J U R N A L M E T A M O R F O S A
Journal of Biological Sciences
ISSN: 2302-5697
http://ojs.unud.ac.id/index.php/metamorfosa

DIVERSITY OF SPECIES CRUSTOSE LICHEN OF *Plumeria* spp. IN BALI ISLAND

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ABSTRACT

The research of species crustose lichen was conducted in the lowlands of the Bali Island and was conducted randomly at a height of 0-500 m above sea level. The aim is to find out the diversity of species crustose lichen living in *Plumeria* spp. The method used is descriptive qualitative analysis method. Data collection was done by field observation and specimen collection. The lichen specimens were observed and identified morphologically, anatomically, and chemically. In this study found of four families consisting of six genera and 15 species, namely *Graphina* sp., *Phaeographina* sp., *Graphis* sp., *Graphis immersella*, *G. nilgiriensis*, *G. modesta*, *G. nana*, and *G. conferta* (Graphidaceae); *Lecanora* sp.1, and *Lecanora* sp.2 (Lecanoraceae); *Lepraria* sp. (Stereocaulaceae); *Caloplaca* sp. (Teloschistaceae). The most common species is *Graphis* sp. (88%).

Keywords: diversity, lichen, crustose, Bali Island

PENDAHULUAN

Lichen is symbiotic organisms arising from a symbiotic relationship between the fungi component (called mycobiont) and the component of green algae (Chlorophyta) or Cyanobacteria (called photobiont) (Ahmadjian, 1993, Nash, 1996). Lichen has a different nature from those of its component organisms where two organisms are grown together relying on each other to survive. Lichens can be found abundantly in the bark of trees, rocks, or various man-made substrates (Hale, 1974, Nash, 1996). Symbiosis in lichen brings benefits to fungi and algae since fungi receive carbohydrates from algae needed for its existence. The photosynthetic algae were protected by the fungi hypha from rapid water loss and from intensive solar rays (Wirth, 1995). Lichen is cosmopolitan and adaptable, may be found in all habitats in the world environment. However, the general properties of lichen vegetation in an area is determined mainly by the high and climatic variations (Zulkifly et al., 2011) and can be found from the tropics to the polar regions (Ahmadjian, 1993, Nash, 1996). Lichens were first identified as sensitive organisms to gaseous pollutants such as sulfur dioxide (Rose and Hawksworth 1981), so that lichen was used as an indicator of urban pollution and emission sources from uncontrolled burning sources (Stolte et al.,1993). Lichens are also found to act as elemental accumulators, such as trace metals and sulfur (Puckett 1985; Tyler 1989).

Lichen can be used to detect the causes of ecological stress including habitat changes conditions and dust accumulation. Epiphytic lichen species often have a higher level of contaminants accumulation of airborne particles and rain than higher plants and even algae. It is a passive absorbent of air and

rainwater material because the lichen does not have stomata and wax cuticle for the protector (Richardson, 1992). It is found almost in every habitat, it has a role as a relevant natural indicator to monitor and detect environmental changes and effects of air pollution (Kuldeep and Prodyut, 2015).
The growth and development of lichen in its habitat is influenced by many factors, such as macroclimate, microclimate, location, substrate characteristics (Silva and Senanayake, 2015). The physical properties of substrate rods also affect the variation on corticolous lichen presence (Hawksworth, 1975). Factors such as tree age, sun exposure, and dust are important to colonize of lichen species on tree trunks (Cornelissen and Gradstein 1990, Wolf 1993). Important factors in the site that can cause variations are lights, humidity, and temperatures. In addition, the character of substrate tree types such as skin type, surface wrinkle, moisture retention, pH and skin nutritional status, also affect the growth of lichen in trees. Lichen growth patterns in different geographic regions are also influenced by varied macroclimate factors such as rainfall and temperature (Mulligan, 2009).
Some researchers who have contributed in adding lichen collection in Indonesia are Sipman (2003) collecting lichen in Cibodas, Bogor (Indonesia) and Singapore. Sudaryanto et al. (1992) also observe the species of lichen as an air pollution bioindicator in Denpasar City (Bali Island, Indonesia). Lucking et al. (2009) noted that are 23 species of lichen Graphis collected by several researchers (whose specimens come from Java Island, Krakatau, Celebes, Borneo), and according to Lucking et al. (2014) that in Indonesia have 82 species.
This study was conducted to determine the diversity of lichen epiphyte known as environmental bioindicator. Wolseley and Aguirre-Hudson (1997) state that lichen is an organism that is sensitive to changes in atmospheric conditions and micro-climate and has been used as bio-indicators to determine the environmental pressures in the countries of the tropical and temperate. As well as researchers in several countries are using a variety of methods of observing the diversity of species of lichen or investigate the relationship between species of lichen and different environmental conditions. (Sipman 2009; Zulkiflyet al., 2011; Muigai, 2012; De Silva and Senanayake, 2015).

