# EPIPHYTIC LICHEN DIVERSITY IN DIFFERENT AREAS OF NAKHON RATCHASIMA, THAILAND

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## Abstract

**Lichens are accepted as bioindicators of air quality and biomonitors of environmental changes. This work aimed to identify epiphytic lichens in Nakhon Ratchasima, Thailand in 2015 by comparing six areas i.e. the center of Mueang district, four directions (N, W, E, S) and at the Boong Ta Lua Water Park. Lichens were investigated and collected on 180 tree samples based on the Verein Deutscher Ingenieure (VDI) protocol. Fifty-four taxa were identified from the 1,044 samples; they belong to 16 families and 30 genera. The highest frequency was *Pyxine cocoes* for 111 followed by *Hyperphyscia adsendes* for 81. There were six species found all study plots; *Dirinaria applanata*, *Hyperphyscia adsendes*, *Laurera megasperma*, *Pyxine cocoes*, *Graphis* sp.1 and *Graphis* sp.2. The species that found only one site were *Hyperphyscia flavida*, *Hypogymnia hypotrypa* and *Hypotrachyna osseoalba*, which found only at the south direction of the city, *Myriotrema microporellum*, *Ocellularia crocea*, *Rinodina intrasa* and *Sarcographa* sp., which found only at the park area. The species richness and Shannon-wiener diversity index were highest at the park for 44 and 3.66 respectively and showed significant different from other sites ($p<0.01$), whilst the evenness was highest at the north of the city. The Sorensen's similarity coefficient showed the highest value between the park site and the north sites for 77.22 and lowest between the north and south areas for 33.33. For the correlation between lichen frequency and the physiological condition found lichen diversity have a negative correlation with the distance from road. The species that found specific in one sites are interested for using as bioindicator of air pollution in this area.**

**Keywords: Lichens, biodiversity, bioindicator, environmental quality**

## Introduction

Atmospheric pollutants are the main source of environmental problem and human health over the last few decades. They are reported as the important causes of the respiratory and cardiovascular diseases (Godinho *et al*., 2008). In the city, traffic is the main source of air

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pollution; nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), carbon monoxide (CO), carbon dioxide ($CO_2$) and ozone ($O_3$) are released from road traffic and maintain in the air. The ecotoxicological perspective, contaminants are all chemical compounds that are fundamentally released into the environment and injured to the living organisms (Conti *et al*., 2001). Lichens are accepted as a good of bioindicator of air pollution and biomonitoring of environmental changes. They are symbiotic organism of fungus (mycobiont) and at least one photosynthetic alga or cyanobacterium (photobiont) (Hamada and Miyawaki, 1998; Loppi *et al*., 2001). Furthermore, the effect of atmospheric pollutants to lichens at both cellular and population or community level (Purvis *et al*., 2007). They are used to evaluate specific species in relation to pollutants (Giordani *et al*., 2002; Fuga *et al*., 2008; Zschau *et al*., 2003) or to verify any alterations in the lichenized mycota due to atmospheric contaminants (Fuga *et al*., 2008; Saipunkaew *et al*., 2007). The correlation of lichens and air pollutants has been reported e.g. $SO_2$ (Batty *et al*., 2003) and nitrous oxides (NOx) (van Herk *et al*., 2003). In addition, Bartók (1999) suggested that agricultural activities influenced lichen diversity, whilst Purvis *et al.* (2007) admitted that nitrogen deposition mainly come from emissions of $NO_x$. In addition, Gombert *et al.* (2003) mentioned that the nitrogen concentration of the nitrophytic *Physcia adscendens* collected near roadsides was related to traffic flow.

In Thailand, a few studies have been carried out using lichens as indicators of air pollution and the existing ones are limited to the use of determined lichen species to specially evaluate the presence of $SO_2$ in the air (Saipunkaew *et al*., 2007). The methodology of using lichens for bioindicating air pollution are followed the Verein Deutscher Ingenieure (VDI) protocol. This protocol was approved in various countries including Thailand; it uses lichen frequency from one aspect of each tree in tropical condition (VDI, 1999).

Nakhon Ratchasima is the largest area of Thailand and the center of the Northeast of Thailand. The industrial in this province was expended rapidly. Therefore, the forest in the city was decreased while the population number is increased. This work aimed to investigate lichen diversity in different areas of Nakhon Ratchsima.

This work aimed to investigate lichens in the city of Nakhon Ratchasima and other four aspects of the city and in the park where lichens were less disturb from pollutions.

