The effects of stand characteristics on reindeer lichens and range use by semi-domesticated reindeer

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Abstract: The study was carried out in Kuusamo (66°15'N, 29°05'E) and Inari (68°30'N, 28°15'E), northern Finland, where 24 and 22 Scots pine stands were studied respectively. Clear-cutting (logging residue) caused a decline in lichen biomass for some few years, but otherwise the age of the stand had no effect upon lichen biomass. Instead, a positive correlation was found between litter/logging residue and the mean height of lichens; in Kuusamo, logging residue decreased significantly with the age of the stand. Grazing pressure in terms of fecal group density increased with the age of the stand. The preference of old forests came visible also as a lower mean height of lichens, which eliminates the possibility that the preference of old forests is associated only to the use of arboreal lichens. In Inari, grazing pressure sharply increased after the stand had reached the age of 100 years despite scarce litter/logging residue and fair lichen ranges in younger forests; there prevailed a negative correlation between stand density and grazing pressure. It has been suggested that there might be three main reasons for reindeers preferring old forests: 1) hardening of the snow (because of winds) on clear-cut areas, 2) logging residue preventing digging for the food beneath the snow, and 3) poor visibility in young pine stands (Inari) which might increase predation risk.

Key words: Ecology, forestry

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Introduction

In Fennoscandia, a major proportion of semi-domesticated reindeer (*Rangifer tarandus L.*) confine themselves in winter in coniferous forests where timber is commonplace the main forest product. The impacts of wood production on winter ranges can be described briefly as follows:

1. Clear-cutting on fresh mineral soils adds *Deschampsia flexuosa* improving range conditions in autumn and early winter (Sulkava and Helle, 1975; Helle and Saastamoinen, 1979; Mattila, 1981).
2. Cutting reduces arboreal lichens *(Usneaceae)*, since forests with abundant sources of them are normally older than 100 years (Mattila, 1979); arboreal lichens are used mainly in late winter when ground vegetation is not available to reindeer because of deep or hard snow.
3. Reindeer lichens *(Cladonia ssp.)* are the most

important component in the winter diet of reindeer. However, the opinions on the effects of forestry on lichen biomass and lichen use by reindeer are some what conflicting. Mattila and Helle (1978) and Mattila (1981, 1988) stated that in Finnish reindeer management area there is no significant difference in lichen biomass in young (<70 yrs.) and older forests. On the other hand, there exists evidence that reindeer likely graze in old forests (R. Helle, 1984; Helle and Aspi, 1985). The question on availability of reindeer lichens is coming more important with the reduction of arboreal lichens caused in northern Finland by cuttings and air pollution (Kautto et al., 1986; Mattila, 1988; Helle et al., 1989).

This paper deals with that obvious discrepancy between absolute (total biomass) and relative (biomass available to animals) lichen resources (see Andrewartha and Birch, 1954). Our hypothesis is that forestry practices influence, by altering and modifying stand and site characteristics, habitat selection of reindeer and thus effect on the actual lichen use. It claimes that the impacts of forestry can not be evaluated only on the basis of lichen biomass. The hypothesis was tested by measuring the main characteristics of lichen vegetation and quantifying grazing pressure by reindeer in same areas, and relating them to stand and site characteristics.

Material and methods

Study area

The study was carried out in Kuusamo (66°15'N, 29°05'E) in the herding association of Alakitka and in Inari (68°30'N, 28°15'E) in the herding association of Ivalo. In Kuusamo 24 and in Inari 22 sample areas, located on poor mineral soils (*Calluna-Cladina* type) in pine forests, were studied in 1983 and 1984. The size of the sample areas was 1 ha, and they were selected for the study on the basis of the estimated age of the stand in order to obtain a representative sample from forests of various age.

Sampling

Percent cover of various plant species and litter (including logging residue) was estimated from 15 randomly selected plots each of which 0.25 m^2 in size in each sample area.

The density of the stand and grazing pressure in terms of fecal group density were determined by the method of plotless sampling (e.g. Greig-Smith, 1964; Pielou, 1977), i.e. by measuring the distance from a random point to the nearest item.