MATERIALS AND METHODS

Research area

This research was conducted in the lowlands in the Bali island. Administratively, the area under study covers Denpasar City, Klungkung, Bangli and Jembrana districts. Geographically, Lumintang Village (Denpasar City) lies in the ordinate between 8 ° 38'9 "S and 115 ° 12'44" E; at altitude 69 meters above sea level (m asl); Gunaksa Village (Klungkung district) in the ordinate between 8 ° 33'17 "S and 115 ° 27'35" E; at altitude 35 m asl; Bunatin Village (Bangli District) in the ordinate between 8 ° 31'14 " S and 115 ° 20'43 "E, at altitude 240 m asl, and Bunut bolong village (Jembrana district) in the ordinate between 8 ° 23 '11' 'S and 114 ° 52'E, the height of 491 m asl (Figure 1). The altitude varies from 0 m to 491 m above sea level; the temperature range from 24.6 ° -30.7 ° C; the relative humidity is 72.87%, an average rainfall is about 1640.6 mm (Ngurah Rai Station, BPS Bali 2015), the temperature range from 23.3 -30.4 ° C, the relative humidity 68-86%, an average rainfall is about 1796.6 mm (station Karangasem, BPS Bali 2015), the temperature range from 23.2º-30.9º C, the relative humidity is 72-90%, an average rainfall is about 1428.5 mm (station Negara, BPS Bali 2015).

Sampling

Lichens were collected randomly on the mainland of Bali Island at altitude 0 - 500 m a.s.l. sampling locations can be recorded appropriately using the Global Positioning System (GPS). All lichen crutose species found with their habitat (especially on frangipani trees) were recorded and unknown species of lichen were collected for identification in the laboratory.

