

Rapid assessment of lichen diversity in Baliem Valley, Jayawijaya, Papua, Indonesia

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Abstract. Suharno, Chrystomo LY, Sujarta P, Tanjung RHR. 2020. Rapid assessment of lichen diversity in Baliem Valley, Jayawijaya, Papua, Indonesia. *Biodiversitas* 21: 2403-2409. Lichen is a form of mutualistic symbiosis between phycobiont and mycobiont. Lichens play an important role in environment, either to maintain the biological diversity and the function of ecosystems. This study is aimed to determine the diversity of species of lichens in the Baliem Valley region, Jayawijaya, Papua. The method used was explorative surveys in several villages in Jayawijaya District. Species identification was based on morphological characteristics. The results showed that there were 37 species of lichen belong to 24 genera and 11 families on several habitats on altitude ranging from 1655 to 2179 m asl with temperatures between 18-26°C. The dominant species were from the families of Parmeliaceae, Cladoniaceae, and Teloschistaceae. The results indicate that the Baliem Valley region rich in lichen diversity and the existence of particular lichen species suggests that the region has healthy environmental conditions. This study provides new information on the existence of lichen diversity in Papua.

Keywords: Baliem valley, lichens, symbiosis, Jayawijaya

INTRODUCTION

Tropical rain forests have ecosystems with complex dynamics that contain a variety of habitats for the life of various species. As a country located in tropical region, Indonesia is rich in biological resources, including in Papua (Agustini et al. 2015; Kadir et al. 2020). Papua has a high diversity of ecosystems, ranging from beaches, lowlands, highlands, to mountains and even snow despite it is located in the equator (Kartikasari et al. 2013; Agustini et al. 2015). Papua's highland forest ecosystem has a unique vegetation structure.

Despite the importance of Papuan forests in harboring biological diversity, some forest areas in Papua have experienced deforestation and forest degradation due to regional development of regional land conversion for other land uses, such as housing, plantations, and agriculture. These changes can affect forest ecosystems and flora that grow in them (Agustini et al. 2015), including lichen (Sujetoviené 2017).

Lichen is a classic example of flora that lives in a symbiotic mutualism (Seckbach and Grube 2010). It originates from a mutualistic association between biotrophic fungi (mycobiont) and photosynthetic microorganisms (photobionts, for example, chlorophytes and/or cyanobacteria) (Goward and Arsenault 2000; Muggia and Grube 2018). Lichens play an important role in environment, either to maintain the biological diversity and the function of ecosystems, such as providing nesting, food, and shelter for other organisms (Esseen and Renhorn 1998; Singh 2011; Ellis and Coppins 2006). Moreover,

when lichens are in the form of litter, they become an important source of nitrogen and iron in forest ecosystems (Begon et al. 2006; Jovan 2008), as well as an important element in nutrient cycling (Esseen and Renhorn 1998). Lichens have important values as ecological indicators through their sensitivity to various kinds of environmental stressors such as air quality and climate change (Jovan 2008; State et al. 2011; Sujetoviené 2017; Tarasova et al. 2017). Lichens also serve as biotic pioneers of terrestrial habitats (Firdous et al. 2017; Hardini et al. 2018).

Lichens can be found from the tropics to the polar regions (McMullin and Andersen 2014). Lichen habitats are very diverse, ranging from soil, rock surfaces, and trees or various other substrates in various locations, ranging from newly cleared forest land, burnt forests even to traces of volcanic lava flows (Temina and Nevo 2009; Balaji and Hariharan 2013; Firdous et al. 2017). They do not require complex living conditions as other species need (Hardini et al. 2018). There are several cosmopolitan and highly adaptable lichens that can be found in various types of world ecosystems. However, the general nature of lichens vegetation in an area is determined mainly by variations in climate and altitude (Bruun et al. 2006; Grytnes et al. 2006).

Around 25,000 species of lichens have been identified globally (Chapman 2009; Firdous et al. 2017). On the island of New Guinea (Papua New Guinea and Papua, Indonesia) at least 495 species from 126 genera have been described (Streimann 1986). This number is likely to increase as more botanical explorations and accurate identification works with molecular techniques are conducted (Orock et

al. 2012). In Indonesia, the exploration of diversity in lichen has not been done thoroughly (Hardini et al. 2018) including in Papua. Therefore, the purpose of this study is to determine the diversity of species of lichens in the Baliem Valley region, Jayawijaya, Papua. This study will provide new information on the existence of lichen diversity in Papua.

