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Status of the red-listed lichen *Lobaria pulmonaria* on the Åland Islands, SW Finland

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The population of *Lobaria pulmonaria* (tree lungwort) has been regarded as a relict on the Åland Islands (Ahvenanmaa). Fresh findings of apothecia imply the opposite. Censusing of 13 localities with more than 200 trees has shown that the lichen predominantly grows along the NW–NE sector of tree trunks with porous bark in easterly slopes. In light and dry wooded meadows the lichen has a lower vitality than in undisturbed, shady and moist forests. Most thalli occurred on *Acer platanoides*, *Fraxinus excelsior* and *Populus tremula*, even though *Quercus robur*, *Tilia cordata* and some other species were also represented. About half of the trees were found in Höckböle and it was also there and at Ingersholma that we found apothecia.

Key words: apothecia, conservation, habitat ecology, *Lobaria pulmonaria*, reproduction, wooded meadows

Introduction

The epiphytic lichen *Lobaria pulmonaria* (tree lungwort) in the order Lecanorales, has both vegetative and sexual reproduction. Its vegetative reproduction takes place by fragmentation and/or dispersal of soredia and/or isidia. Fragmentation is the simplest way of propagation: a fragment establishes itself as a new individual at some other place. If this process is to succeed, the period of establishment must be moist (Gauslaa *et al*. 2006). Soredia consist of algal cells enclosed in fungal hyphae. The diameter of the soredia is 20–50 μm (Büdel & Scheidegger 1996), and they are dispersed by insects, water and wind mainly within a radius of 25 m (Öckinger *et al*. 2005). Young specimens grow before they start producing soredia as the reproductive efforts strongly hamper their growth (Gauslaa 2006). The sexual reproduction takes place by apothecia, producing fungal spores with a size of 23–29 × 6–10 μm (Denison 2003). Since the fungal spores are much smaller than the soredia they may disperse at longer distances. Despite this, sexual reproduction is presumably less common, because a fungal spore must find the right kind of algal cell to form a new lichen.

A prerequisite for the production of apothecia is that the thallus of the lichen has reached a certain minimum size, since the production of apothecia also reduces growth (Gauslaa 2006). Apothecia persist and release spores for a year

after formation (Denison 2003), but they do not occur in all populations. Apothecia were observed in SW Finland in 1921 in the archipelago of Turku (Regio Aboensis, Turunmaa; Bruun 2000). Two latter finds were made in Espoo, west of Helsinki, in 1934 (Leg. M. Puolanne) and 1950 (Leg. E. Häyrén). The occurrence of apothecia suggests high genetic diversity (Zoller *et al*. 1999). Sexual reproduction does not take place if the whole lichen population consists of a single genotype.

In the beginning of the 20th century, *L. pulmonaria* was widespread over large areas of Europe. Today it is red-listed and considered sterile in many areas. Discharge of sulphur dioxide (SO_2) is considered one of the reasons for the decline (Öckinger *et al*. 2005).

Light is beneficial for growth with a contemporary risk of photoinhibitory damage (Gauslaa *et al*. 2006). Hydration in daylight is necessary for growth (Renhorn *et al*. 1997). The ideal environment for *L. pulmonaria* is an old open-shade forest with regular precipitation (Gauslaa *et al*. 2006). Thinning of the forest may negatively affect the light and moisture conditions. *Lobaria pulmonaria* does best on old trees such as maple (*Acer platanoides*), ash (*Fraxinus excelsior*) and aspen (*Populus tremula*) with a bark pH above 5. *Lobaria pulmonaria* is assumed to be a signal species of long ecological continuity. The habitat requirements combined with a low ability to disperse make landscape fragmentation a serious threat to the species.