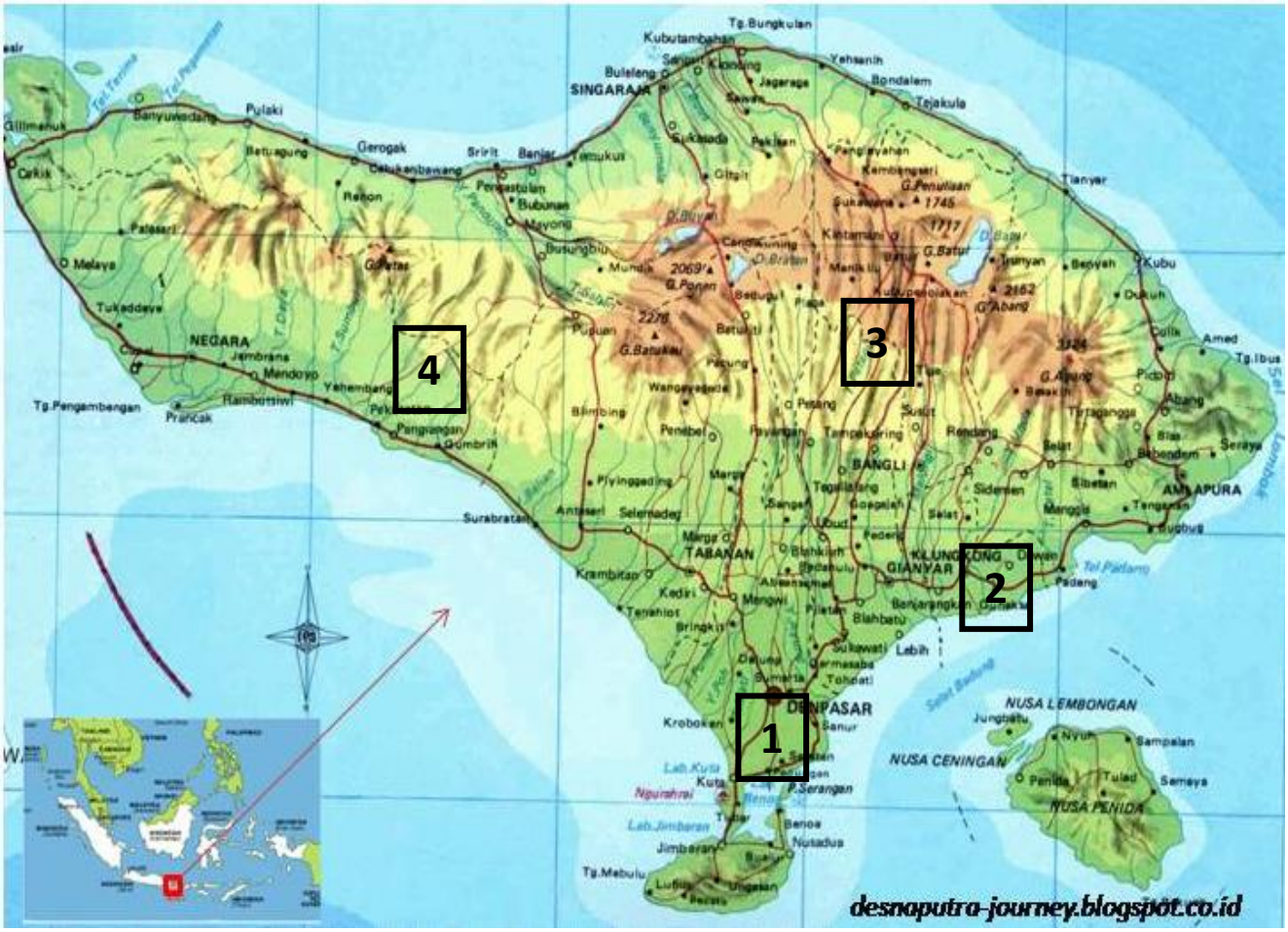

Figure 1. The research area of crustose lichen on Bali Island. 1. Lumintang Village (Denpasar City); 2. Gunaksa Village (Klungkung District); 3. Bunutin Village (Bangli District); 4. Bunutbolong Village (Jembrana District)

Other field data recorded at each sampling site were the number of individuals, habitat conditions, humidity and temperature.

Collection and Identification Lichen

The lichen crustose samples were collected with the substrate tree bark to prevent damage to the thallus and ascomata. Lichen samples were slashed by taking sufficient bark of trees as thick as 2 mm to 3 mm and taken thallus fertile. Brown paper bags were used as temporary bags to collect lichen samples.

Lichen specimens were collected from 40 frangipani trees (ten trees per site), extracted from tree bark at a height of between 1.5 m from the surface of the soil. Each sample was separated from the substrate using a knife and recorded field data that were ordinate location, altitude, temperature and humidity. The sample identification was done in the Laboratory of Plant Systematic of Faculty o Biology, Universitas Gadjah Mada. Lichens were identified by studying the morphological, anatomical and chemical character of the specimen. Observations of thallus and ascomata morphological characters were used in the stereo microscope (Olympus) i.e. the surface of thallus, isidia and soralia, ascomata (ascomata surface, color, relative length, branching, labium, pruinous, disc). Observations of anatomical thallus and ascomata characters were used light microscopes, photographs and measurements with optilab, by making cross section thallus and ascomata in water and 1% lactofenol cotton blue. The characters observed were thallus (cortex, crystal oxalate); ascomata

(thalline margin, excipulum carbonization, hymenium, hymenium pigment), ascospores (number of ascospores/ascus, length and width of ascospores, number of loculus, transverse septa, longitudinal septa and ascospora muriform). Spot tests for chemical tests were also used as part of the identification process (Hale, 1974; Huneck and Yoshimura , 1996), namely sodium hypochlorite (NaOCl), potassium iodide (KI), potassium hydroxide (KOH), and paraphenyldiamine (PD).

