THE GROWTH RATE OF *CLADONIA RANGIFERINA* AND *C. MITIS* IN RELATION TO FOREST CHARACTERISTICS IN NORTHEASTERN FINLAND.

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Abstract: The growth rate of *Cladonia rangiferina* and *C. mitis* was studied in Kuusamo, northeastern Finland, where they share more than 90 percent of the total lichen biomass. The material was collected from 5 pine forests of different ages in *Calluna-Cladina* heaths.

The length growth rate of *C. rangiferina* varied by site from 3.9 to 4.3 mm·yr $^{-1}$ and that of *C. mitis* from 3.0 to 3.5 mm·yr^{-1} *C. rangiferina* achieved the fastest growth in a younger (60 years) shadowy forest; growth was slowest in a clear-felled area and in an old (180 years), already thinned forest. *C. mitis* grew fastest in a site with young (10 years old) pine plants and slowest in a younger shadowy site.

The results do not support suggestions that clear-felling itself might negatively influence the growth of lichens. However, it is important also from the point of view of range management to create a new forest as soon as possible, since both species studied here grew faster in young forests than in clear-felled areas.

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Yhteenveto: Harmaaporonjäkälän (*Cladonia rangiferina*) ja mietoporonjäkälän (*Cladonia mitis*) kasvunopeutta tutkittiin Kuusamossa. Aineisto kerättiin 5 puustoltaan eri-ikäiseltä jäkäläkankaalta.

Harmaaporonjäkälä kasvoi pituutta keskimäärin 3.9 - 4.3 mm/v ja mietoporonjäkälä 3.0 - 3.5 mm/v kasvupaikasta riippuen. Harmaaporonjäkälän kasvu oli nopeinta nuorehkossa (60 v) tiheässä metsässä, hitainta paljaaksihakkuulla ja vanhassa (180 v), jo harventuneessa metsässä. Mietoporonjäkälä kasvoi nopeimmin 90 cm:n taimikossa ja hitaimmin varjoisimmalla kasvupaikalla.

Tulosten perusteella on vaikea yhtyä käsitykseen, että paljaaksihakkuu sinänsä vähentää poronjäkälien kasvunopeutta. Myös poronhoidon kannalta on kuitenkin tärkeää, että uusi metsä saadaan aikaan mahdollisimman nopeasti, sillä molemmat lajit kasvavat nopeimmin eri-ikäisissä nuorissa metsissä.

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INTRODUCTION

About 75 percent of the present population of Finnish semidomestic reindeer, totalling approximately 180 000 over - 1 year - old animals, confine themselves the year around to the coniferous forest belt, the area which is also used increasingly for wood production. Most silvicultural practices, including, since the early 1950's, clear-felling, prescribed burning and later also ploughing of the reforestation area (see Pohtila 1977), are considered more or less detrimental to the winter ranges of reindeer.

It is shown, for example, that in dry and sub-dry sites clear-felling reduces remarkably the amount of reindeer lichens (*Cladonia* ssp.) (Eriksson 1976, Helle & Saastamoinen 1983), the chief determinant for the carrying capacity of reindeer ranges in northern Finland (Helle & Säntti 1982). The reduction in lichen biomass is caused by the mechanical destruction of heavy forest harvesters as well as by residues from felling covering the ground. In addition, it is suggested that changes in micro-climate reported by Odin & Perttu (1966) and Odin (1969) in clear-felled areas, may influence the growth rate of reindeer lichens negatively (e.g. Kärenlampi 1973, Eriksson 1975).

The present paper reports the growth rate of *Cladonia rangiferina* and *C. mitis* in dry pine forests of different ages in northeastern Finland. There, as well as elsewhere in the central and southern part of the Finnish reindeer management area, these two species share the greatest

Table 1. The forest characteristics of the study sites.

