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ScienceDirect
Environmental Pollution 146 (2007) 366–374
ENVIRONMENTAL POLLUTION
www.elsevier.com/locate/envpol

Epiphytic macrolichens as indicators of environmental alteration in northern Thailand

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Received 15 October 2005; accepted 10 March 2006

Epiphytic lichens in urban and rural areas of northern Thailand can be used as indicators of the levels of pollution associated with increasing population.

Abstract

Epiphytic lichens were sampled on mango trees (*Mangifera* spp.) in 32 sites in urban centres and surrounding rural areas in seven provinces of upper northern Thailand. Species were recorded on each tree and frequency estimated in a grid of ten 100-cm^2 units. Analysis of macrolichen data showed that lichen diversity was inversely correlated with human population, and that lichen diversity was lowest in the cities with the highest population. The distribution and frequencies of species belonging to families *Physciaceae* and *Parmeliaceae* contributed to the groups identified by cluster analysis that corresponded to gradients in rainfall and population density. Comparison with modelled pollution data and local pollution records showed greater correspondence of lichen data with the effects of PM10 than with anthropogenic sulphur.

Keywords: Atmospheric pollution; Biomonitoring; PM10; South East Asia; Urban areas

1. Introduction

Epiphytic lichens have been widely used as bioindicators of the effects of atmospheric pollutants and for changes in environmental conditions in temperate regions (Nimis et al., 2002; Will-Wolf et al., 2002). Their use in tropical zones has been hampered by the lack of taxonomic knowledge of tropical lichens and the absence of data on environmental and pollution conditions. It is now becoming apparent that the fate of atmospheric pollutants in tropical monsoon climates with high rainfall in strongly contrasting seasons may be rather different to that in temperate climates (Hien et al., 2004). In Europe two types of biomonitoring methods using lichens have been widely applied to assess atmospheric pollutant levels in and around urban sites. VDI (1995) uses lichen frequency from one aspect of each tree, whereas Asta et al. (2002) calculate lichen diversity values (LDV) from frequency data from five consecutive 10-cm square quadrats placed on 4 aspects of each tree sampled. Both methods have shown good correlations with deposition of atmospheric pollutants in urban and surrounding areas (Kirschbaum and Hanewald, 1998; Larsen et al., 2007). However, in tropical conditions the VDI method allows the selection of the lichen-rich aspect of the trunk and avoids aspects often dominated by sterile crustose species that are difficult to identify. Saipunkaew (2000) used the VDI to demonstrate that epiphytic lichen communities in the Chiang Mai region of northern Thailand were affected by conditions in Chiang Mai city. A more recent analysis of the same lichen data has shown the effects of altitude on both macrolichen and crustose lichen floras (Saipunkaew et al., 2005). Results

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0269-7491/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.envpol.2006.03.044

showed that in upland areas above 600 m tree trunks were dominated by foliose species and in lowland areas from 250–400 m trunks were frequently dominated by crusts. An analysis of the lowland data based on genera only failed to distinguish urban from agricultural areas. However, analysis of macrolichen species distinguished rural and agricultural sites from urban sites and identified associations of species (Saipunkaew et al., 2005).

In the present paper, lichen data collected on mango trees in urban and rural areas of lowland parts of northern Thailand are tentatively correlated with climatic and population data to identify lichen taxa responding to climatic and geographical gradients and select taxa that could be used as bioindicators of environmental alteration.

2. Study area

Upper northern Thailand comprises 8 provinces of a rather mountainous nature. Each province is geographically separated by mountain ranges and the capital cities are separated in different alluvial plains except the provinces of Chiang Mai and Lamphun, which are located in the Mae Ping river plain. The main rivers and their tributaries rise in the mountain ranges and extend from north to south through the river valleys to the central plain of Thailand (Ogawa et al., 1961; Santisuk, 1988) (Fig. 1).

A strongly alternating climate affects the distribution of pollutants in northern Thailand where a consistent pattern of cool and hot dry seasons alternates with warm rainy seasons. The cool dry season lasts from October to February, when the northeast monsoon brings cool and dry air masses from China, followed by hot dry season with relatively high daily time temperature. The wet season occurs from May to September with the southwesterly monsoon. Annual rainfall in lowland areas with elevation below 500 m ranges between 600 and 1000 mm but becomes more than 1000 mm in mountain areas.