MATERIALS AND METHODS

Research area and period

This research was conducted in the Baliem Valley region across several sub-districts in Jayawijaya District, Papua Province, Indonesia (Figure 1; Table 1), including Sub-districts of Kurulu, Tagineri, Koragi, Silokarnodoga, Asologaima, Mulianam, and Napua. Survey of the existence and diversity of lichen was conducted from October to December 2018.

Survey method

Lichen samples were collected from various types of vegetation in 7 sub-districts. The survey was conducted by

exploring various areas thought to be lichen habitat, including soil, trees, twigs, leaves, and rocks. Lichen that grows on trees was also taken, although not in all locations depending on the level of ease in sampling. Each sample was given a label (number) and field identity. The specimen was dried and put into an envelope or sample collection box, then taken to the laboratory for identification.

Identification of lichens

The samples of lichen were identified based on morphological characters and reproductive characters (Huneck and Yoshimura 1999; Brodo et al. 2001; Kelly 2006; Aptroot 2009; Nimis et al. 2009; McMullin and Anderson 2014; Anon 2019). Identification used some of the latest references (i.e. Grube and Hafllner 1990; Aptroot 2009; Muggia and Grube 2018).

Data analysis

Data were analyzed qualitatively. Data are classified based on taxa groups in a table based on morphological identification results.

