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A SURVEY OF LICHENS IN THE KANDY MUNICIPAL REGION

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ABSTRACT

Lichen flora found on bark of trees and on rocks in ten selected sites within the Kandy Municipal Region were studied. About 50 lichen species belonging to 18 families and 32 genera were recorded. Of them 33 (66%) were crustose lichens, 11 (22%) foliose , 4 (8%) placcodioid and the remaining 4% were fruticose and squamulose lichens. A high number of lichens were recorded in the National Botanic Gardens, Peradeniya and Walkerawatta forest stand. The most frequently encountered species of lichens in many of the sites within the Kandy Municipal Region were *Pertusaria pertusa*, *Pyxine consocians*, *Lecanora* sp_1., *Parmotrema tinctorum*, *Leptogium* sp., *Buellia* sp_1. and *Chrysothrix candelaris*. The presence of *Pyxine consocians* and *Dirinaria consimilis* in all the sites and the absence of fruticose lichens such as *Usnea articulata* and *Cladonia* sp. in any of the sites but recorded in the past may indicate environmental pollution in the area.

Key words
Crustoses, Folioses , Kandy, Photobiont,

INTRODUCTION

Lichens are the symbiotic phenotype of nutritionally specialized fungi (mycobiont) that live as ecologically obligate biotrophs in symbiosis with algal and /or cyanobacterial photobionts (Honegger, 1991). This association has been so successful that there are now about 20,000 recorded species of lichens represented in most habitats of the world and covering about 8% of the world's land surface (Nash III, 1996). The lichen thallus may be crust-like (crustose), shrub-like (fruticose), or leaf-like (foliose). Intermediate forms can be small, separate and scale-like (squamulose) or closely appressed and disc-like (placodioid).

Lichenised fungi constitute about 1/5 of all known fungi. Of them 98% belong to the Ascomycotina and 2% to the Basidiomycotina (Poelt, 1994). The photobiont is a member of the chlorophyta (green algae) in about 90% of cases, and is one of the cyanobacteria (blue-green algae) in about 10% of cases (Lange *et al.*, 1989). The most common lichen photobiont by far is the genus *Trebouxia* followed by *Trentepohlia*. Amongst the cyanobacteria, *Nostoc* is the most common genus (Lange *et al*, 1989).The photobiont is not known to reproduce sexually in a lichen state. The fungal partner is specific to the lichen taxon, so that the classification of lichens is based on the sexual characteristic of the fungal partner (Wolseley and Aguirre-Hudson, 1995).

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The photobiont is sensitive to a range of environmental conditions and will determine the distribution of a lichen. The mycobionts contain a diversity of chemical substances which help to protect the photobionts and extend their ecological range. Furthermore, these chemical compounds have been extensively used in the determination of lichen genera and species (Wolseley and Aguirre-Hudson, 1995). In the field lichen taxa can be circumscribed by a number of morphological characters that are the result of the partnership of both symbionts. In order to distinguish genera and species these characters arewidely used in artificial keys (Wolseley and Aguirre-Hudson, 1995). Lichens are sensitive to changes in atmospheric and micro-climatic conditions and have been used as environmental bioindicators (Wolseley and Aguirre-Hudson, 1997a).

G.H.K. Thwaites was the first to collect lichens in Sri Lanka, in 1868. W.A. Leighton examined Thwaites' collection and determined 199 species (Leighton, 1870). Almquist's collections in 1879 formed the basis of Nylander's Lichenes Ceylonenses (1900). A.H.G. Alston listed 89 lichen species common to the Kandy district (Alston, 1932). Between 1966-1968 Kurokawa and Mineta reported lichens mainly in the montane forests (Kurokawa and Mineta, 1973). During the 1970's, F. Hale collected lichens in lowland rain forests. These collections resulted in a regional monograph of *Relicina* (Hale, 1980) and Thelotremataceae in Sri Lanka (Hale, 1981).

Following a botanical excursion from the University of Vienna in 1984, Brunnbauer compiled a bibliographic description of lichens in Sri Lanka in 15 fascicles (Brunnbauer, 1984-1987). This included 550 species belonging to 122 genera and 48 families. Further publications by Moberg (1986, 1987), Awasthi (1991), Makhija and Patwardhan (1992), Breuss *et al.* (1997) and Vezda *et al.* (1997) have raised the recorded number of lichens in Sri Lanka up to 659 species. Apart from the above mentioned references no other systematic work has been made on the Sri Lankan lichen flora. Hence the objective of the present investigation was to identify the lichen flora and their distribution in and around Kandy town.

