Lichen ranges, animal densities and production in Finnish reindeer management

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Abstract: In the 1970s, mean lichen biomass ranged by the earmark districts (comprising of 2-9 adjacent herding associations) between 54 kg and 380 kg DM per ha correlating negatively with animal density per lichen ranges (range 1.5 - 14.3 ind. per km^2). Biomasses were far below economic carrying capacity of lichen ranges (900 kg DM per ha). The condition of lichen ranges was poorest in the southern half of the area where alternative food to reindeer lichens *(Deschampsia flexuosa,* arboreal lichens and supplementary feeding) was available. In 1980-86, recruitment (calves per 100 females) was 33% higher than in the 1970's, on an average (65 vs. 49), despite a 90% increase in animal numbers between 1970 and 1986; recruitment has not been dependent on the condition of lichen ranges. The increase in production has been some higher than expected on the basis of animal numbers. The reasons for the increasing trends in animal numbers, recruitment and production remains some unclear, but they may include favorable winter conditions, supplementary feeding, medical treatment against parasites and proper harvesting policy.

Key words: reindeer, range, carrying capacity

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Introduction

Economic carrying capacity is referred as an equilibrium where animal density is levelled so that it allows maximum primary production of the range (Caughley, 1976). Subsequently, consumption by animals is in maximum providing in turn maximum sustained yield. Both theoretical and empirical evidence shows that primary production peaks at the biomass value which is about 50% from ecological carrying capacity K (Caughley, 1976; Kärenlampi, 1973; Gaare and Skogland, 1980; Skogland 1986).

The most important winter ranges of reindeer are dominated by reindeer lichens *(Cladonia ssp.).* Due to high preference by reindeer but slow growth rate reindeer lichens are vulnerable to over-grazing, i.e. to the reduction of biomass below the 50% limit of K. In fact, over-grazing seems to be closely associated elsewhere to intensive reindeer economy now and past (Andreev, 1971; Kärenlampi, 1973; Skogland, 1986).

In this paper we relate the existing range data (Mattila and Helle, 1978; Mattila, 1979, 1981)

to animal density in northern Finland and consider how animal production and recruitment, its main determinant (see Skogland 1983, 1986), have developed in different range conditions since the beginning of the 1970's.

Material and methods

The Finnish reindeer management area is divided into 56 herding associations, which perform 14 larger units, so called earmark districts, each including 2-9 adjacent herding associations (Fig. 1). Most parts of the earmark districts of Utsjoki and Enontekiö are sub-alpine and alpine areas, whilst the others are located in coniferous forest zone (with some fells in northern Lapland).

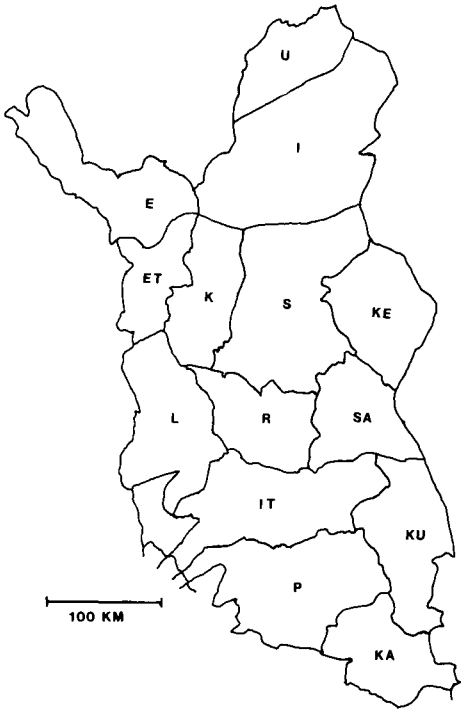

Fig. 1. The map of the reindeer management area in Finland. The earmark districts are: U = Utsjoki; I = Inari; E = Enontekiö; ET = Etelä-Lappi; K = Kittilä, S = Sodankylä; KE = Keminkylä; SA = Salla; R = Raudanjoki; L = Läntinen; IT = Itäkemijoki; KU = Kuusamo; P = Pudasjärvi; KA = Kainuu.

