

SPECIES DIVERSITY AND DISTRIBUTION PATTERN OF LICHENS ALONG ALTITUDINAL GRADIENT AT KHAO YAI NATIONAL PARK

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Abstract: Diversity and distribution patterns of lichens along altitudinal gradient were studied at Khao Yai National Park (KYNP). The aims were to categorize diversity, distribution pattern and groups of lichens that inhabited mountain slope at the elevation between 100 - 1200 m. Quadrates (50 x 10 cm) were placed on tree trunks at 130 cm above ground in 4 x 4 m plots. Lichens in the plots were observed on all trees with DBH \geq 4.5 cm at every 100 m elevation. 141 lichen thalli were found which consisted of 75 species, which were macrolichens, 6 thalli of 3 species, and microlichens, 72 thalli from 135 species. Shannon index values were 0.87 and 4.06, respectively. The three highest Important Value Indices were recorded from *Thelotrema colobicum*, Sterile soredia 6, *Ocellularia* sp.2 and Sterile non-propagule 2 accounting for 12.72, 8.51, 7.09 and 7.09, respectively. The Shannon index of lichens at elevations 700, 1000 and 1200 m. were 3.05, 2.99 and 2.48, respectively. These lichens can be categorized into 4 groups based on the altitudinal gradient.

Introduction: Variation of environment of factor varied within topography. Differences of rainfall, temperature and etc. along altitudinal gradient determine types of forests, diversity and distribution pattern of organisms.¹ Each organism has specific ecological niche and tolerance limit.¹¹ Appearance of different organisms in each habitat is the product from their responses to environmental factors.

Khao Kheow is one of the highest peaks at KYNP. It encompasses a Lower montane rain forest at the elevation 1,200 m above sea levels.⁹ This specific topography, (temperature and pressure) directly affects individual lichen as well as lichens community. Since lichens cannot move away from unsuitable changes of habitat to appropriate places, as a result they have to adapt to the existing condition. Distribution patterns and species richness of lichens have been influenced mainly by climatic factors of the elevation.¹

Lichens are epiphytic on a wide range of habitat.^{2,4,5} Baniya *et al.* in 2010¹ reported that species richness of lichens increased at each 100 m altitude of the Himalayas. This study determined the effects of elevation on lichens diversity and distribution patterns at KYNP by using Shannon-Wiener index.¹⁰

Methodology:

Study area: Khao Yai National Park is located at 14° 22' 7.28" N and 101° 24' 0.15" E, on elevations about 100-1200 m. The average mean annual air temperature is 19.4-21.6 °C. This study started from the entrance of KYNP at about 100 m elevation, and followed the road 3077 that passed through the park reaching Khao Kheow at 1,200 m elevation. The vegetation of the area can be categorized into the following altitudinal zone: secondary forest (lower altitude, 100 - < 200 m), tropical rain forest (middle altitude, 300 - < 900 m), and lower montane rain forest (high altitude, 1,000 – 1,200 m) (Fig 1).

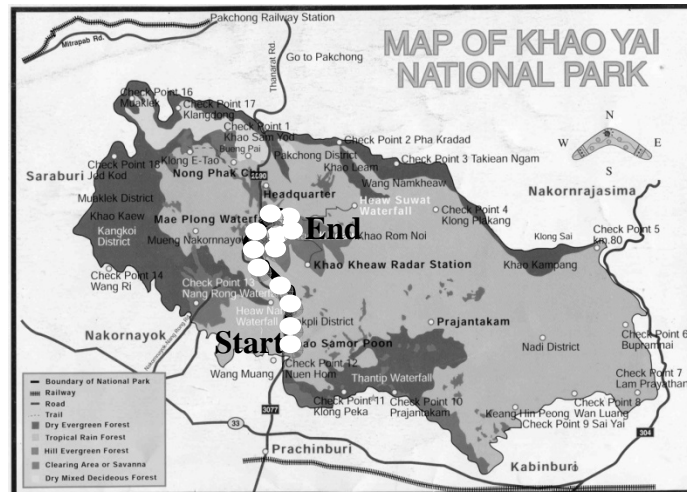


Figure 1. Modified map of the study sites at KYNP showing the road where lichens were collected at various elevations from the entrance to the end at Khao Kheaw. Source: World Trip CO., LTD. (1999)

Sampling methods: Lichens sampling were collected in 12 plots of every 100 m span from 100 – 1200 m above sea levels. A total of subplot (50 x 10 cm) was placed within 4 x 4 m of sampling site. The sampling plots were placed on barks of all trees on the east facing aspect at 1.3 m above ground. All lichens in sampling plot were then collected for taxonomic identification at the Ramkhamhaeng University laboratory. Lichen growth forms were grouped into two categories including macrolichens (composed of foliose, fruticose and filamentose) and microlichens (consisted of crustose). They were sub-divided into different groups based on the reproductive structure, which were crustose with - perithecium, crustose with disc - like apothecium, crustos with lirellate apothecium, crustose sterile and macrolichen consisted of foliose and filamentose.