METHODS AND MATERIALS

Site description

This study was carried out in and around Kandy town. Observations and collections being made along eight directions radiating from the centre so as to represent as many areas of the Kandy municipal limits. This included Gatambe, Dodanwela, Bahirawakande, Mahaiyawa, Asgiriya, Aruppola, Lewella, and Kandy town. In addition, special collections were made from the National Botanic Gardens, Peradeniya and Walkerawatta forest reserve. The study was not done in Udawattakelle forest as there were certain limitations for researchers in the site. Approximately 2/3rd of the area of Kandy Municipal region was covered during the present study and it was approximately 1950 ha.

Geographical co-ordinates of Kandy are approximately 70° 15′ N and 80° 36′ E (Sri Lanka Survey Department, Kandy Sheet, 1979). The climate in Kandy may be characterized as hot, humid and subtemperate (Bailey 1958; 1960). Mean annual temperature is 24.1 C^0; mean annual precipitation is 2131 mm. Rainfall is received from both North East and South

West monsoons and is evenly distributed throughout the year (Greller *et al,* 1980). The elevation of the Kandy municipal region ranges from 485 m to about 520 m. According to the phytosociological survey done by Greller *et al* (1980), forests in the vicinity of Kandy were assigned to the *Filicium-Artocarpus-Pometia-Myristica* series (Gaussen *et al.* 1964).

Collection of lichens

Lichens were observed and recorded on rocks and on barks of randomly selected trees up to 2 m above the ground using magnifying lenses (x10). Those found on felled trees, fallen twigs and branches were also recorded. The number of trees observed in each site varied from about 10 to 30 depending on the vegetation. Foliose lichens were collected with part of the substrate to prevent damage to the thallus and rhizines. Crustose species were cut off taking sufficient bark from the trees and those that were present on rock were chiselled off with parts of the substrate. Ordinary brown paper bags were used as temporary packets to collect the lichen specimens. Fragile specimens were wrapped in absorbent soft tissue before bagging.

Identification

The specimens were identified up to generic level and where possible to species level using morphological characters of lichens that have been used in "artificial field keys to common lichen genera in Thailand" (Wolseley and Aguirre-Hudson, 1995) and a colour key to lichens (Wolseley, and Aguirre-Hudson, 1997a). Microscopic observations of free-hand sections of thallus and fruiting bodies were also made on most of the lichens in order to follow the keys. Chemical spot tests were carried out to distinguish some species of lichens using freshly prepared calcium hypochlorite, 10% aqueous solution of potassium hydroxide and freshly prepared paraphenylenediamine. Colour reactions of the thallus to the above chemicals were observed by applying a small drop to the cortex on the upper surface or to the medulla after scraping off the cortex to expose the medulla. In addition lichen specimens were exposed to long-wave UV from an Ultraviolot lamp (360 mm) to observe fluorescence. Some lichen species were identified by extensive matching with correctly identified specimens deposited at the National Herbarium, National Botanic Gardens, Peradeniya

Preservation

Lichens were preserved in packets by oven drying at 60 C^0 for six hours. Each specimen was transferred to a new envelope made out of ordinary photocopying paper. Fragile specimens were mounted on pieces of Bristol board before putting them into envelopes. Information such as the name, family, site, altitude, tree species, recorders' names and date of collection were reordered on the envelope. The completed collection is deposited in the Botany laboratory, Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Polgolla.

RESULTS

The survey revealed that there are about 50 lichen species belonging to 19 families and 32 genera in the Kandy municipal region. Of these species 33 (66%) were crustose lichens, 11 (22%) foliose, 4 (8%) placcodioid and the remaining 4% were fruticose and squamulose lichens. Taxa with *Trebouxia* as a photobiont occurred in about 23 (46%) taxa, *Trentepohlia* occurred in about 20 (40%) taxa and 6 (12%) taxa were with cyanobacteria

(Table 1). Some of the sterile crustose species were not identified. Some foliose and placcodioid species were not identified due to the lack of sufficient literature on them. Hence, the percentage of identified crustose and foliose species was 60-70%. One fruticose species, *Ramalina farinacea* and one squamulose genus, *Phyllopsora*, were recorded on Palm trees (*Borassus flabellifer*) and on very old (about hundred years) *Canarium vulgare* trees respectively, in the National Botanic Gardens, Peradeniya.

Crustose taxa were predominant on trees that were found in more shady areas at Walkerawatta forest stand and also on old *C. vulgare* trees in the National Botanic Gardens, Peradeniya. Nevertheless, most of the foliose and placcodioid taxa were common on trunks of trees along roadsides with exposure to direct sunlight irrespective of the nature of their barks, whether they were smooth or rough. Mango (*Mangifera indica*) and jak (*Artocarpus heterophyllus*), found in many of the home gardens, were rich in foliose and placcodioid lichens such as *Parmotrema tinctorum, Dirinaria consimilis* and *Pyxine consocians* belonging to the families Parmeliaceae and Physciaceae. Moreover, these species were commonly found on trees that were found along roadsides and the tree avenues in the National Botanic Gardens, Peradeniya and occasionally in open areas of the Walkerawatta forest stand.