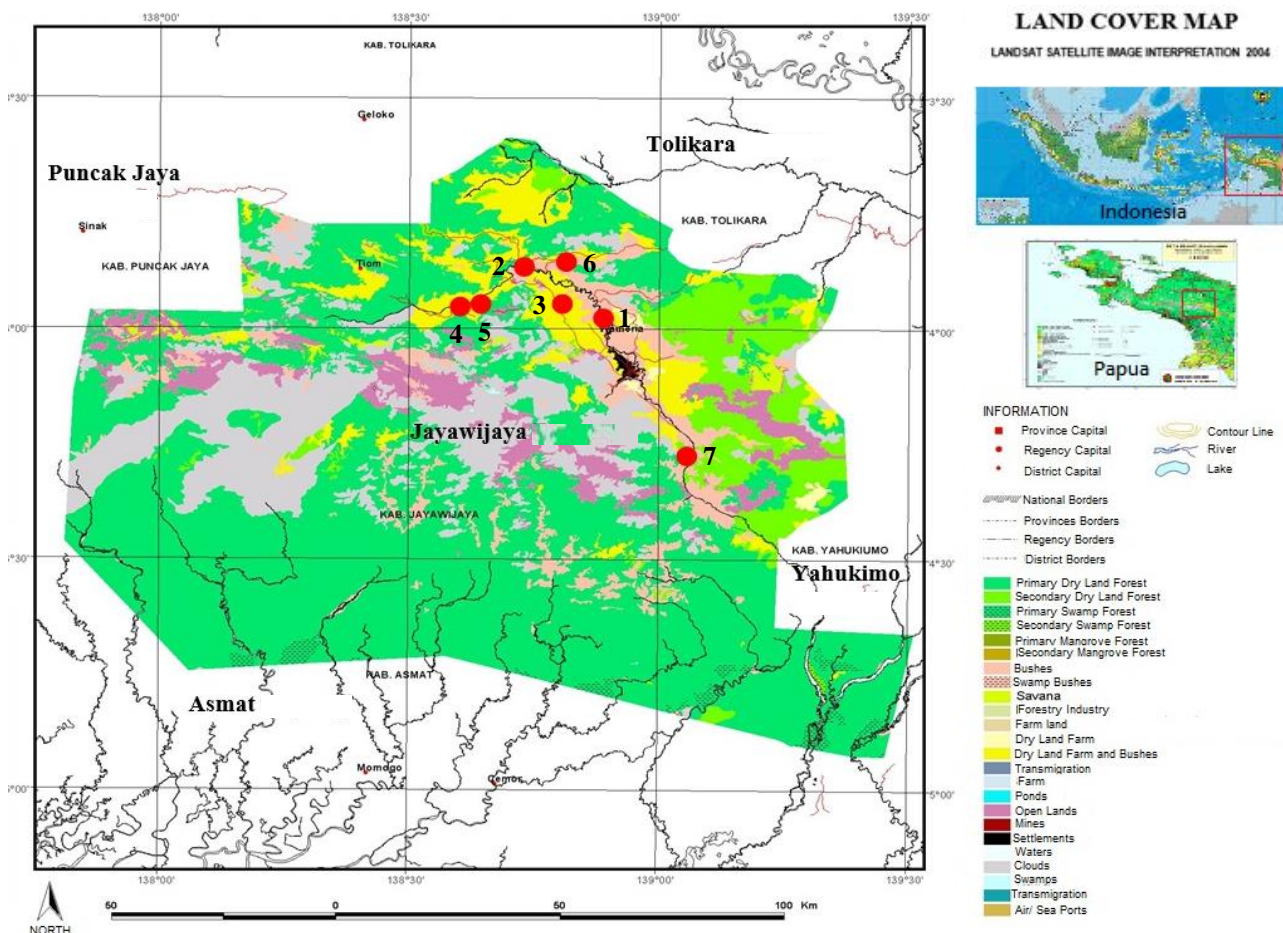


Figure 1. Study location of lichens in the Baliem Valley, Jayawijaya, Papua, Indonesia. Numbers refer to sampling sites in Table 1

Table 1. The sampling sites of lichens in the Baliem Valley region, Jayawijaya, Papua, Indonesia

| No. | Sub-district (<i>Kecamatan</i>) | Village | Position of coordinate | Altitude (m asl.) | Temperature (°C) |
|-----|--------------------------------------|--------------|----------------------------------|----------------------|---------------------|
| 1. | Kurulu | Kurulu | S: 04°02' 54,4"; E: 138°56'45,8" | 1670 | 25 |
| 2. | Tagineri | Meleme | S: 03°51'02,5"; E: 138°48'02,7" | 2217 | 18 |
| | | Rumbepaga | | 2074 | 20 |
| 3. | Koragi | Tagipaga | S: 03°51'02,5"; E: 138°48'02,7" | 1996 | 22 |
| 4. | Silokarnodoga | Apnay Kosili | S: 03°54'27,6"; E: 138°47'20,0" | 1664 | 24 |
| 5. | Asologaima | Walak | S: 03°54'49,2"; E: 138°47'03,2" | 1686 | 25 |
| 6. | Mulianam | Konam | S: 04°59'59,9"; E: 138°48'29,8" | 1736 | 23 |
| 7. | Napua | Napua | S: 04°06'59,0"; E: 138°53'38,1" | 1678 | 26 |

RESULTS AND DISCUSSION

Habitat of lichens

The sampling locations in the Baliem Valley region of Jayawijaya District, Papua Province, Indonesia, ranged in altitude, starting from 1664 m asl in the Apnay Kosili village of Silokarnodoga Sub-district to 2217 m asl in the Meleme village of Tagineri Sub-district. The temperature also varied between 18–26°C. Altitude has strong relationship with air temperature, which affects the physiological activity of organisms (Grytnes et al. 2006; Agustini et al. 2015; Parizadeh and Garampalli 2017), including lichens (Rafat 2014; Firdous et al. 2017). For lichens, altitude is very influential on species diversity (Baniya et al. 2010), even to the content of secondary metabolites (Temina et al. 2010).