A healthy population of *L. pulmonaria* on the Åland Islands apparently occurred in the middle of the 19th century. In 1997 Bruun (2000) found *L. pulmonaria* on only 52 trees distributed at nine sites and noted that the large thalli were old. A study made in Småland, Sweden, in 1992–2001 showed that *L. pulmonaria* colonized new trees during this period. In addition apothecia were found in 2001 (Öckinger *et al*. 2005). *Lobaria pulmonaria* is protected as a "species with special need of protection" in the Åland Islands (Hæggström & Koistinen 1999) but nationally it probably belongs to threat category LC (Least Concern) as it is not mentioned in Rassi *et al*. (2001). In Sweden and Estonia, it is regarded as NT (Near Threatened) (Gärdenfors 2005, Randlane *et al*. 2008).

The purpose of our study is to assess the status of *L. pulmonaria* on the Åland Islands (SW Finland) today.

Material and methods

We visited all the localities visited by Bruun (2000) during the period November 2006–April 2007. In addition, we visited Ingersholma, mentioned but not visited by Bruun (2000) and three other places (Järsö, Skabbö and Gottby), which were previously unknown. On each tree with *L. pulmonaria* we recorded the species of the host-tree and its diameter, the lowest and highest level of the thalli, exposition to one of the eight main aspects, diameter of host-tree and the condition of the thalli as well as occurrence of soralia och apothecia. We also recorded the type of habitat as well as the ground vegetation.

The localities visited by us were Höckböle, Toböle, Skag, Bergö, Skabbö, Prästgårdsnäset, Mangelbo, Gottby, Ramsholmen, Järsö, Marsö, Apalholmen and Ingersholma (Fig. 1).

Results

We found *L. pulmonaria* on more than 200 trees. The dominant host-trees were maple (*Acer platanoides*), ash (*Fraxinus excelsior*), aspen (*Populus tremula*) and oak (*Quercus robur*) with some lime (*Tilia cordata*), elm (*Ulmus glabra*), goat willow (*Salix caprea*) and rowan (*Sorbus aucuparia*). In addition, it was also found on one mountain currant (*Ribes alpinum*), and on some dead junipers (*Juniperus communis*) and on decaying logs and tree trunks as well as on rocks and stones. The diameter of the tree trunks varied between 6–60 cm but the mountain currant and the junipers were thinner (Table 1).

The forest floor of the localities was mostly covered by e.g. *Anemone nemorosa*, *Dryopteris filix-mas*, *Galium odoratum*, *Hepatica nobilis*, *Laserpitium latifolium*, *Lonicera xylosteum, Ribes alpinum* and a variety of graminoids and mosses. In addition, many other lichens, e.g. *Usnea* spp., *Ramalina* spp. and *Peltigera horizontalis* were found. In the Höckböle Nature reserve, there were more lichen-bearing trees in

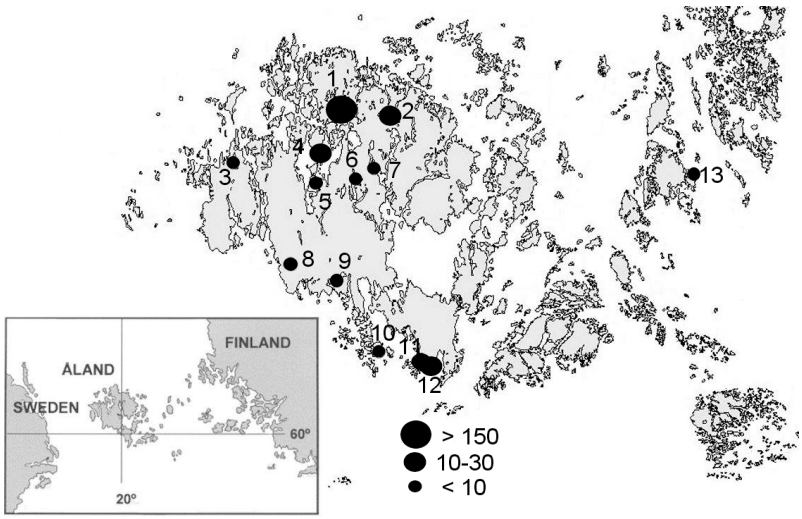

Fig. 1. Map of the area. The size of the dot refers to the number of trees with *Lobaria pulmonaria*. 1: Höckböle, 2: Toböle, 3: Skag, 4: Bergö, 5: Skabbö, 6: Prästgårdsnäset, 7: Mangelbo, 8: Gottby, 9: Ramsholmen, 10: Järsö, 11: Marsö, 12: Apalholmen, 13: Ingersholma.