Lichen identification was based on morphological, anatomical and chemical characters (Lucking, 2009). Lichen identification was performed in accordance with the key identification of lichen from Wirth (1995), Huneck and Yoshimura (1996), Sipman (2003), Archer (2006, 2007), Nash (2008), Lucking et al. (2009), Lucking (2009), and Rivas Plata et al. (2010). A resource for the identification of lichen Graphidaceae, Dr. Robert Lucking (Curator for cryptogams: lichens, fungi, bryophytes, Botanischer Garten und Botanisches Museum Berlin-Dahlem) (pers.com).

Table 1. Species lichen at four research area

No	Species	Lumintang 1	Batuan 2	Bunutin 3	Bunut-bolong 4	Total
1	*Graphis* sp.1	39	50	62	80	231
2	*Graphis* sp.2	40	52	58	55	205
3	*Graphina* sp.	0	0	0	5	5
4	*Graphis nana*	0	6	0	0	6
5	*Phaeographina* sp.	0	0	0	10	10
6	*Graphis immersella*	0	0	0	11	11
7	*Graphis nilgiriensis*	0	0	0	8	8
8	*Graphis* sp.3	45	47	43	50	185
9	*Graphis modesta*	16	0	0	2	18
10	*Graphis conferta*	14	0	0	7	21
11	*Lecanora* sp.1	0	0	17	7	24
12	*Lepraria* sp.	6	12	12	6	36
13	*Caloplaca* sp.	0	0	6	4	10
14	*Lecanora* sp.2	9	0	15	10	34
15	*Graphis* sp.4	44	48	69	69	230
	Total	213	215	282	324	1034

A total of 15 lichen taxa were found from frangipani trees, i.e. six genera were identified that were Graphis, Graphina, Phaeographina, Lecanora, Lepraria, Caloplaca and five species were identified that were Graphis immersella, Graphis nilgiriensis, Graphis nana, Graphis modesta, Graphis conferta (Table 1). Identification was conducted using morphological, anatomical and chemical of lichen characters.

The pie charts (Figure 2) were created to analyze lichen distributions in four research areas. The pie chart shows that most lichen families were found in the lowlands at altitude 0-500 m asl. are Graphidaceae (90%), and Lecanoraceae (6%), Stereocaulaceae (3%), Teloschistaceae (1%), and the diversity of

species lichen most commonly were found in locations 4, village Bunutbolong (Jembrana), at location an altitude of 491 m asl., humidity 70%, temperature 25ºC, a total of 14 species.

