantovea District, Donggala Regency, a total of 10 lichen species belonging to five families were recorded, occupying three substrate types, namely corticolous, saxicolous, and folicolous. The environmental conditions at the study site with an average temperature of 27.66°C, humidity of 66%, and light intensity of 828.66 cd were considered optimal for supporting lichen growth, particularly those with crustose and foliose thallus types.

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Competing Interests: The authors declare that there is no conflict of interest.

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