## Materials and Methods

### Study Sites

The study site is located at Nakhon Ratchasima province, Thailand. It is a central city of business in the northeast region of Thailand. It situates between 14”16°N, 101”103°E at around 150-300 m above sea level.

### Sampling and Identification

Lichens were sampling on the bark of tree trunk from 16 sites located at Nakhon Ratchasima province. The 16 plots were selected base on the aspects around the city of Mueang Nakhon Ratchasima. The plots of 1 × 1 km were established the center and the four aspects and Boong Ta Lua Water Park. Ten sampled trees were randomly selected in each plot following the standard lichen monitoring protocol[15]. Further criteria, the diameter at breast height (DBH) of tree trunk ranged from 50 to 150 cm. All epiphytic lichen species and frequencies were recorded using a quadrat (surveying grid frame) of 20 × 50 cm consisting of 10 small quadrat squares (10 × 10 cm). The surveying grid frame was placed on the selected tree trunk at 1.5 m above ground level on side where the most lichens were presented. Lichen frequency was calculated as percent frequency (total frequency of all in all study sites divided by the total of all species found in this work). The ecological indices were used to compare lichen diversity between inside and outside municipality and among municipalities. The lichen specimens were identified using a stereomicroscope and chemical spot tests, a UV lamp, and TLC following the standard checklists of Hale (1969); Awasthi (1991) and Sipman (2003).

### Physical and Chemical Factors

The acidity of the bark of the mango trees was measured followed Staxäng (1969). Samples of tree bark were taken from two sides