Lichens in the studied areas were found on a variety of substrates, such as soil, rocks, trees, and twigs (Figure 2). Lichen groups that grow on trees depend on the diversity and abundance of vegetation in an area. Most of the vegetation in the highlands in Papua has a low diversity. Conversely the lower the altitude of an area, the higher

diversity of plant species (Kartikasari et al. 2013). The type and condition of vegetation, and the altitude of the habitat influence lichen diversity in an area (Bruun et al. 2006), including lichen epiphytes (Teminaim et al. 2009; Baniya et al. 2010).

Lichens diversity

The results of the research in the Baliem valley, Jayawijaya Papua showed that there were 37 species of lichens belong to 25 genera recorded (Table 2; Figure 3). The observation found 11 families, which were dominated by Parmeliaceae (16 types), Cladoniaceae (7 types), and Teloschistaceae (4 types). Balaji and Hariharan (2013) found 103 species of macrolichens from 9 families and 27 genera in Siruvani Hills, Tamil Nadu, India. Another study from Temina and Nevo (2009) found 350 species from 52 families and 117 genera in Israel. Kusmoro et al. (2018) found 133 species from 62 genera and 17 families of lichens in Kamojang Geothermal areas. When compared with the results of the study, the level of lichen diversity in the Baliem Valley is low. Low species diversity can occur due to different methods, locations, and climate factors.