Lichens with cyanobacterial photobionts such as *Leptogium* and *Collema* were mostly found on trees growing in shady moisture-saturated environments in many of the sites. Nevertheless, they also occurred on open palm trees and some other trees along avenues at the National Botanic Gardens, Peradeniya. Some trees found along heavily polluted roadsides such as the "lake round" in the Kandy town were completely devoid of lichens. However, *Pyxine consocians, Pyxine* sp. (yellow coloured) and *Dirinaria consimilis* occurred occasionally on some trees such as *Roystonia regia, Myroxylon balsamum* and *Mangifera indica* in the Kandy town. The most frequently encountered species of lichens in many of the sites of the Kandy Municipal Region were *Pertusaria pertusa, Pyxine consocians, Dirinaria consimilis, Lecanora* sp.$_1$, *Parmotrema tinctorum, Leptogium* sp., *Buellia* sp. and *Chrysothrix candelaris.*

DISCUSSION

Factors influencing the distribution of epiphytic lichens were discussed by Hawksworth and Rose (1977). These include macroclimatic factors of rainfall and temperature; microclimatic factors such as shade, humidity and temperature; site factors such as age and composition of the forest, management and pollution effects; and substrate characteristics of tree species, bark type, surface corrugation and age, moisture retention, pH and nutrient status. The present study suggests that the distribution of lichen species in and around the Kandy municipal region is influenced by many of the above factors.

The sensitivity of the photobiont to the conditions of the environment, specially temperature and moisture, is a critical factor in the survival of the lichen-algal symbiosis (Wolseley and Aguirre- Hudson, 1997b). The presence of different photobionts in sampled sites illustrates this (Table 1). Lichens with *Trebouxia* as photobiont include lichen families Parmeliaceae, Physciaceae, Lecanoraceae and Pertusariaceae, and these families are more frequent in more xerophytic habitats where relative humidity is low such as on trees along

Table 1

Lichen species recorded in all sites of the Kandy municipal region.

Family	Species	Life form	Sites occurred 1 2 3 4 5 6 7 8 9 10
Arthoniaceae	*Arthonia* cf. *tumidula*[a] Ach.	Crustose	+ +
	Arthonia sp[a]. Ach.	Crustose	+ + + + +
Bacidiaceae	*Phyllopsora* Müll. Arg sp[b].	Squamulose	+
Chrysotricaceae	*Chrysothrix candelaris*[b] (L) Laundon	Crustose	+ + + + + + + + +
Coccocarpiaceae	*Coccocarpia palmicola*[c] (Sprenge.) Arv. & D. Galloway	Foliose	+ + + + + + +
	Coccocarpia pers. sp[c].	Foliose	+
Collemataceae	*Collema* Wigg. sp[c].	Foliose	+ + + + + +
	Leptogium denticulatum[c] (Rabenh.) Körb.	Foliose	+
	Leptogium (Ach.) Gray sp[c].	Foliose	+ + + + + + + +
	Physma byrsaeum[c] (Ach.) Tuck.	Foliose	+
Graphidaceae	*Graphina balbisii*[a] (Fèe) Müll. Arg	Crustose	+ + + + + +
	Graphina fissofurcata[a] (Leight.) Müll. Arg	Crustose	+ + + +
	Graphina poitaei[a] (Fèe) Müll. Arg.	Crustose	+ + + + + + +
	Graphis anguilliformis[a] Tayl	Crustose	+ + + +
	Gyrostomum scypuliferum[a] Fèe	Crustose	+ + + + + +
	Phaeographina caesioradians[a] (Leight.) Red.	Crustose	+ + +
	Phaeographina contexta[a] (Pers) Müll. Arg.	Crustose	+ + + + + + + + +
Lecanactidaceae	*Lecanactis* sp.[a] (Nyl.)	Crustose	+ +
Lecanoralase	*Lecanora atra*[b] (Huds.) Ach.	Crustose	+ + + + +
	Lecanora subfusca[b] Ach.	Crustose	+ +
	Lecanora sp.$_1$[b]	Crustose	+ + + + + + + + +
	Lecanora sp.$_2$[b]	Crustose	+ + + + + + + + +
	Lecanora sp.$_3$[b]	Crustose	+ + + + + +
Parmeliaceae	*Parmotrema crinita*[b] (Arch.) M.Choisy	Foliose	+ + + +
	Parmotrema nilgherrense[b] (Nyl.) Hale	Foliose	+ + + + +
	Parmotrema tinctorum[b] (Despr. Nyl.) Hale	Foliose	+ + + + + + + + + +
	Rimelia reticulata[b] (Taylor) Hale & A. Flet.	Foliose	+
Pertusariaceae	*Pertusaria pertusa*[b] (Weigel.) Tuck.	Crustose	+ + + + + + +
	Pertusaria DC sp.[b]	Crustose	+ + + + + +
Physciaceae	*Buellia disciformis*[b] (Fr.) Mudd.	Crustose	+ + + + + + +
	Buellia sp.$_1$[b]	Crustose	+ + + + + +
	Buellia sp.$_2$[b]	Crustose	+ + + + + + +
	Dirinaria consimilis[b] (Stirton) Awas.	Placcodioid	+ + + + + + + + + + +
	Heterodermia Trevis. sp.[b]	Foliose	+ + +
	Physcia (Schreber) Michaux sp.[b]	Placcodioid	+ + + +
	Pyxine coccifera[b] (Fèe) Nyl.	Placcodioid	+
	Pyxine consocians[b] Vain	Placcodioid	+ + + + + + + + + + +
	Pyxine Fr. sp. (yellow coloured)	Placcodioid	+ + + +
Pyrenulaceae	*Anthracothecium duplicans*[a] (Eschw.) R.C. Harris	Crustose	+ + + +
	Pyrenula Ach. sp.[a]	Crustose	+ + + + + + + +
Ramalinaceae	*Ramalina farinacea*[b] (L.) Ach.	Fruticose	+
Roccellaceae	*Schismatomma gemmatum*[b] Zahlbr.	Crustose	+ +
Teloschistaceae	*Caloplacca* sp.[a] Nyl. (Leight.)	Crustose	+ +
Thelotremataceae	*Myriotrema compunctum*[a] (Ach.) Hale	Crustose	+
	Myriotrema glaucophaenum[a] (Krempelh.) Hale	Crustose	+
	Ocellularia sp.[a]	Crustose	+
Trapaliaceae	Unknown	Crustose	+
Trichotheliaceae	*Porina innata*[a] (Nyl.) Müll.. Arg	Crustose	+ + + + + + +
	Porina sp.[a] (Ach.)	Crustose	+ + + + +
Trypetheliaceae	*Trypethelium tropicum*[a] Müll. Arg	Crustose	+ + + +
Uncertain	green crust[a]	Crustose	+ + + + + + + + + +