the unmanaged parts than in the parts that had been cleared 14 years ago.

The thalli of *L. pulmonaria* were found mainly on northerly aspects, with about 60% to N or NE and an additional 10% to NW (Fig. 2), and from ground level up to about 6.5 m (Table 1). After wind spells, many loose thalli were found on the ground or stuck in the bush vegetation. The condition of the thalli varied. In some places they were melanic but healthy, but with no clear signs of lobal growth (e.g. Prästgårdsnäset, Järsö), while in other places they were lush green (e.g. Apalholm, Höckböle) (Fig. 3). Soralia were found on about 80% of the thalli. In Höckböle and Ingersholma, about 25% of the trees had thalli with apothecia during the period November–March.

Most localities were on easterly hill slopes in present or former wooded meadows (Hæggström 1983). The most odd locality was on a solitary goat willow, surrounded by a young pine forest plantation, which had been left on a clear cut area about 15 years ago.

Discussion

About one third of the host-trees were maples. This is in accordance with the situation in a studied area in Switzerland, where 30.8% of the observations of *L. pulmonaria* were on sycamore (*Acer pseudoplatanus*; Stofer 2008, Stofer *et al.* 2008). The rest of our observations are mainly from ash, oak and aspen, i.e. rich-bark trees with the exception for oak. The reason for this might be that maples and oaks were younger than ash and aspen which usually had a larger circumference. This suggests that the properties of the substratum is more important than the circumference of the tree. The lichen grows on some dead junipers but on no single living juniper, as the wood becomes more porous after the decaying

Table 1. The most common tree species and their diameter ± SD (range) with *Lobaria pulmonaria*, and the lowest and highest location of the lichen thalli on each tree species.

	Tree diameter (cm)	Lowest (m)	Highest (m)
Fraxinus excelsior (*n* = 23)	31.1 ± 14.9 (11–59)	1.1 ± 1.1 (0–3.1)	2.6 ± 2.7 (1–6.5)
Populus tremula (*n* = 23)	33.6 ± 10.5 (18–58)	0.3 ± 0.3 (0–0.9)	2.4 ± 1.3 (0.7–5.3)
Quercus robur (*n* = 22)	24.5 ± 9.2 (12–46)	0.6 ± 0.6 (0–1.8)	2.6 ± 1.6 (0.4–6.6)
Tilia cordata (*n* = 21)	43.8 ± 12.3 (28–70)	0.6 ± 0.4 (0.1–1.2)	1.0 ± 0.6 (0.5–3)
Acer platanoides (*n* = 58)	26.3 ± 9.6 (6–46)	0.4 ± 0.6 (0–2)	3 ± 1.6 (0.5–6.6)

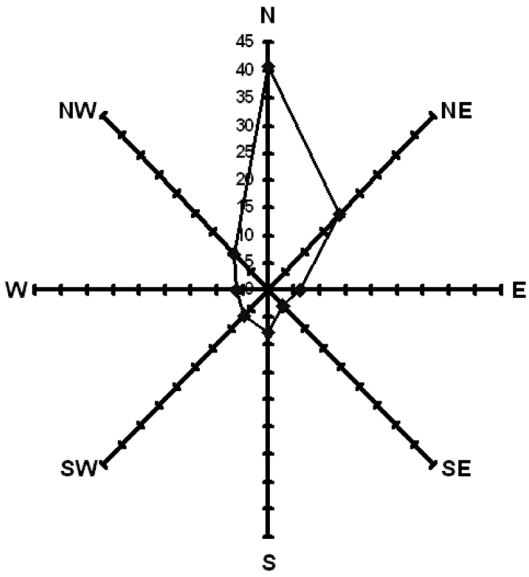

Fig. 2. Percentage aspects of the *Lobaria*-thalli. *n* = 195.

process has started. The occurrence of *L. pulmonaria* on rocks is atypical but is known from the northern parts of the country.