Data analysis: Lichen assemblages were quantitatively analyzed for density and frequency.³ The importance value index (IVI) used here is the sum of relative frequency (RF) and relative density (RD) and determined following Phillips in 1959⁷:

$$IVI = RF + RD$$

$$RF = 100 \times (\text{frequency of species } i / \text{sum of frequency value of all species})$$

$$RD = 100 \times (\text{density of species } i / \text{sum of density value of all species})$$

Alpha diversity (H') was calculated and compared according to method of Shannon and Weaver in 1949¹⁰ as follow:

$$H' = -\sum_{i=1}^s (p_i \ln p_i)$$

H' = Shannon-Wiener index.

p_i = Proportion of the abundance of number of species i compared to the total.

s = Number of species found in the community.

Cluster Analysis was used to categorized the differences in species composition among sites. The importance values of each species were used for cluster analysis by utilizing PCORD 5.

Results, Discussion and Conclusion: Considerable differences in species composition of lichens were found among various elevations. A total of 75 lichen species, 141 thalli consisted of 3 species, 6 thallus (4.26%) of macrolichens, and 72 species, 135 thalli (95.74%) of microlichens were found. Fruticose lichen was not found because this group of lichen is usually absent from lower elevation.⁸ The top five highest IVI were *Thelotrema colobicum* (Fig 2), *Ocellularia* sp.2, sterile non-propagule 2, *Byssoloma* sp.1 and sterile soredia 6 accounting for 11.84, 8.09, 7.18, 6.47 and 5.16 respectively. Senglek *et al.* in 2009⁹ found that *Thelotrema colobicum* had wide distribution



Figure 2. Thallus and apothecia of *Thelotrema colobicum*

Table 1. List of growth form and IVI of lichens inhabited along altitudinal gradient at KYNP.

Lichens	Altitudinal range (m)	Life form	IVI
Microlichens			
<i>Acanthothecis gracilis</i>	700	Crustose-perithecium	1.62
<i>Acanthothecis</i> sp.1	700	Crustose-perithecium	2.53
<i>Anthracothecium cristatellum</i>	400	Crustose-perithecium	1.62
<i>Anthracothecium depressum</i>	100	Crustose-perithecium	2.33
<i>Arthopyrenia</i> sp.1	100	Crustose-perithecium	1.62
<i>Bacidia</i> sp.1	100-900	Crustose-disc-like apothecium	3.24
<i>Byssoloma</i> sp.1	100-800	Crustose-disc-like apothecium	6.47
<i>Carbacanthographis</i> sp.1	1,000	Crustose-lirellate apothecium	1.62
<i>Dimerella</i> sp.1	700-800	Crustose-disc-like apothecium	3.24
<i>Diorygma</i> sp.1	1,000-1,200	Crustose-lirellate apothecium	3.95
<i>Diorygma</i> sp.2	1,000	Crustose-lirellate apothecium	1.62
<i>Fissurina</i> sp.1	700	Crustose-lirellate apothecium	1.62
<i>Fissurina</i> sp.2	100	Crustose-lirellate apothecium	1.62
<i>Fissurina</i> sp.3	800	Crustose-lirellate apothecium	1.62
<i>Fissurina</i> sp.4	700	Crustose-lirellate apothecium	1.62
<i>Graphina</i> sp.1	700	Crustose-lirellate apothecium	1.62
<i>Graphina</i> sp.2	700	Crustose-lirellate apothecium	1.62
<i>Graphis</i> sp.1	100	Crustose-lirellate apothecium	3.04
<i>Graphis</i> sp.2	1,100	Crustose-lirellate apothecium	2.33
<i>Graphis</i> sp.3	700	Crustose-lirellate apothecium	1.62