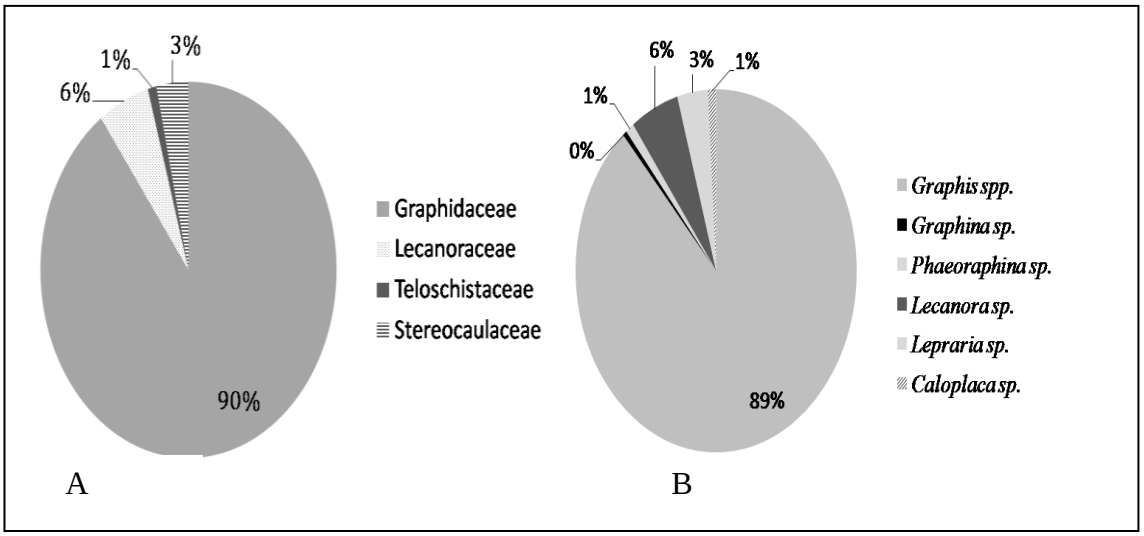

Figure 2. A. Distribution of lichen family; B. Distribution of lichen species

Discussion

The species crustose lichen of Graphidaceae family were most commonly found in frangipani young trees that have a smooth stem bark. This is consistent with the statement Hale (1961) and Caldiz (2005) that the species crustose lichen tend to choose the young trees with smooth bark as a habitat. Where frangipani tree (Plumeria spp.) on the Bali Island consists of P. acuminata (white flowers), P. alba (white and yellow flowers), P. rubra (flowers of orange, red, pink, scarlet) (Wrasiati et al., 2011). Lichen diversity is found in young trees with fresh and smooth stem bark compared with old trees with dry and peeling skin. This tree condition is an important factor in the distribution and diversity of lichen species (Tore and Ozturk, 2009). Epiphytic lichen growing on seven tree Quercus taxa are old and are in various locations. The lichen diversity shows similarities on the same substrate and this situation confirms that there are similarities in lichen growing in trees with similar ecological requirements despite different locations (Tore and Ozturk, 2009).

The lichen data were collected different at each location, because the substrate (Plumeria spp.) conditions were different. In young trees with smooth bark were found the large numbers of lichen in the village of Bunutbolong (Jembrana), whereas the trees with dry and peeling skin stems were found the lichen sterile (thallus without ascomata), so the lichen could not be collected. The condition of such trees was found in Lumintang Village (Denpasar City), Gunaksa Village (Klungkung District), Bunatin Village (Bangli District). Mulligan (2009), suggested that there were differences in substrate characteristics of tree species such as skin type, surface wrinkle, moisture retention, pH and skin nutritional status. According to Wirth (1995), this affects the number of lichen species that occupy a particular substrate because it was associated with the pH conditions of the tree, nutrient supply, water capacity, and chemical and physical properties of the substrate.

In this study most crustose lichen diversity (14 species) was found in Bunutbolong Village with 70% humidity and 25ºC temperature, compared with the other three study sites (7 to 10 species) with humidity of 40% to 54% and temperature 33° to 34°C. This indicates that the lichen composition in the

tropics is determined by a number of factors: moisture and temperature. Muigai (2012) states that lichen can be abundant and varied in areas where the humidity is high even though actual precipitation may be occasional. Due to differences in the two factors of temperature and humidity, the results can be affected the pattern of vegetation distribution and lichen diversity. Differences in the lichen community can be attributed to differences in micro habitat created by factors determined by altitude, temperature and humidity.

CONCLUSIONS

The Graphidaceae family was found to grow well in all study sites, the most dominant (89.94%) compared with other families, and consisted of 6 genera and 15 species. Graphis species found most (88%) of them are Graphis immersella, G. nilgiriensis. , G. modesta, G. nana, and G.conferta. Other families found that are Lecanoraceae (5.62%) consist of two species Lecanora sp.1 and Lecanora sp.2; Stereocaulaceae (3.48%) consisted of Lepraria sp. and Teloschistaceae (0.96%) consisted of Caloplaca sp. The species crustose lichen are found to grow well in Frangipani trees (Plumeria spp.) That has smooth bar shell surfaces favored by most crustose lichen.

ACKNOWLEDMENT

This research is part of a Doctoral Dissertation at the Biological Science Program, Faculty of Biology UGM, and funded by the Directorate General of Higher Education (DGHE), Ministry of Education and Culture of RI for the Scholarship of National Graduate Study Program.

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