From lichens (including *Cladina* species and *Stereocaulon spp.)* the mean height of the living thallus was measured by the accuracy of 1 mm. Lichen biomass was calculated on the basis of percent cover and height of lichens using formulas presented by Mattila (1981).

Density of trees and fecal groups was calculated using Pielou's (1977) formula

$$(1) \qquad \tilde{\lambda} = \frac{n-1}{n} \cdot \frac{1}{\bar{w}}$$

where w is the squared distance ($w = r^2$) from the random point to the nearest item and n is the number of observed values (15 in this case).

The method requires that the items are randomly distributed. The test of randomness was made after Greig-Smith (1964) and it showed that the distribution of trees and fecal groups did not differ significantly from random distribution.

Fecal group density as an index of grazing pressure

One of the basic weaknesses of fecal counting method is that the rate of decomposition of fecals is dependent on soil characteristics and vegetation. Because all the sample areas were situated on the same forest type, this problem might not be serious in this study. That was tested by using a following procedure. The distance from the centre of the sample plot was measured separately to the nearest fresh (< 1 year) and old (> 1 year) fecal group in 16 sample areas in Kuusamo in order to determine the average decomposition time for fecal groups.

If the grazing pressure in a known area is constant, the circle of radius, which contains at least one fresh item, is every year:

(2) $$r_f = \sqrt{1/\lambda}$$

were the Poisson parameter λ denotes the mean number of items per circle of unit radius (see Pielou, 1977). If the fecal groups are observable only one year, then the distance from the random point to an old fecal group is the same as the distance to a fresh group. Generally, if fecal group is observable t years, then distance to an old group is:

(3) $$r_t = \sqrt{1/(t \times \lambda)}$$

Thus the ratio between old and fresh group in the stand is:

(4) $$r_t/r_f = (\sqrt{1/(t \times \lambda)})/(\sqrt{1/\lambda})$$

and the age (t) of the fecal group is found to be:

(5) $$t = 1/(r_t^2/r_f^2)$$

If the sample areas younger than 10 years are excluded, the average time that fecal groups are visible accounts to 4.9 years, and the rate of decomposition is not dependent on the age of the stand (Fig. 1). In young stands (< 10 yrs.) many old but only few fresh fecal groups were found giving seemingly an indication of a very slow rate of decomposition. However, the result is an obvious artefact. Very likely, the abundance of old fecal groups is associated to normal winter feeding behaviour of reindeer: they gather in late winter to logging areas to feed on arboreal lichens from fallen trees (see Helle and Saastamoinen, 1979). Therefore, densities in young forests are obvious over-estimates, which should be taken into account when interpreting the results.

Results

General features of study areas

The means for the main characteristics of the study areas are given in Table 1.

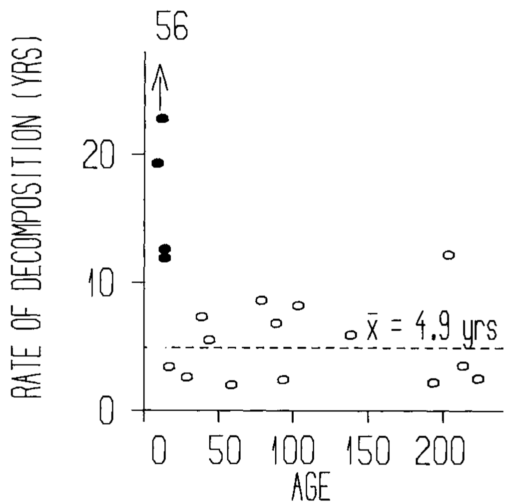

Fig. 1. The rate of decomposition of fecal groups in stands of various age.
● = stands <10 year; o = stands >10 year

The lower percent cover of lichens in Kuusamo is largely a result from heavier grazing pressure. In the late 1970's, the lichen range area per reindeer older than one year (close to animal number of winter herd) amounted in Kuusamo to 19 ha and in Inari to 68 ha. That explains also the lower mean height of lichens as well as the smaller proportion of *Cladonia stellaris* (0.3% vs. 33.7%, calculated from percent cover), whose poor resistence to heavy and frequently repeated grazing is well-known (Ahti, 1961).