Range data have been obtained from a range survey carried out as a part of the Finnish National Forest Inventory (Mattila and Helle, 1978; Mattila, 1979, 1981). Biomass or relative abundance of reindeer lichens, *Deschampsia flexuosa* and arboreal lichens *(Alectoria ssp.* and *Bryoria ssp.)* was estimated from a field sample consisting of 3 282 plots.

The term "lichen range" used here includes dry and barren sites (mainly *Calluna-Cladina* - type) and sub-dry sites (mainly *Empetrum-Myrtillus* -type) in the earmark districts of Utsjoki, Inari, Enontekiö, Etelä-Lappi, Kittilä, Sodankylä and Keminkylä (where percent cover exceeds 10% at present and 50% without grazing). Ungrazed lichen biomass amounts on dry and barren sites to 3000 kg per ha and on sub-dry sites half of that.

Reindeer data are based on official statistics. Densities presented here include only $\geqslant$1 year-old animals (both slaughtered and those left alive in round-ups kept between October and February), but they match quite well to density of winter herd, since slaughtered animals are compensated by calves.

Results

Range lands and animal density

Gross density and density per lichen range are given by the earmark districts for the periods of 1970-79 and 1980-86 in Table 1. From it appears that the proportion of lichen range from the total land area varied between 7% and 84% i increasing towards the north. During both the periods, there prevailed a significant expontential relationship between the proportion of lichen range and gross density with respective r-values of 0.563 ($p < 0.05$) and 0.771 ($p < 0.01$). In 1970-79, a 10-fold increase in the proportion of lichen range (7% → 70%) resulted in a density increase from 0.9 to 1.7, whilst in 1980-86 it allowed an increase from 1.1 to 2.7 individuals per km^2.

Table 1. Gross density (GD) and density per lichen ranges (LD) ind./km^2 by the earmark districts in periods of 1970-79 and 1980-86. Range data from Mattila (1981).

Earmark district	1970-79		1980-86	
	GD	LD	GD	LD
Utsjoki	2.1	2.5	3.6	4.3
Inari	1.0	1.5	2.0	3.0
Enontekiö	1.6	2.2	2.7	3.7
Etelä-Lappi	1.5	3.6	2.2	5.2
Kittilä	1.0	3.1	1.6	4.9
Sodankylä	1.2	2.4	1.8	3.5
Keminkylä	1.6	2.8	1.5	3.9
Salla	1.0	14.3	1.2	16.9
Raudanjoki	1.2	10.0	1.6	13.3
Läntinen	0.9	12.5	1.1	15.9
Itäkemijoki	1.0	12.5	1.3	16.8
Kuusamo	1.2	5.3	1.5	6.8
Pudasjärvi	1.1	12.5	1.2	13.9
Kainuu	0.4	1.7	0.7	2.8

Condition of lichen ranges

The mean height of lichens (living part) ranged between 8 and 13 mm by the earmark districts without any clear correlation to animal density per lichen range. Instead, percent cover and biomass of lichens were strongly dependent on animal density (Figs. 2 and 3). From Fig. 4 appears that lichen biomasses accounted only to 6 (Salla) - 44 (Inari) % from the most productive lichen mat being about 900 kg DM per ha. The condition of lichen ranges revealed a clear geographic pattern. Heavily grazed ranges were typical to the southern half of the area

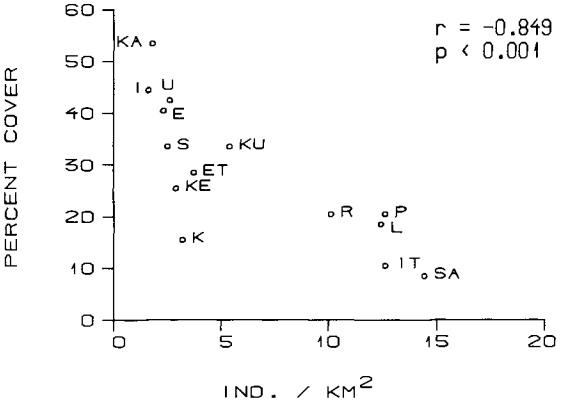

Fig. 2. The relationship between animal density per lichen range and percent cover of reindeer lichens. For abbreviations see Fig. 1. Range data from Mattila (1981).