<i>Graphis</i> sp.4	1,100	Crustose-lirellate apothecium	1.62
<i>Graphis</i> sp.5	1,000	Crustose-lirellate apothecium	1.62
<i>Graphis</i> sp.6	1,000	Crustose-lirellate apothecium	1.62
<i>Hemithecium</i> sp.1	1,000	Crustose-lirellate apothecium	1.62
<i>Hemithecium</i> sp.2	700	Crustose-lirellate apothecium	1.62
<i>Hemithecium</i> sp.3	800	Crustose-lirellate apothecium	1.62
<i>Hemithecium</i> sp.4	1,000	Crustose-lirellate apothecium	1.62
<i>Laurera madreporiformis</i>	1,200	Crustose-perithecium	1.62
<i>Laurera phaeomelodes</i>	800	Crustose-perithecium	1.62
<i>Lirrellate lichen</i>	700	Crustose-lirellate apothecium	1.62
<i>Malmidea</i> sp.1	700-1,200	Crustose-disc-like apothecium	4.85
<i>Malmidea</i> sp.2	200-800	Crustose-disc-like apothecium	3.24
<i>Micarea</i> sp.1	100-200	Crustose-disc-like apothecium	3.95
<i>Myriotrema</i> sp.1	800	Crustose-disc-like apothecium	1.62
<i>Ocellularia concolor</i>	400-1,200	Crustose-disc-like apothecium	3.24
<i>Ocellularia</i> sp.1	500	Crustose-disc-like apothecium	1.62
<i>Ocellularia</i> sp.2	500-1,100	Crustose-disc-like apothecium	8.09
<i>Phaeographis</i> sp.1	700	Crustose-lirellate apothecium	1.62
<i>Phaeographis</i> sp.2	700	Crustose-lirellate apothecium	1.62
<i>Porina decrescens</i>	900	Crustose-perithecium	1.62
<i>Porina eminentior</i>	100	Crustose-perithecium	1.62
<i>Porina</i> sp.1	1,200	Crustose-perithecium	1.62
<i>Pyrenula kurzii</i>	300	Crustose-perithecium	2.33
<i>Pyrenula</i> sp.1	1,000-1,100	Crustose-perithecium	3.95
<i>Pyrenula</i> sp.2	500	Crustose-perithecium	1.62
<i>Pyrenula wilmsiana</i>	1,000	Crustose-perithecium	2.33
<i>Sarcographa</i> sp.1	700-1,000	Crustose-lirellate apothecium	3.24
<i>Sarcographa</i> sp.2	700	Crustose-lirellate apothecium	2.33
Sterile isidia 1	700-1,000	Crustose-Sterile	3.95
Sterile isidia 2	600-1,200	Crustose-Sterile	4.85
Sterile isidia 3	1,000-1,200	Crustose-Sterile	3.24
Sterile isidia 4	1,000	Crustose-Sterile	1.62
Sterile isidia 5	100	Crustose-Sterile	1.62
Sterile isidia 6	900	Crustose-Sterile	1.62
Sterile isidia 7	1,000	Crustose-Sterile	1.62
Sterile isidia 8	1,100	Crustose-Sterile	1.62
Sterile non-propagule 1	1,000	Crustose-Sterile	3.75
Sterile non-propagule 2	200-900	Crustose-Sterile	7.18
Sterile non-propagule 3	800-1,200	Crustose-Sterile	3.24
Sterile non-propagule 4	700-1,200	Crustose-Sterile	2.33
Sterile non-propagule 5	200	Crustose-Sterile	3.24
Sterile soredia 1	100	Crustose-Sterile	3.75
Sterile soredia 2	100-200	Crustose-Sterile	3.24
Sterile soredia 3	200	Crustose-Sterile	1.62

Sterile soredia 4	1,000	Crustose-Sterile	1.62
Sterile soredia 5	200	Crustose-Sterile	1.62
Sterile soredia 6	200	Crustose-Sterile	5.16
Sterile soredia 7	1,000	Crustose-Sterile	1.62
<i>Thelotrema colobicum</i>	400-1,200	Crustose-disc-like apothecium	11.84
<i>Thelotrema dilatatum</i>	1,000-1,200	Crustose-disc-like apothecium	4.66
<i>Thelotrema</i> sp.1	800	Crustose-disc-like apothecium	2.33
<i>Trypethelium</i> sp.1	1,000	Crustose-perithecium	1.62
Macrolichens			
<i>Coenogonium</i> sp.1	700	Filamentose	1.62
<i>Parmotrema platyphyllum</i>	1,200	Foliose	1.62
<i>Physcia</i> sp.1	700-1,200	Foliose	4.66

The highest and subsequently lower numbers of species were found at the elevation of 1,000, 700 and 1,200 m, accounting for 23, 22 and 13 species respectively. The Shannon's indices of macrolichens and microlichens were 0.87 and 4.06, respectively. High values of Shannon's index were found at elevation 700, 1,000 and 1,200 m, (3.05, 2.99 and 2.48, respectively; Fig 3). These elevations hosted tropical rain forest and lower montane rain forest, which implied that the two forests had high biodiversity. In contrast the elevations 300 and 600 m had zero Shannon's index values, of which only one lichen species was found. This could be because very few lights, as a result, the area has a lower index value or zero, when one species is present.⁶ The lichens found at these two elevations were *Pyrenula kurzii* and sterile isidia sp.2, respectively.