**Figure 2.** Habitat of lichen in Baliem Valley, Jayawijaya District, Papua Province, Indonesia: A. Branch, or tree (woods); B. Soil; C. Rock

Based on the thallus type, lichens in the Baliem Valley region were dominated by fruticose types (16 species), and foliose (13 species), and only 8 species were found for the crustose type (Table 2). The results of the study are different from those conducted by Firdous et al. (2017) in Pakistan (Western Himalayan region) which was dominated by lichen foliose type followed by crustose, fruticose, and squamulose. The results of other studies showed a strong correlation of lichen fruticose with the altitude of location (Pinokiyo et al. 2008).

There is relatively little research on the relationship between lichen's diversity patterns and elevation (Bruun et al. 2006; Grytnes et al. 2006). However, lichen is one of the most successful organisms in extreme environments such as the cold arctic and alpine environments where most plants cannot grow (McCune and Antos 1982; Grytnes et al. 2006). Lichen also shows high diversity as epiphyte. Lichen can benefit from the diversity of trees and shrubs as substrates (Baniya et al. 2010).

Usnea is a genus of lichen that has a wide distribution throughout the world (Rafat 2014). Three species of *Usnea*

found in the Baliem Valley were *Usnea australis*, *Usnea* sp., and *U. longissima*. These species were found on tree substrates, while *U. longissima* was also found on rocks/cliffs. From the genus of *Lobaria*, there were two species, namely *L. pulmonaria* and *Lobaria* sp. *Lobaria pulmonaria* is a type of lichen that is sensitive to air pollution. This type is often used as a parameter of air pollution. Its existence in the Baliem Valley region indicates that this region has a low level of air pollution.

Parmotrema stuppeum (foliose lichen) is a type of lichen found in the Baliem Valley. According to Louwhoff and Elix (1999), the revised biosystematics of the genus *Parmotrema* (Ascomycotina: Parmeliaceae) in Papua New Guinea show that this genus consists of 50 species. Twelve species are new records for Papua New Guinea and six are described as new to science, namely: *Parmotrema kurolawianum*, *P. malonprotocetraricum*, *P. menyamyaense*, *P. sipmanii*, *P. verrucatum* and *P. watutense*. Fourteen of the 50 species of *Parmotrema* are considered endemic to Papua New Guinea.

Table 2. Diversity of lichen species in the Baliem Valley region, Jayawijaya, Papua, Indonesia

| Family | Species | Habitat | Type of thallus |
|-----------------|--|----------------------|------------------|
| Teloschistaceae | <i>Polycauliona coralloides</i> (Tuck.) Hue | Rock | Fruticose lichen |
| | <i>Flavoplaca marina</i> (Wedd.) Arup | Rock | Crustose lichen |
| | <i>Variospora thallincola</i> (Wedd.) Arup | Rock | Crustose lichen |
| | <i>Teloschistes flavicans</i> (Sw.) Norman | Rock | Fruticose lichen |
| Cladoniaceae | <i>Cladonia chlorophaea</i> (Flörke ex Sommerf.) Sprengel. | Soil | Fruticose lichen |
| | <i>Cladonia cristatella</i> Tuck. | Soil | Fruticose lichen |
| | <i>Cladonia floerkeana</i> (Fr.) Flörke. | Soil | Fruticose lichen |
| | <i>Cladonia ochrochlora</i> Flörke. | Soil | Fruticose lichen |
| | <i>Cladonia</i> sp. | Soil | Fruticose lichen |
| | <i>Cladonia</i> sp2. | Soil | Fruticose lichen |
| | <i>Pilophorus aciculare</i> (Ach.) Th. Fr. | Rock | Fruticose lichen |
| | <i>Dimelaena radiata</i> (Tuck.) Müll. Arg. | Rock | Crustose lichen |
| Caliciaceae | <i>Diploschistes actinostomus</i> (Ach.) Zahlbr. | Rock | Crustose lichen |
| Graphidaceae | <i>Bryoria fremontii</i> (Tuck.) Brodo & D. Hawksw. | Rock, wood | Fruticose lichen |
| Parmeliaceae | <i>Evernia prunastri</i> (L.) Ach. | Rock, wood | Fruticose lichen |
| | <i>Flavoparmelia caperata</i> (L.) Hale. | Branch or tree | Foliose lichen |
| | <i>Hypogymnia imshaugii</i> Krog. | Wood | Foliose lichen |
| | <i>Hypogymnia</i> sp. | Wood | Foliose lichen |
| | <i>Letharia</i> sp. | Moss, Rock | Fruticose lichen |
| | <i>Letharia vulpina</i> (L.) Hue | Rock | Fruticose lichen |
| | <i>Parmotrema stuppeum</i> (Taylor) Hale. | Wood | Foliose lichen |
| | <i>Platismatia</i> sp. | Wood, rock | Foliose lichen |
| | <i>Usnea australis</i> | Wood | Fruticose lichen |
| | <i>Usnea longissima</i> Ach. | Rock, wood | Fruticose lichen |
| | <i>Usnea</i> sp. | wood | Fruticose lichen |
| | <i>Parmelia</i> sp. | Wood, rock | Foliose lichen |
| | <i>Parmelia</i> sp.1 | Rock | Foliose lichen |
| | <i>Xanthoparmelia</i> sp. | Rock, wood | Foliose lichen |
| | <i>Hypotrachyna catawbiensis</i> (Degel.) Divakar | Wood | Foliose lichen |
| Lecanoraceae | <i>Lecanora gangaleoides</i> Nyl. | Rock | Crustose lichen |
| | <i>Lecanora rupicola</i> (L.) Zahlbr. | Rock, wood | Crustose lichen |
| Lobariaceae | <i>Lobaria pulmonaria</i> (L.) Hoffm. | Wood | Foliose lichen |
| | <i>Lobaria</i> sp. | Wood | Foliose lichen |
| Pannariaceae | <i>Pannaria lurida</i> (Mont.) Nyl. | Wood | Foliose lichen |
| Physciaceae | <i>Physcia millegrana</i> Degel. | Wood, rock | Foliose lichen |
| Trapeliaceae | <i>Placopsis</i> sp. | Rock | Crustose lichen |
| Rhizocarpaceae | <i>Rhizocarpon</i> sp. | Wood, Branch or tree | Crustose lichen |