Also percent cover of mosses and litter was greater in Kuusamo. Most of litter in young stands was logging residue in both study areas. Material from Kuusamo comprised of younger regeneration areas, which might explain the abundance of logging residue.

Reindeer lichens

The characteristics of lichens were not dependent on the age of the stand in Kuusamo, whilst in Inari the mean height of lichens correlated negatively ($r = -0.521$, $p < 0.05$, $df = 20$) and percent cover positively ($r = 0.445$, $p < 0.05$, with the age of the stand. One should note, however, the drastic decline in lichen biomass in Kuusamo immediately after clearcutting (Fig. 2), when about 60% of the ground was

Table 1. General characteristics (mean ± standard error) of the sample areas in Kuusamo and Inari.

	Kuusamo		Inari	
	$\bar{x} \pm$ S.E.	Range	$\bar{x} \pm$ S.E.	Range
Age of stand, yrs.	76 ± 16	0.5—230	99 ± 12	12—230
Trees per ha	1846 ± 415	140—8554	1521 ± 270	285—5138
Lichens:				
percent cover	24 ± 2	7—41	55 ± 2	38—67
mean height, mm	13.7 ± 0.7	9.3—20.5	22.1 ± 0.7	15.3—27.2
Biomass, kg/ha	232 ± 26	47—452	480 ± 27	137—703
Percent cover of:				
Mosses	10 ± 2	0—47	2 ± 1	0—9
Dwarf shrubs	13 ± 2	6—38	21 ± 2,	8—33
Litter (including logging residue)	15 ± 3	4—60	5 ± 1	0—14

covered by logging residue. The most harmful effects of logging residue seem to be over in some few years, which is obviously associated to dropping-off of needles from the branches. Material from Inari comprised only of older regeneration areas, but a corresponding reduction in lichen biomass just after clear-cutting i expected, because stand densities (and volumes) are quite similar to those in Kuusamo. It is interesting to note that in Inari the observed age-specific trends in mean height and percent cover of lichens counterbalanced each other, because of which lichen biomass was not dependent on the age of the stand.

Percent cover of lichens correlated in Kuusamo with litter/logging residue negatively (r = -0.411, $p < 0.05$, df = 22), but the mean height and biomass were not influenced by stand and

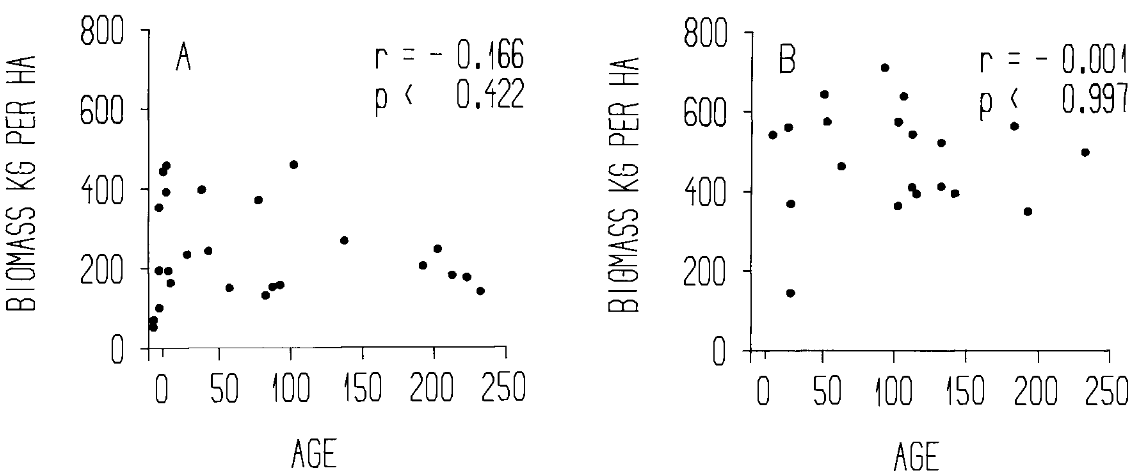

Fig. 2. The age of the stand and lichen biomass in Kuusamo (A) and Inari (B).