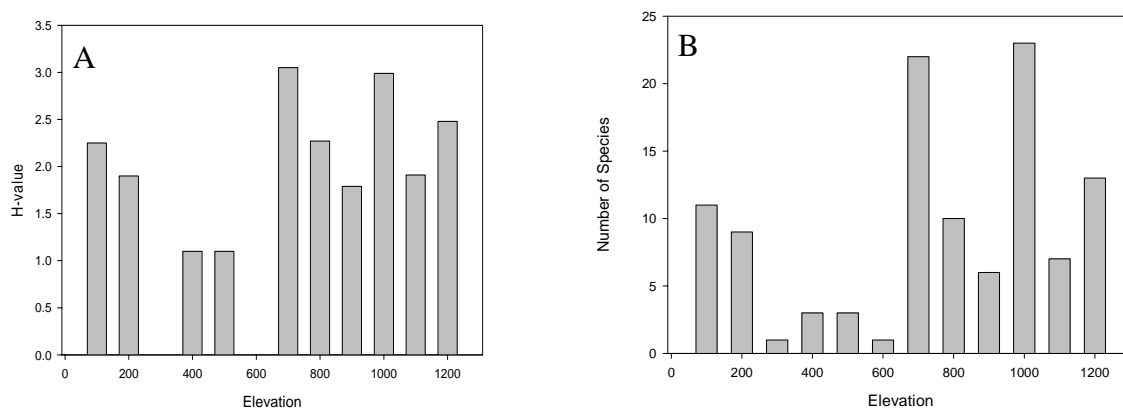


Figure 3. (A) Number of species and (B) Shannon-Wiener index value of lichens inhabited along elevation gradient at KYNP.

Lichens found along the elevation gradient can be categorized into 4 groups. Group 1 is located near the entrance to KYNP consisted of the lichens at elevations 100, 200 and 800 m above sea level. The secondary forest with pioneer trees occurred in these areas. The lichens were microlichens dominated by *Byssoloma* sp.1, sterile soridia 6 and *Ocellularia* sp.2. Group 2 consisted of large trees with relatively dense canopy cover, deep shaded and high moisture. It occurred at elevation 300 and 600 m, which Shannon's index value was 0. The lichens were *Pyrenula kurzii* and sterile isidia sp.2, which could be regarded as shade tolerant species. Group 3 had Shannon's index value more than 1 occurred at elevations 400 and 500 m. The areas were dominated by *Thelotrema colobicum*, and *Ocellularia* sp.2, which

were known to have wide distribution.². Group 4 had Shannon's index value more than 1 - 2, found at elevation 700, 900 - 1200 m above sea levels. Macrolichens were found consisted of *Coenogonium* sp.1, *Physcia* sp.1 and *Parmotrema platyphyllum*. Lichens at 700 m dominated by sterile non-propagule, whereas those at 900 - 1,200 m were *Thelotrema colobicum* (Fig 4).

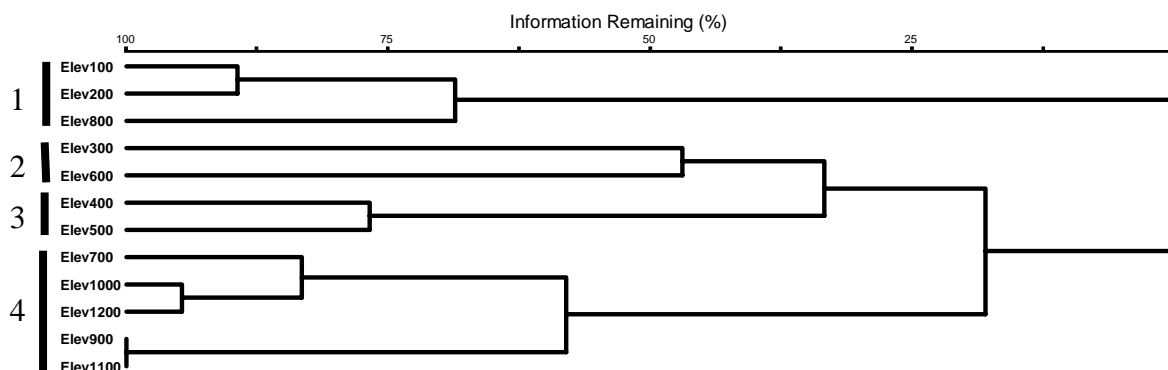


Figure 4. Groups of lichens along elevation gradient at KYNP categorized by cluster analysis, which had dissimilarity value of 45%

In conclusion, the lichen flora of the KYNP is remarkably rich and diverse, with pattern of species diversity varied among elevations. Each elevation had unique community structure. The highest diversity was recorded at elevations above 700 m. The results demonstrated that spatial heterogeneity presumably abundance of phorophyte, rainfall and temperature along altitudinal gradient influenced diversity of lichens community. These informations are essential for conservation and management of lichens sustainability.

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