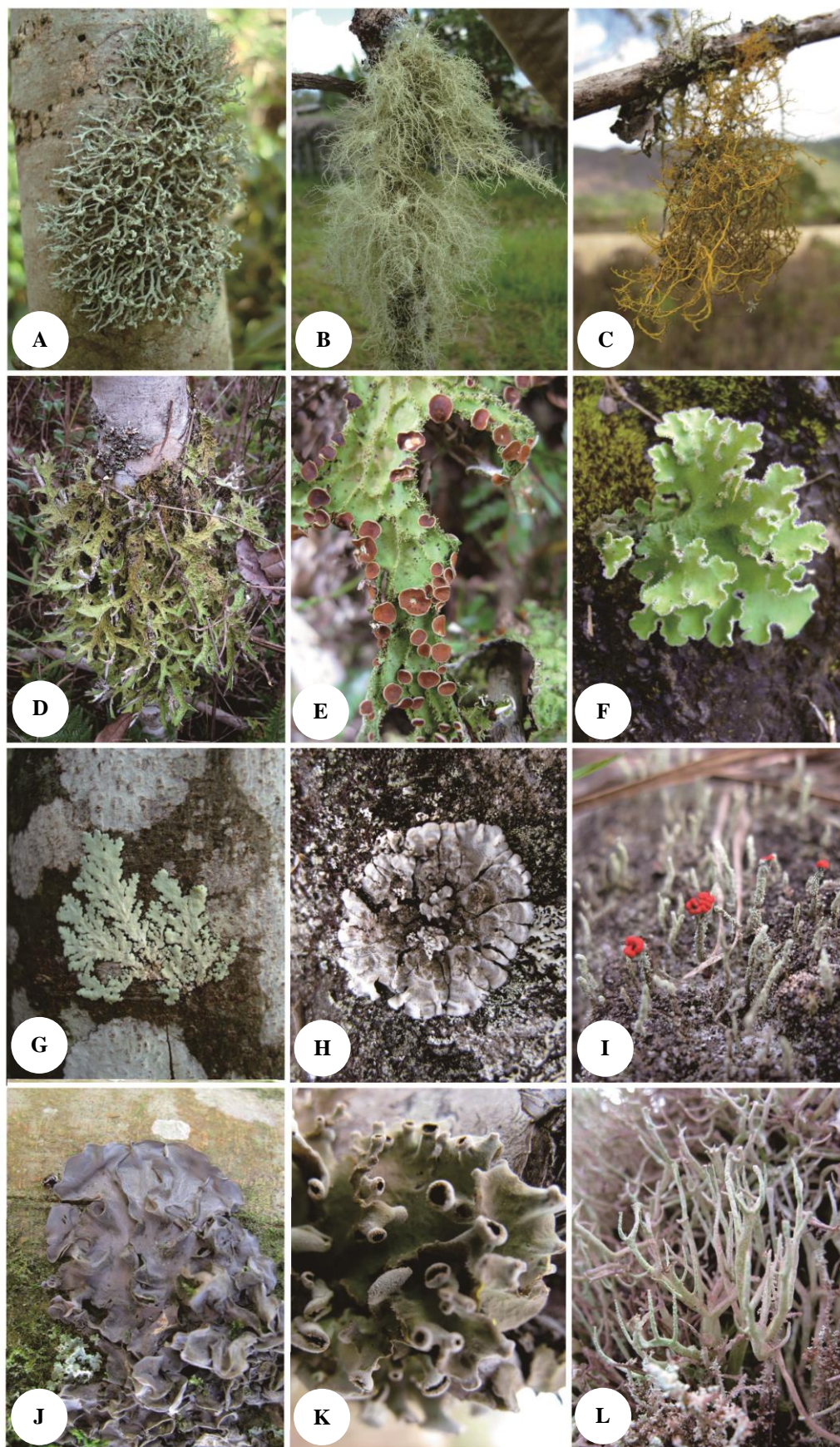


Figure 3. Diversity of lichen in Baliem Valley, Jayawijaya, Papua, Indonesia: A. *Hypotrachyna catawbiensis*; B. *Usnea longissima*; C. *Teloschistes flavicans*; D. *Lobaria* sp.; E. *Lobaria pulmonaria*; F. *Lobaria* sp.2; G. *Pannaria* sp.; H. *Xanthoparmelia* sp.; I. *Cladonia* sp.; J. *Parmelia* sp.; K. *Parmelia* sp.1; L. *Cladonia* sp.2.

Forest sustainability has been shown to play a major role in the existence and abundance of lichen species (Sillett et al. 2000). Changes in forest succession produce different lichen habitats, primarily related to changes in light penetration, and characteristics of host's bark (McCune and Antos 1982). More complex structured forests usually have higher diversity. Old forests are structurally more complex and contain greater lichen epiphytic biomass than younger forests (Esseen and Renhorn 1998; Sillett et al. 2000). The lichen community can experience temporal change through several processes, ranging from traditional Clementsian succession to the hierarchy of competitive displacement (Kantvilas 2016). Changes in the lichen community do not reflect succession, but there may be changes in species diversity patterns due to their dispersal ability (McCune and Antos 1982; Begon et al. 2006).

These results are consistent with the findings of Müller (2001) who concluded that the diversity and distribution of lichen is strongly influenced by environmental conditions. Altitude appeared as a limiting factor governing the diversity and distribution of lichens in various habitats and microclimates. Maximum diversity was reported from high temperate locations while lower subtropical locations represent the lowest values. Furthermore, a very poor diversity of lichens correlated with intense anthropogenic disturbances, higher levels of pollution and geographic and climate conditions that were not suitable.

In the Baliem Valley region there were also *Lobaria oregana* and *Lobaria* sp. According to Jovan (2008) the group (Lobariaceae) makes an important contribution to the nutritional cycle in forest areas. This condition is supported by cyanobacteria partners in fixing atmospheric nitrogen (N_2) into a form that can be used by plants. Nitrogen input from cyanolichens may be quite large, especially in old moist forests. It is estimated that *L. oregana* alone fixing $16.5 \text{ kg } N_2 \cdot \text{ha}^{-1} \cdot \text{year}^{-1}$ at several high biomass locations in the western Cascades of Oregon. This lichen, like other species, is an important component of the ecosystem and directly affects the health of the forest. Furthermore, Jovan (2008) revealed that some species of lichens are very sensitive to environmental changes, so that they are used as bioindicators in the assessment of natural resources. Lichen is generally used as an indicator of forest health and ecological functioning, because lichen is a major producer related to the nutrient cycle and food webs in forest ecosystem.

The low discoveries of species found by rapid assessment carried out in this study suggests that further similar research is required, especially in other regions, considering lichen research is still lacking in Papua. In fact, perhaps, this research is the first in Papua. It is hoped that other species will be discovered, including new species in Papua. The results of an examination of around 3000 recent lichen collections from Papua New Guinea, 112 are known to be new records. When considering the topographical and geological conditions of the region, it is possible that the Papua still holds high lichen diversity, moreover, this kind of research has not been carried out intensively in all areas

of Papua (Aptroot and Sipman 1991). For this reason, the use of molecular techniques can help to advance identification techniques. Many species of lichens are identified based on the DNA nucleotides that form lichens. Utilization of DNA in the identification process will enrich the diversity of species of lichens (Orock et al. 2012; Leavitt et al. 2013).

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