range characteristics. In Inari, the mean height of lichens correlated positively with mosses ($r = 0.521$, $p < 0.05$) and dwarf shrubs ($r = 0.423$, $p<0.05$) and lichen biomass with litter/-logging residue ($r = 0.424$, $p<0.05$). A significant negative correlation occurred between percent cover of lichens and litter/logging residue ($r = -0.480$, $p< 0.05$), dwarf shrubs ($r = -0.457$, $p < 0.05$) and mosses ($r = -0.537$, $p<0.05$).

The correlations between percent cover and mean height of lichens and ground vegetation (including litter/logging residue) were studied also at the level of the single sample areas.

In Kuusamo, percent cover of lichens was negatively correlated ($p < 0.05$) with litter logging residue in 8 sample areas, of which 7 were located in stands younger than 15 years. A positive correlation between mean height of lichens and litter/logging residue prevailed in 8 sample areas, from which 7 were in stands younger than 35 years.

In Inari, a negative correlation between percent cover of lichens and litter/logging residue existed in 3 sample areas, from which 2 were located in stands younger than 50 years. The correlation between mean height of lichens and litter/logging residue appeared significandy positive in 5 sample areas without any clear association to the age of the stand. The effects of mosses and dwarf shrubs on the reduction of lichens were occasional.

Distribution of grazing

Fecal group density increased with the age of the stand in both study areas (Fig. 3). It correlated negatively with mean height of lichens in both study areas (Fig. 4), in addition to which a negative association between fecal groups density and litter/logging residue occured in Kuusamo ($r = -0.414$, $p<0.05$, $df = 22$).

The relationship between fecal group density and lichen biomass appeared to be quite similar in both areas (Fig. 5). Especially in Inari, fecal group density remained quite low in young forests despite of fair lichen biomasses; it showed

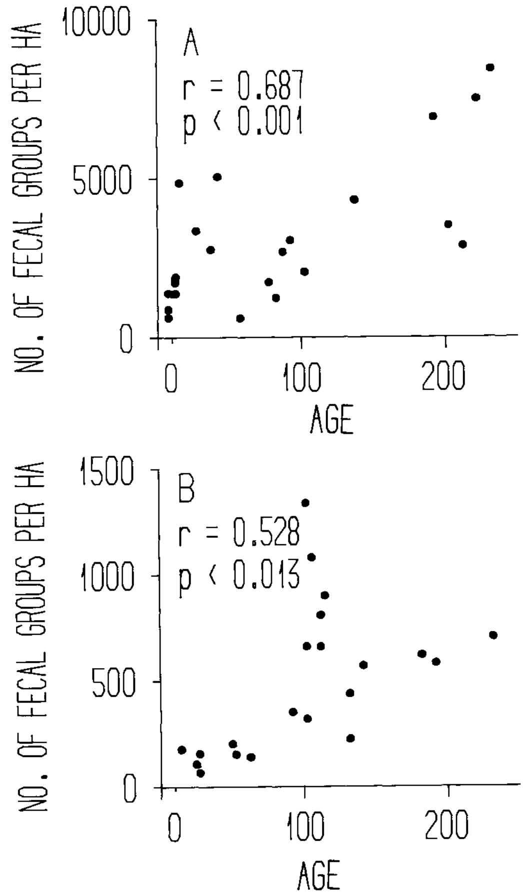

Fig. 3. The relationship between the age of the stand and grazing pressure in Kuusamo (A) and Inari (B).

a clear increase after the stand had reached the age of 100 years. In Inari, a negative correlation was found between stand density and fecal group density (Fig. 6).