**Table 1. Lichen species and frequencies found in each study site**

| Family | Genus | Species | Thallus | Lichen frequency | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | C | N | S | E | W | P | TF |
| Arthoniaceae | Cryptothecia | *Cryptothecia candida* | crustose | | 5 | | | | 5 | 10 |
| | | *Cryptothecia punctosorediata* | crustose | 3 | | 3 | 3 | 3 | 2 | 14 |
| | Arthonia | *Arthonia catenatuta* | crustose | 4 | | 4 | | | 4 | 12 |
| | | *Arthonia cinnabarina* | crustose | | 13 | | | 13 | 13 | 39 |
| | | *Arthonia elegans* | crustose | | 12 | | 14 | | | 26 |
| | | *Arthonia incospicua* | crustose | 4 | 4 | | | 4 | 4 | 16 |
| | | *Arthonia tumidula* | crustose | | | 7 | 7 | | | 14 |
| Caliciaceae | Amandinea | *Amandinea extunata* | crustose | 5 | 3 | 10 | | | 3 | 21 |
| | | *Amandinea punctata* | crustose | | 3 | | | 2 | 4 | 9 |
| | Buellia | *Buellia erubescens* | crustose | | | | 3 | | 20 | 23 |
| Chrysotrichaceae | Chrysothrix | *Chrysothrix candelaris* | crustose | | 4 | | | | 4 | 8 |
| | | *Chrysothrix xanthina* | crustose | 5 | 5 | 3 | | 2 | 24 | 39 |
| Crocyniaceae | Crocynia | *Crocynia pyxinoid* | crustose | | | | | 3 | 3 | 6 |
| Graphidaceae | Graphis | *Graphis* sp.1 | crustose | 2 | 3 | 3 | 7 | 7 | 23 | 45 |
| | | *Graphis* sp.2 | crustose | 3 | 3 | | 5 | 7 | 23 | 41 |
| | Sarcographa | *Sarcographa* sp. | crustose | | | | | | 8 | 8 |
| Lecanoraceae | Lecanora | *Lecanora achrosa* | crustose | 2 | 2 | | 2 | 2 | 2 | 10 |
| | | *Lecanora helva* | crustose | | 5 | 5 | | | | 10 |
| | | *Lecanora tropica* | crustose | | 4 | | 4 | | 4 | 12 |
| Parmeliaceae | Hypogymnia | *Hypogymnia hypotrypa* | foliose | | | 4 | | | | 4 |
| | Hypotrachyna | *Hypotrachyna osseoalba* | foliose | | | 5 | | | | 5 |
| | Parmotrema | *Parmotrema praesorediosum* | foliose | 5 | | | 7 | 4 | 13 | 29 |
| | | *Parmotrema tinctorum* | foliose | | | | 6 | 3 | 12 | 21 |
| Physciaceae | Dirinaria | *Dirinaria applanata* | foliose | 13 | 2 | 12 | 2 | 5 | 3 | 37 |
| | | *Dirinaria confluens* | foliose | | 2 | | 7 | 2 | 7 | 18 |
| | | *Dirinaria pica* | foliose | | 3 | | 3 | 3 | 3 | 12 |
| | Hyperphyscia | *Hyperphyscia adglutinata* | foliose | 12 | | 15 | 4 | 5 | 6 | 42 |
| | | *Hyperphyscia adsendes* | foliose | 15 | 12 | 14 | 12 | 23 | 5 | 81 |
| | | *Hyperphyscia flavida* | foliose | | | 3 | | | | 3 |
| | Physcia | *Physcia atrostriata* | foliose | 8 | | | | | | 8 |
| | | *Physcia dimidiata* | foliose | 10 | | 5 | | | | 15 |
| | | *Physcia poncinsii* | foliose | 3 | | 3 | | | 3 | 9 |
| | Pyxine | *Pyxine cocoes* | foliose | 13 | 34 | 26 | 15 | 11 | 12 | 111 |
| | | *Pyxine subcinerea* | foliose | 3 | | | | 8 | 10 | 21 |
| | Rinodina | *Rinodina intrasa* | crustose | | | | | | 14 | 14 |
| Porinaceae | Porina | *Porina eminentior* | crustose | | 1 | | | | 8 | 9 |
| | | *Porina internigrans* | crustose | | 3 | | | | 9 | 12 |
| Pyrenulaceae | Anthracothecium | *Anthracothecium prasinum* | crustose | | 3 | | 12 | 5 | 18 | 38 |
| | Pyrenula | *Pyrenula confinis* | crustose | | 4 | | | | 3 | 7 |
| Ramalinaceae | Bacidia | *Bacidia pallidocarnea* | crustose | 5 | 2 | | 7 | 5 | 5 | 24 |
| Roccellaceae | Dichosporidium | *Dichosporidium boschianum* | crustose | | | | 2 | 5 | 4 | 11 |
| | Lecanographa | *Lecanographa atropunctata* | crustose | | 2 | 2 | | | 2 | 6 |
| | Opegrapha | *Opegrapha stirtinii* | crustose | | 2 | | | | 2 | 4 |
| Stereocaulaceae | Lepraria | *Lepraria atrotomentosa* | crustose | | 2 | 2 | 4 | 2 | 2 | 10 |
| Teloschistaceae | Caloplaca | *Caloplaca diplacia* | crustose | 7 | | | | | 13 | 20 |
| | | *Caloplaca diplacioides* | crustose | | | 13 | 4 | 12 | | 29 |
| | | *Caloplaca gambiensis* | crustose | 2 | 2 | | | 2 | 2 | 8 |
| Thelotremataceae | Myriotrema | *Myriotrema microporellum* | crustose | | | | | | 2 | 2 |
| | Ocellularia | *Ocellularia crocea* | crustose | | | | | | 3 | 3 |
| Trypetheliaceae | Laurera | *Laurera benguelensis* | crustose | 2 | | | 2 | 3 | 5 | 12 |
| | | *Laurera megasperma* | crustose | 1 | 3 | 1 | 3 | 3 | 3 | 14 |
| | Trypethelium | *Trypethelium eluteriae* | crustose | 12 | | | | | 3 | 15 |
| | | *Trypethelium tropicum* | crustose | | | | 6 | 6 | 16 | 28 |
| **Total frequency** | | | | **139** | **143** | **140** | **142** | **150** | **334** | **1044** |

*Note: C = city, N = North, S = South, E = East, W = West, P= Park.*

**Table 2. Ecological indices in each study plot; C= city, N = North, S = South, E = East, W = West, P = park**

| Ecological indices | C | N | S | E | W | P |
|---|---|---|---|---|---|---|
| Species Richness | 23 | 28 | 20 | 24 | 25 | 44 |
| Shannon- Wiener diversity Index | 2.97 | 3.32 | 2.78 | 2.92 | 3.26 | 3.66 |
| Evenness | 0.95 | 0.99 | 0.91 | 0.92 | 0.98 | 0.97 |

**Table 3. The species similarity between study plots; C= city, N = North, S = South, E = East, W =West, P = park**

| | N | S | E | W | P |
|---|---|---|---|---|---|
| C | 43.14 | 60.45 | 51.06 | 64 | 62.69 |
| N | - | 33.33 | 50 | 58.18 | 77.22 |
| S | - | - | 49.91 | 42.55 | 34.38 |
| E | - | - | - | 74.51 | 58.82 |
| W | - | - | - | - | 70.42 |

of each trunk - the roadside, and the reversed side at a height of 100-150 cm above the ground, and subsequently oven dried. The tree circumference or the DBH of each tree was measured at 150 cm above ground level. The bark properties were classified into three groups: (i) smooth bark; (ii) moderately smooth bark; and (iii) rough bark. The directions of surveying quadrat were placed on the tree trunk at the side where the most lichens were presented. The distance from selected trees to the road were divided into ranges of 1.0-5.0 m, 5.01-10 m, 10.01-15 m, 15.01-20 m, and greater than 20 m.