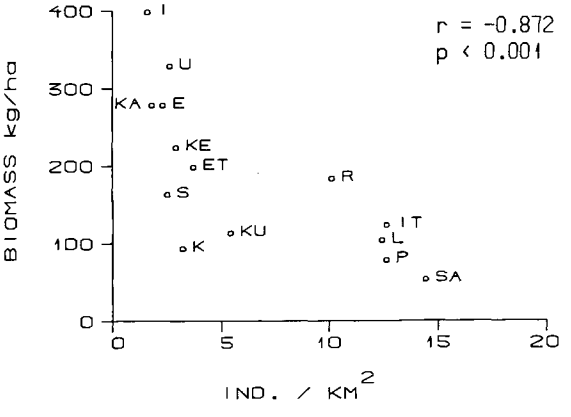

Fig. 3. The relationship between animal density per lichen range and lichen biomass. For abbreviations see Fig. 1. Range data from Mattila (1981).

(excluding Kainuu) characterized by abundant sources of *Deschampsia*, some arboreal lichens and intensive supplementary feeding (see Helle and Saastamoinen, 1979; Mattila, 1979, 1981).

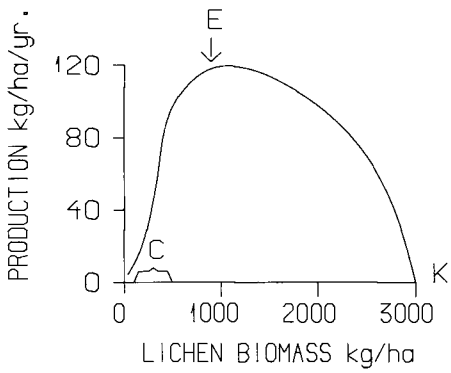

Fig. 4. The relationship between lichen biomass and annual lichen production. K = ecological carrying capacity; E = economic carrying capacity; C = the range of the mean biomasses in the 14 earmark districts in the 1970's. The production curve calculated from data of Kärenlampi (1973).

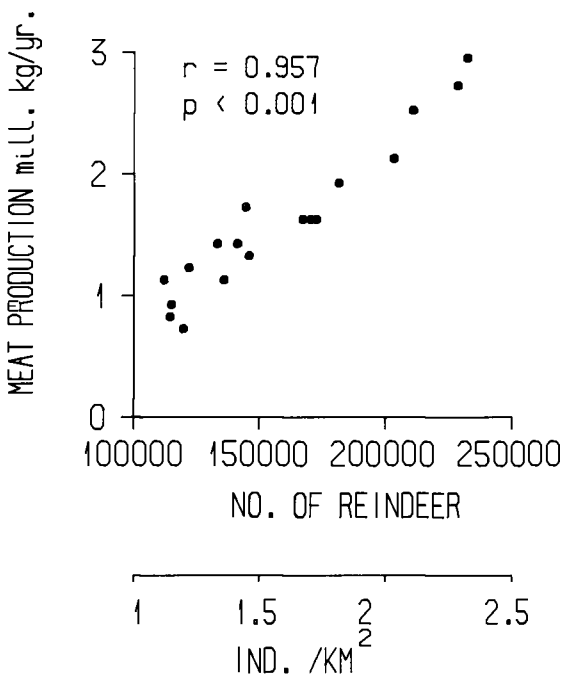

Fig. 5. The relationship between the number of reindeer (or gross density) and meat production in 1970-1987.