Discussion

The behavioral responses of animals to variation in their food resources are commonly described by means of the concept of functional response (Holling, 1959). In several herbivorous mammals, food intake increases linearly or exponentially as the function of plant biomass (Alldeen and Whittaker, 1970, Batzli et al., 1981; Short, 1985; Spalinger et al., 1988). Similar relationship is found also in reindeer in summer (Trudell and White, 1981; 1980, Skogland). In this study (Fig. 5), however, that relationship differed from the theoretical pre-

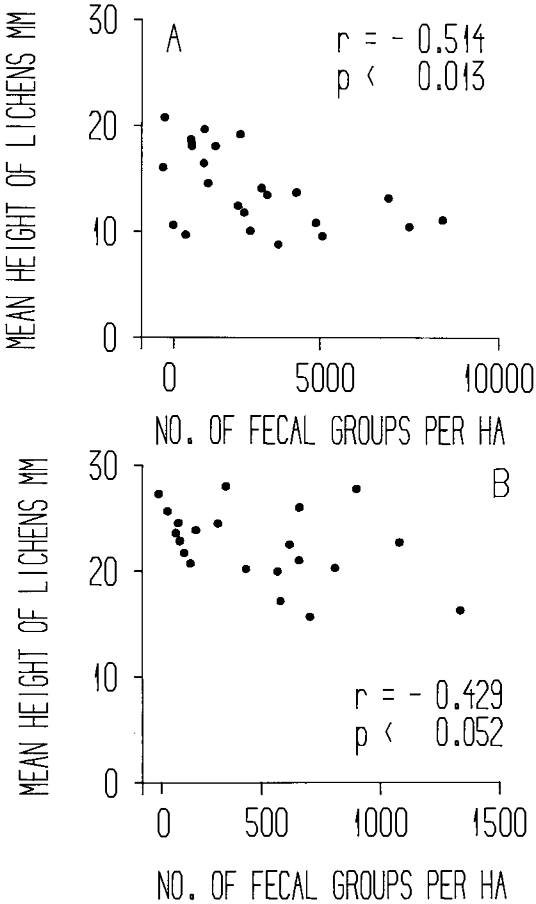

Fig. 4. The relationship between grazing pressure and the mean height of lichens in Kuusamo (A) and Inari (B).

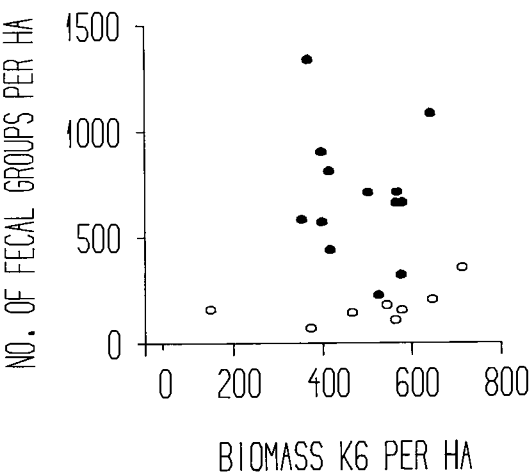

Fig. 5. The relationship between lichen biomass and grazing pressure according to the age of the stand in Inari.
o = stands<100 years; ● = stands>100 years

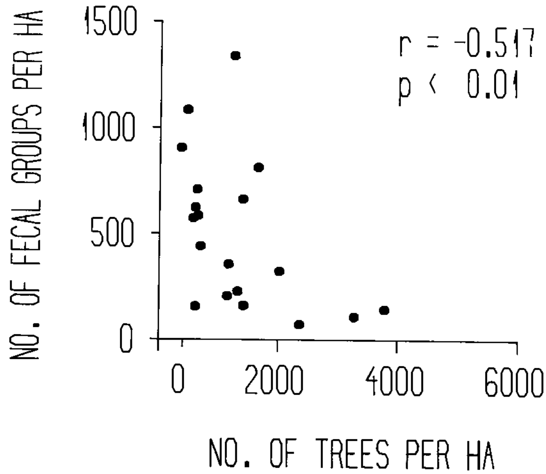

Fig. 6. The relationship between stand density and grazing pressure in Inari.

dictions as well as the earlier empirical findings indicating that lichen use by reindeer is influenced also by other factors than lichen biomass only.