### Data Analyses

T-test was used to compare the variation difference between study sites for all data. The correlation between lichens and the environmental parameters of each study site were analysed using the Sorensen's coefficient correlation.

## Results and Discussion

### Lichen Diversity and Ecological Indices

Two types of lichens found in this work were crustose (38 species) and foliose (16 species). They were identified into 54 species belonging to 30 genera and 16 families. The families representing the highest number of taxa were Physciaceae (12 species) followed by Arthoniaceae (7 species), whereas the genera with the largest species representativeness were *Arthonia* (5 species). The highest frequency was *Pyxine cocoes* (111 samples) followed by *Hyperphyscia adsendes* for 81 samples (Table 1). There were six species found all study plots; *Dirinaria applanata*, *Hyperphyscia adsendes*, *Laurera megasperma*, *Pyxine cocoes, Graphis* sp.1 and *Graphis* sp.2. The species that found only one site were *Hyperphyscia flavida*, *Hypogymnia hypotrypa* and *Hypotrachyna osseoalba*, which found only at the south direction of the city, *Myriotrema microporellum*, *Ocellularia crocea*, *Rinodina intrasa* and *Sarcographa* sp., which found only at the park area.

The present results clearly show that the lichen diversity is higher in the park than inside the city. From the thallus characteristics, the crustose lichens are highest, this result is similar to the study of Saipunkaew *et al.* (2007) who mentioned that crustose lichens were prominent in the areas where were from 250 to 400 m above sea level, whilst the foliose lichens were presented in more over 600 m. The species that found specific sites could be developed as a bioindicator of the environmental quality (Blanco *et al.*, 2006). Family Physciaceae represents the highest species dominance and richness, they occurs specially in forest of tropical and subtropical regions around the world, on trunks and twigs of trees and bushes

(Staiger *et al*., 2006). Physciaceae is typified as the second most abundant family in number of species in Thailand and other tropical area (Saipunkaew *et al*., 2007; Wolseley *et al*., 1994), they have been associated with both increasing temperatures and increasing availability of nutrients (Lange *et al*., 1993).

The two species of *Pyxine cocoes* and *Dirinaria picta* found in all current study, they were reported as normal species that are widespread in the city and reported as a tolerant species (Saipunkaew *et al*., 2005). *Hyperphyscia adsendes* was wildly distributed species in continental areas, occurring in natural forest, parks and avenues; this species was reported as a tolerant species that found both inside and agricultural area (Ng *et al.*, 2006). The family Parmeliaceae, synergistic effects could therefore explain the absence or scarcity of certain sensitive lichen species, especially *Parmelia*, from the semi-altered zone, despite the low levels of $SO_2$ and $NO_x$ (Loppi *et al*., 2002). Species richness and diversity index were highest at the park (P) for 44.00 and 3.66 while the lowest found at the south for 20 and 3.66 (Table 2).

The variation test using t-test showed significant different ($p<0.05$) between the park (F) with other study sites. However, the evenness was not significant difference between study plots. The species similarity was highest between the area in the north and the park for 77.22 followed by the sites of the east and the west (74.51) and the lowest at the south and the north (33.33) (Table 3).

### Environmental Factors Correlation

The correlation between environmental parameters and lichen frequency were analysis. Significant parameters that influencing on epiphytic lichens include average day of rainfall, annual rainfall, and average year temperature, latitude, traffic effect. Another important substrate parameter is the acidity of the tree's bark pH value, which has a strong influence on epiphytic lichens ($r = -0.264$, $p<0.01$).

## Conclusions

Lichen diversity was highest at the park area and significant difference from other study sites. The similarity species found highest between the north side of the city and the park. In addition, annual rainfall, and bark pH were considered as microclimate supported lichen diversity. In contrast, the distance from road had negative correlation with lichen diversity. The current study suggested the *Dirinaria applanata*, *Hyperphyscia adsendes*, *Laurera megasperma* and *Pyxine cocoes* to be tolerant species while the *Myriotrema microporellum*, *Ocellularia crocea*, *Rinodina intrasa* and *Sarcographa* sp. as sensitive species. They were suggested to use as indicator of environmental quality in this area.

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