The main aspects of NW–NE for the thalli may reflect the need for some shade from the strongest sunlight in the middle of the day. The afternoon sun may also be strong but is avoided on east-facing slopes. This is in accordance with Gauslaa *et al*. (2001) who in transplant experiments found that photosynthesis in *L. pulmonaria* exposed to the sun is reduced in all directions but north.

Bruun (2000) regarded the *L. pulmonaria* population of the Åland Islands as a relict occurrence and possibly this is true for Bergö, Prästgårdsnäset, Gottby, Ramsholmen and Järsö. It is hard to determine whether the melanin in the cortex provides adequate shelter from direct sunlight, but the occurrences of soralia and some young thalli suggest that the lichen is vital under such environmental conditions. Most localities were close to water, which may offer a higher humidity in general and, in summer a thick canopy gives shelter to the sun. Contrary to most of the other localities, Höckböle, Apalholm and Ingersholma have a long ecological continuity and a high lichen diversity.

The high incidence of wind-blown thalli shows that *L. pulmonaria* is sensitive to strong winds and does best in sheltered localities, but

Fig. 3. Maples with lush growth of *Lobaria pulmonaria*. Photo: Ralf Carlsson.

on the other hand, wind may also be an aid in dispersal. It may also reflect the annual production under stable conditions.

The larger number (tenfold increase) of trees with lichens in Höckböle in 2006–2007 than in 1997 may be a sign of an increasing population size, but another likely explanation is that they were overlooked by Bruun (2000). However, the small *Lobaria* on young twigs of *Ribes alpinum*, as well as occurrences on thin tree trunks, may imply that the lichen has dispersed and grown during the last years.

After many years without recorded apothecia there were more than twenty thalli with apothecia in 2006–2007. It is impossible to tell whether this is a result of better air quality or depends on the observer, but Öckinger *et al*. (2005) also suggested that the production of apothecia increased during the first years of the 21th century.

In Åland, *L. pulmonaria*, which is often claimed to live in old forests, seems to prefer areas affected by man (e.g. Gu *et al*. 2001), i.e.

wooded meadows. Man-made habitats may have longer ecological continuity than forests (Hæggström 1983).

Conclusions and future prospects

The *L. pulmonaria* population of the Åland Islands is viable and developed apothecia in two areas. However, one must keep in mind that not much would be needed to destroy it. The pros and cons will have to be weighed up carefully between cultural inheritance and biodiversity. Maintaining wooded meadows increases the general biodiversity but may harm a red-listed species like *L. pulmonaria* if too many trees are cut. Letting the forests be overgrown is, on the other hand, also a threat. Landowners should be informed about *L. pulmonaria* in order to prevent the habitats from being destroyed.

A thorough investigation, covering the whole landscape would give a better status of *L. pulmonaria*. It would also be necessary to investigate more isolated islands of the archipelago. The whole *L. pulmonaria* population of the Åland Islands may be regarded as a metapopulation (Gu *et al*. 2001), where the investigated areas may be seen as subpopulations. The forests are presumably full of aspens and goat willows that are suitable as substrates to *L. pulmonaria*. Assuming that large parts of the Åland Islands fulfill the habitat demands, it is possible that previously unknown localities occur. A photographic documentation of known colonies would also facilitate future studies, giving an opportunity to compare and follow the development.

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