Site	Age,yr	Trees/ha	Development class[1]	Crown canopy, %	Forest type
I	0	500	0	0	*Calluna - Cladina*
II	10	7000	1	20	*Calluna - Cladina*
III	30	1600	2	30	*Calluna - Cladina*
IV	60	1100[2]	3	70	*Empetrum - Myrtillus - Cladina*
V	180	500	6	15	*Calluna - Cladina*

1) Development classes:
0 = Open area (just after clear-felling)
2 = Small seedling stand (plants <2 m)
3 = Seedling or sapling stand (plants >2 m)
4 = (Thinning stand)
5 = (Seed tree stand)
6 = Mature stand (old, already thinned forest)

2) In natural state, not thinned

proportion of the total lichen biomass (Sulkava & Helle 1975, Mattila 1981).

MATERIAL AND METHODS

The study was carried out in the herding association of Alakitka situated in Kuusamo, northeastern Finland. The area belongs to the northboreal section of the boreal coniferous forest zone (Ahti & al. 1968). The yearly mean temperature is about 0°C and the annual accumulated temperature (threshold value + 5°C) is about 820 d.d. The period of permanent snow lasts normally from the end of October to the end of May. The precipitation between June and September is about 260 mm.

The material was collected from 5 sites of different ages situated in the valley of Oulanka River. The main characteristics of these sites are given in Table 1.

In mid May 1982, just after the melting of the snow and just before the onset of a new growing season a great number of *C. rangiferina* and *C. mitis* were collected from each site. For both species the age of 52 - 60 randomly selected individuals per site was determined and the length measured with an accuracy of ± 0.5 mm; however, individuals having signs of interference from grazing or trampling by reindeer were excluded. The linear growth rate was determined by dividing the length of the living part of the podetium by the number of the internodes on it (Andreev 1954).

RESULTS

The linear growth rate of *C. rangiferina* varied by site from 3.9 ± 0.1 to 4.3 ± 0.1. mm-yr^{-1} and that of *C. mitis* from 3.0 ± 0.1 mm-yr^{-1} to 3.5 ± 0.1. mm-yr^{-1} respectively (Table 2). In *C. rangiferina* the growth by length was significantly higher in all sites (t - test, $p<0.001$).

Figs 1 and 2 present the growth rate by length of both species in relation to the crown canopy and development class of the forest. For *C. rangiferina* the greatest growth rate was found in a younger, very dense forest (site IV), where it was about 8 percent higher than in a clear-felled area (I) and in an old, already thinned forest (V). *C. mitis* reached the fastest growth in a reforestation area with 90 cm high pine plants (II); there the growth rate was about 13 percent higher than in the densest forest (IV) with the lowest growth rate.

DISCUSSION

The growth rate of reindeer lichens is influenced by several climatological and other environmental factors. Barashkova (1961) observed that *C. rangiferina* grows fastest during moist periods. Kershaw & Rouse (1971) showed explicitly that the net assimilation rate of *C. rangiferina* correlates with the moisture content of the thallus. As poikilohydric organisms the water content of lichens is largely depending on the atmospheric humidity. The strong positive correlation between the relative growth rate and precipitation is shown by Kärenlampi (1971) for various lichen species, e.g. *C. rangiferina* and *C. mitis*. In addition, already Andreev (1954) found that the length of the growing season is of importance for the growth of lichens.

The growth rate for length of *C. rangiferina* found in this study is approximately of the same magnitude as in other relatively continental taiga and tundra regions with short growing season (e.g. Andreev 1954, Scotter 1963), but figures clearly below that found in more maritime regions with longer summers, e.g. Newfoundland (Ahti 1959), Nome Peninsula, Alaska (Pegau 1968) and southern Finland (Vasander 1981). In *C. mitis* the observed growth rate is somewhat lower than

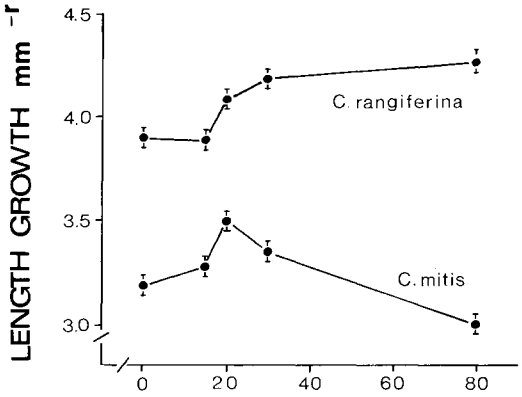

Fig. 1. The linear growth rate (mean ± S.E.) of *Cladonia rangiferina* and *C. mitis* in relation to crown canopy.