Production

In 1970, reindeer population totalled 121 000 animals, and by 1986 it has increased to 230 000 animals. Fig. 5 shows that meat production has increased during that period some what faster than should be expected on the basis of the number of animals. The same analysis has been made for every single herding association (n = 56) with essentially same results even in cases where gross density exceeds at present 4 individuals per km^2.

The mean recruitment (calculated per +1 year-old females in June-July) for the periods of 1970-79 and 1980-86 is plotted against density per lichen range in Figs. 6 and 7. It appears

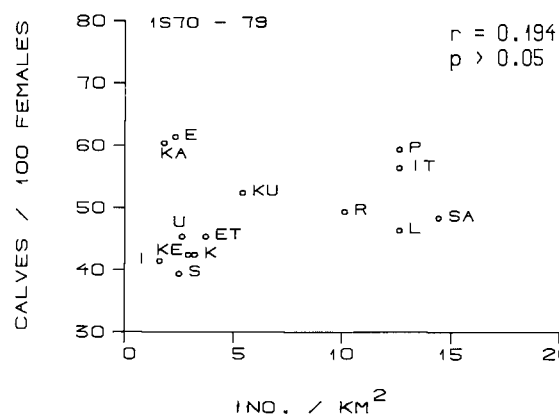

Fig. 6. The relationship between animal density per lichen range and calf crop in 1970-79. For abbreviations see Fig. 1.

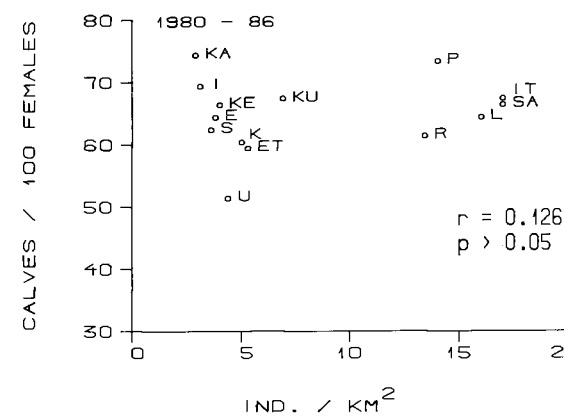

Fig. 7. The relationship between animal density per lichen range and calf crop in 1980-86. For abbreviations see Fig. 1.

that the variation in density has not had any significant effect upon recruitment. Instead, they show that recruitment has been in 1980-86 about 33% higher, on the average, than in the 1970's (65 vs 49), and that recruitment has increased especially in northern earmark districts; in 6 of them, the mean value for 1980-86 was higher than the highest value in the 1970's.

Discussion

The earliest studies suggest that 8-10 ha of lichen range (density 10-13 ind. per km^2) are required per reindeer per year (Palmer, 1926; Poijärvi, 1945; Andreev, 1954; Skuncke, 1958; Alaruikka, 1964; Helle, R. 1966). However, the present findings show that such densities over a longer period result in severe overgrazing of lichens (Figs. 2 and 3).

The low grazing value can be exemplified as follows. According to Holleman et al. (1979), the intake requirement of an adult reindeer is about 2.5 kg DM of lichen per day. The intrinsic growth rate of reindeer lichens averages in northern Finland 11% (Kärenlampi, 1973). Thus the yearly production of 10 ha of range (136 kg, Fig. 4) corresponds to only 26 days of a reindeer forage requirement; the winter season lasts about 200 days. This calculation takes into account that about 50% of the biomass removed becomes wastaged in foraging (Gaare and Skogland, 1980). So, it is evident that densities mentioned above are possible only in presence of alternative food. From the managemental point of view those estimates are not very informative because they do not take into account effects of grazing on lichen ranges and possible density-dependent influences on reindeer population.