(1=National Botanic Gardens, Peradeniya, 2= Walkerawatta, 3=Getambe, 4=Dodamwela, 5=Bahirawakande, 6=Mahaiyawa, 7=Asgiriya, 8=Aruppola, 9=Lewella, 10=Kandy town. a=*Trentepohlia* as the photobiont, b=*Trebouxia* and related genera, C=Cyanobacteria, +=Presence of taxa in sites)

roadsides exposed to direct sunlight. These families are also frequent in disturbed and degraded areas at all altitudes (Wolseley and Aguirre-Hudson, 1997b). Furthermore, lichens with *Trentepohlia* as photobiont in families Arthoniaceae, Pyrenulaceae, Thelotremataceae and Trichotheliaceae, are more frequent in moist evergreen forests at all altitudes and areas where atmospheric humidity is high (Wolseley and Aguirre-Hudson, 1997b). In the present study taxa with *Trentepohlia* were restricted to moisture-saturated and shady environments in the National Botanic Gardens, Peradeniya and Walkerawatta forest stand. Hence the presence of high numbers of trebouxioid lichens and the restricted occurrence of trentepohlioid taxa in the Kandy Municipal region suggest that this is a relatively disturbed area.

Although lichen taxa with cyanobacteria are expected to be more common in the environments where moisture and relative humidity are high, species of *Collema* and *Leptogium* were found in many sites surveyed in the present study irrespective of the shade condition. Thalli of *Collema* are gelatinous and appear to be able to tolerate long dry periods and absorb water rapidly in damp conditions. Some species such as *Pyxine consocians* and *Dirinaria consimilis* were frequently found on the bark of trees along heavily polluted roadsides and other areas as well. These species are often found to be tolerant of atmospheric pollutants such as oxides of sulphur and heavy metals and used as environmental bio-indicators to assess air quality (Wolseley and Aguirre-Hudson, 1997a). As such their predominant presence in almost all the sites in the present study indicate that these areas are quite polluted.

Alston (1932) recorded some fruticose species such as *Usnea articulata*, *Cladonia* sp. and *Ramalina farinacea* as common in Kandy District (Alston, 1932). It has been demonstrated that these species are very susceptible to atmospheric pollution (Wolseley and Aguirre-Hudson, 1997a). However, in the present study *Usnea articulata* and *Cladonia* sp. were not found and *Ramalina farinacea* was recorded only on palm trees at the National Botanical Gardens. This suggests that they may have been lost most probably due to changes in the environment. Also their presence in the adjacent areas to the Kandy municipality that fall within the Kandy district has to be studied. Hence, the present list is not a complete list of lichens in the Kandy district and also it might account approximately for only about 60-70% of the total lichen flora present in the Kandy municipality.

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