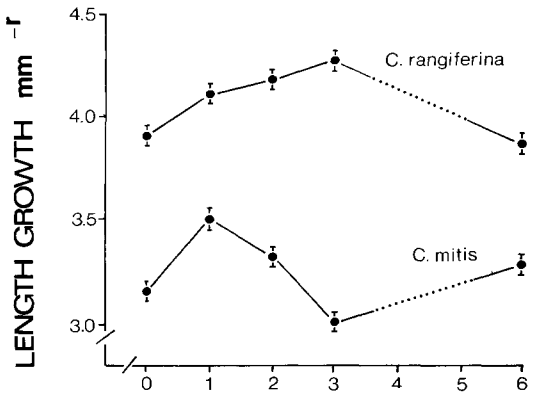

Fig. 2. The linear growth rate (mean ± S.E.) of *Cladonia rangiferina* and *C. mitis* in relation to the development class. The development classes are defined in Table 1.

reported by Scotter (1963) in black spruce forests in northern Canada.

The growth rates of both species were influenced by the forest characteristics affecting apparently the rate of evaporation, illumination and surface temperature. The present results agree well with the earlier observations. It is known that *C. rangiferina* in Finland prefers more shadowy and fresher sites than *C. mitis* and *C. stellaris* (e.g. Kujala 1926, Ahti 1961). Tegler & Kershaw (1980) showed in low arctic Canada that the net assimilation rate of *C. rangiferina* drops drastically when the temperature exceeds + 35°C; therefore *C. rangiferina* was restricted to the shade of *Ledum* shrubs. *C. mitis*, on the contrary, is highly photophilous and xerophilous (Ahti 1961). According the present results, *C. mitis* enjoyed the best growing conditions in a site covered by small pine plants. There light is still available in abundance, but rate of evaporation influencing the moisture content of the thallus is obviously lower than in a clear-felled area.

Because of the radial growth, the weight of an individual grows relatively faster than the length (Kärenlampi 1971). In the study area, the average age of the lichens is only about 5 years due to very hard grazing pressure. It appears from the estimated weights of 5 year old individuals (Helle, unpubl.) that in site IV *C. rangiferina* was about 22 percent heavier than in sites I and V and *C. mitis* in site II about 25 percent heavier than in site IV (c.f. Table 2).

What conclusions can be drawn from the results as regards the relations between the harvesting policy of the forest and reasonable management of the lichen ranges?

First they show that in our study area clear-felling has no significant effect on the growth rate of

Table 2. The length growth rate (x ± S. E.) of *Cladonia rangiferina* and *C. mitis* in different sites. The number of individuals measured in parentheses.

Site	Length growth mm-yr^{-1}	
	C. rangiferina	*C. mitis*
I	3.9 ± 0.1 (52)	3.2 ± 0.1 (60)
II	4.1 ± 0.1 (60)	3.5 ± 0.1 (60)
III	4.2 ± 0.1 (59)	3.4 ± 0.1 (60)
IV	4.3 ± 0.1 (56)	3.0 ± 0.1 (60)
V	3.9 ± 0.1 (59)	3.3 ± 0.1 (60)

lichens. Obviously, micro-climatical conditions important for the growth of lichens, are in an old, already thinned pine forest quite similar to those prevailing in a clear-felled area. However, because the shade provided by pine plants increases the growth of both species studied here, a rapid reforestation of a clear-felled area is also important from the view point of reindeer husbandry. The optimal density of older forests still growing is difficult to determine, since the ecological requirements of *C. rangiferina* and *C. mitis* are different. In addition, it must be taken into account that forests providing microclimatically the optimal growing conditions are not necessarily the same as those where a given species reaches the maximum abundance in terms of percent cover or biomass. This concerns especially *C. rangiferina*, whose biomass is, in spite of rapid growth, quite low in the densest pine forests because of hard competition with *Pleurozium schreberi*, which prefers moist and shadowy sites (Ahti 1961, Helle, Aspi & Tarvainen, unpublished).

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