The only empirical studies including lichen-reindeer interactions have been carried out in southern Norway (Gaare and Skogland, 1980; Skogland, 1983, 1986). Their estimates on population density at economic carrying capacity ranged between 4-20 individuals per km^2 lichen range depending how the term "lichen range" has been defined. The lowest estimate (Gaare and Skogland, 1980) included potential lichen ranges within *Loiseleurio-Arctostaphylion* or *Juncion trifidi* alliances, which corresponds quite well the definition used in this study. In northern Finland, even 4 individuals per km^2 lichen range seem to be too much to maintain lichen range in optimal condition. In the southern half of the area (excluding Kainuu), we considered as lichen range only *Calluna-Cladina* heathers. In Kuusamo, for instance, lichen biomasses are far below the optimum (Figs. 3 and 4) as a result of densities between 5 and 7 individuals per lichen range (Table 1). Earlier the density has been some lower (3-4 ind./km^2), but essential may be that such a stocking rate has continued about 100 years (Kortesalmi, 1960)

As mentioned by Skogland (1986) the Norwegian experiences are not necessarily applicable in other environments. In comparison to alpine habitats, the role of alternative food seems to be quite different in forest areas. For instance, recruitment (this study) at high density levels is in Finland clearly greater than found in southern Norway (Skogland, 1983, 1986).

Traditionally, the reindeer of forest areas have compensated scarcity or poor access of reindeer lichens by relying upon arboreal lichens in mid and late winter. The decrease of the area of old forests with abundant sources of arboreal lichens triggered effective supplementary feeding in the 1970's (Helle and Saaatamoinen, 1979). The dependence on reindeer lichens has decreased even in early winter, since abundant clear-cut areas and young forests (on fresh soils) provide to reindeer a rich resource of *Deschampsia flexuosa*. It seems to be clear that it is not profitable to adjust animal density to correspond to economic earring capacity of lichen ranges, if production of alternative high quality food is greater than that of lichen ranges in an ideal state.

The recent population increase has ruined all

earlier experiences on sensible animal density and production capacity in northern Finland. The new situation has not yet been analyzed from the viewpoint of population dynamics. This paper shows a remarkable increase in recruitment determined in mid-summer. Very probably, calf mortality before mid-summer as well as between mid-summer and winter is at present smaller than in the 1970's and early 1980's (Haukioja and Salovaara, 1978; Nieminen and Eloranta, 1982), which seems to associate to the good physical condition of the reindeer.

The improvement of the net recruitment and possibly lowered adult mortality rate have forced reindeer owners to intensify harvesting in order to avoid exceeding of highest permitted number of reindeer of the herding association. In such a situation criteria for animals to be left alive are very proper. Harvesting is subjected in particular to calves and over-aged or otherwise poorly productive individuals, which improves production capacity of the herd, and contains an element of compensatory mortality.

In the southern half of the area increasing trends in animal numbers and production are based on supplementary feeding, whose economic profitability is not self-clear in all cases (Helle et al., 1985). However, just the same has happened in northernmost Lapland without supplementary feeding. The present densities are there 2-3 times higher than in the 1960's and 1970's. According to Andreev (1971), a remarkable decrease in lichen biomass was observed in northern Lapland between 1959 and 1970. The relationship between density and the condition of lichen ranges (Figs. 2 and 3) suggests that even the resent increase in animal numbers has had a negative effect upon lichen ranges forcing the animals to add to their diet increasing amount of alternative food to reindeer lichens.

One possible explanation to these seemingly contradictionary phenomena is, besides favorable snow conditions during several successive winters, the medical treatment of reindeer against warble larvae and other parasites. It began in 1976 in the central Lapland but spread rapidly over the whole area; Phention and Warbex preparates were replaced by Ivomec in 1985. The positive effects of treatments are shown in several experimental works (e.g. Nieminen et al., 1980; Persen et al., 1982; Nordkvist et al., 1983), and one might suggest that their importance has been greatest in northern Lapland, where the parasitic load has been heaviest (Helle 1980). The effects of the treatments are possible to analyse in detail comparing weights and recruitment in adjacent herding association with the different beginning year in treatments.

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