In Kuusamo, reindeer tended to avoid clear-cut areas and seedling stands, whilst in Inari grazing pressure remained at a low level till the stands had reached approximately 100 years age. Of course, reindeer do not determine stand age, but their habitat preferences are dependent on stands and site characteristics associated to the stand age.

At the first glance, the preference of old forests seems to fit well in feeding behaviour of the reindeer. In easy snow conditions reindeer dig lichens for their food, but revert later in winter upon arboreal lichens, which occur most abundantly in old forests)Mattila, 1979). However, that can not explain the negative correlation between the age of the stand and mean height of lichens; it is a clear indication of light lichen use in young forests. An alternative explanation is that lichens grow faster in young forests than in old ones. Indeed, there exist results that *C. rangiferina* grows fastest in young dense pine stands and *C. mitis* in small seedling stands (Helle et al., 1984). However, the differences are too small to cause any clear negative relationship between the age of stand and mean height of lichens as found in this study.

Eriksson (1976) found that the snow hardens in a clear-cut area more likely than in the shade of forests. There exists, however, no evidence that the snow conditions in young forests are in general less favorable than in older ones.

Especially in Kuusamo, a negative correlation between litter/logging residue and fecal group density occurred and a positive correlation was found between litter/logging residue and mean height of lichens. These facts support the idea that logging residue is a major factor for the low preference of young forests. It is easy to understand that large-sized dry branches and crowns on the ground prevent effectively the reindeer to obtain lichens by digging beneath the snow; the greater is percent cover of logging residue, the smaller the actual availability of lichens.

In Inari, the avoidance of young forests was even more striking than in Kuusamo despite lower percent cover of logging residue. That suggests that there might exist also other factors than possible unfavorable snow conditions and logging residue which influence range selection. It can be hypothesized that good visibility of the range would be of importance, especially in areas where reindeer are used to live partly in open fell terrain as they do in Inari. Good visibility is known to play an important role in habitat selection of barren-ground caribou *(Rangifer t. groenlandicus)* (Pruitt, 1959; Henshaw, 1970) and wild forest reindeer *(Rangifer t. fennicus)* (Helle, 1981), because it obviously reduces predation risk. If seedling stands are excluded, visibility is, no doubt, associated with the age and especially the development class of the stand, because density of trees will decrease and lower branches self-prune with the succession of the forest.

The three hypotheses presented here can be tested with simple field experiments. These should compare lichen use by reindeer (1) in clear-cut stands with and without logging residue, (2) in young stands with different thinning regimen and (3) study snow conditions in different treatments and their possible effect on lichen use.

Practical remarks

High preference of old stands may effect negatively on productivity of the range. Helle et al. (1989) showed that there prevails, in general, a strong positive relationship between lichen range area per reindeer and percent cover of lichens ($y = 10.9 + 0.577\,x$, where y = percent cover of lichens and x = lichens range in ha per reindeer, $r = 0.849$, $df = 12$, $p < 0.001$). The function predicts that a 2-fold and 3-fold increase in animal density result in a 38% and 51% reduction, respectively, in percent cover of lichens by the long run. Extensive forest renovation has thus a detrimental effect on the condition of lichen ranges in old stands.

Now one may argue that lichens gain a corresponding benefit in young stands counterbalancing the losses elsewhere. The present results do not support that; the mean height of lichens was greater in young stands, but not percent cover. Recovery from the obvious mechanical destruction caused by cutting may take time, and later, in dense sapling stands, reindeer lichens are not capable to compete with mosses (especially *Pleurozium shreberi*) (Söyrinki *et al.*, 1977).

Finally, the dynamics of lichen ranges in forests subjected to normal forestry regimen can not be fully understood considering dry and barren sites only. In Northern Lapland (see Mattila, 1981), about 50% of the total lichen biomass is growing on sub-dry sites (*Empetrum-Myrtillus* type), where various kind of methods in site preparation are used. Their effects are not carefully studied, but no doupt they increase grazing pressure in old forests both in sub-dry and dry and barren sites.

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