Northern Thailand was formerly densely forested, so that in 1982 56% of the forested area in the country was in northern Thailand (Royal Forestry Department of Thailand http://www.forest.go.th/stat/stat40/CONTENTS.pdf). Above 1000 m forests are mainly evergreen and below 900 m mainly deciduous, the latter comprising mixed deciduous forest on the alluvial lowland plains and deciduous dipterocarp forest on the drier slopes (Santisuk, 1988). The lowland forests on alluvial plains were formerly dominated by teak and large leguminous trees, but extensive logging and the expansion of agricultural land with rapidly growing settlements has removed all natural forest vegetation except in a few protected areas (Santisuk, 1988). The widespread use of fire in the dry season contributes to the degrading of hill forests and to an increase in atmospheric particles. These fires strongly affect epiphytic lichen communities (Wolseley, 1997). Lowland areas are now extensively managed for agriculture, with rice dominating on irrigated land, and vegetables and fruit trees in the vicinity of rural settlements. Mango (*Mangifera indica* L.) trees are widely cultivated in rural and

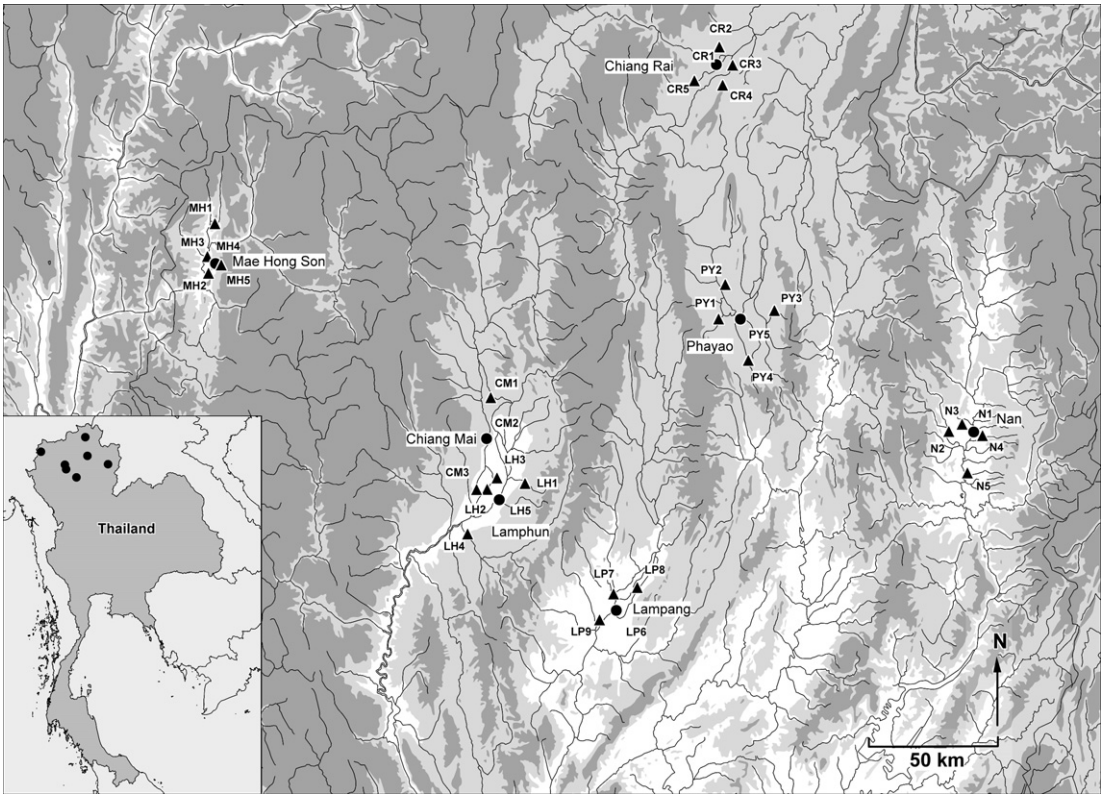

Fig. 1. Map of upper northern Thailand showing urban sampled sites (●) and adjacent rural sites (▲) in seven provinces: Nan, Phayao, Lampang, Lamphun Chiang Rai, Chiang Mai and Mae Hong Son. Mountain regions are indicated by darker grey shading and main river valleys as pale shading.