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Pastures, calf production and carcass weights of reindeer calves in the Oraniemi co-operative, Finnish Lapland

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Abstract: The effects of climatic and density-dependent factors on calf production and carcass weights of reindeer calves were studied between the years 1965-87 in the Oraniemi co-operative, Finnish Lapland (67°50′ N). The Oraniemi area is divided into five pasture regions, in which the annual home range of the reindeer varied from 300 to 600 km^2. The more than trebled reindeer density over the period 1965-87 in Oraniemi had no detrimental effect on calf production (range 15-74 calves/100 females), nor on the mean carcass weight of the calves in 1974-87 (range 16.8-23.2 kg). The annual variations in calf-% were explained best by snow conditions during the previous winter and spring and their effects on the nutritional status of the females. The carcass weights of the calves were greater following a warm, rainy May and lower following a warm, rainy June and July. The weather in spring affects the emergence of green vegetation, which is reflected in the condition of females and their milk production, while the weather in early and mid-supper probably affects the quantities of blood-sucking insects and their activity. Carcass weights upon slaughtering rose from September to the beginning of December but then fell quickly. The differences in reindeer densities between the five pasture regions was not reflected in the calf-% over the period 1984-87, but the carcass weights of calves were lower following high densities in the pasture regions, especially in the winter pastures.

Keywords: climatic influence, habitat use, insect harassment

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Introduction

The effects of increasing animal density on the population structure, reproduction, survival and individual body size and weight of large mammals have been demonstrated in numerous species (e.g. Darling 1937, Moen 1973, Sinclair 1977, Boyce & Wing 1979). As population size increases, food supplies diminish, age at first breeding increases, fecundity declines and juvenile and adult mortality rise (Clutton-Brock *et al.* 1984). Research into populations of the reindeer (*Rangifer tarandus* L.) has also shown that the weights of the animals tend fall in response to increasing population densities, with calf production declining and mortality rising at high densities (Klein 1968, Reimers *et al.* 1983, Skogland 1983, 1985, 1986).

Over the last twenty years the total reindeer population in the reindeer herding area of Finland has grown from approximately 150 000 to 370 000 animals. The growth was most notable between 1980 and 1985, but the high yield of reindeer stocks has continued to be maintained by the constant high number of animals slaughtered. The causes of the rapid growth and high yield of the reindeer stocks have to be looked for in management practices and strategies as well as climatic factors.

The aim of this work was to ascertain the effects of climatic and density-dependent factors on calf production and the body weight of calves in different years and in the various grazing areas of the Oraniemi co-operative in central Lapland.

Materials and methods

Study area

The Oraniemi district, area 4085 km² (Fig. 1), in Finnish Lapland (67°50′N) lies within the northern boreal coniferous forest zone and consists of 48% mires and 51% heath forest (Nieminen & Korteniemi 1990). The mean altitude of the terrain varies in the range 150–300 m. The mean annual temperature is about -1°C, the coldes month being January (mean temperature -14.5°C) and the warmest July (+14°C). The ground is covered by a permanent snow layer by the end of October and the snow melts in open places in the middle of May. There is about 70 cm of snow on the ground in March. Mean annual precipitation is about 500 mm, of which about 175 mm falls in the summer months, i.e. June, July and August (Heino & Hellsten 1983).

The total reindeer population of the Oraniemi district increased from 1727 to 8870 during the years 1965–87, the increase being greatest and steadiest during the late 1960's and early 1980's, while decreases took place in consecutive years in the mid-1960's and throughout the 1970's.

Pastures and movements of reindeer

The pastures of Oraniemi were mapped by questioning the professional reindeer herders about the areas grazed most commonly and most intensively in winter, summer and autumn by reference to a map of scale 1:200 000. Areas of lichen (*Cladonia* sp.) growing in dry pine forests and forest areas rich in arboreal lichens (*Alectoria* sp., *Bryoria* sp.) were the preferred winter pastures, while the summer pasture areas pointed out by the herders were mainly bogs and river banks. Areas rich in grass (mainly *Deschampsia flexuosa*) were chiefly the mapped autumn pasture areas. The areas of these pasture types in km², and the pasture regions and the whole of the Oraniemi district were calculated from this map.

The pasturage cycle followed by the reindeer was determined by tracking marked reindeer and asking the herders about the yearly movements of their reindeer. A total of 140 reindeer were marked with numerical symbols (ear tags) by a local reindeer owner in 1972–87, and 121 of these were observed later, on a total of 406 occasions. A total of 383 calves were marked individually with ear tags in connection with calf marking in summer 1986 and 1987, and 164 of these were identified again at the next slaughtering time.

Calf production, carcass weights and weather conditions

The numbers, sex, age and carcass weights of the reindeer, slaughtering times and slaughtering places were determined from the census lists and slaughtering books of the Oraniemi co-operative and the records of the Association of Reindeer Herding Co-operatives. This made it possible to calculate reindeer densities (reindeer/km²) and calf production (calves/100 females) for the herding years 1965–87 in Oraniemi (herding year = year from June to May). The carcass weights of the calves for the herding years 1974–87 were collected from all the slaughtering places and then divided into five classes according to the five pasture regions (Keskikaira, Koitelainen, Vasaniemi, Voutavaara and Ala-Kitinen) and seven classes according to the month of slaughtering (months from September to March).

Calf production (calves/100 females) and reindeer density figures for the five pasture regions in the herding years 1984–87 were also calculated by means of the annual census lists and the mapped areas of pastures. Information on weather conditions in the years 1965–87 were collected from the local station of the Meteorological Institute in Sodankylä, and a number of measures and indices were calculated to represent weather, snow and humidity conditions in the years concerned. These were snow accumulation in winter (total of the mean snow depths for the winter months), number of days for which the ground was covered by snow in May, mean temperature in May (°C), precipitation in May (mm), total precipitation in the summer months (June, July and August), number of hot days (i.e. days with mean temperature > +15°C) in summer (i.e. June, July and August), number of hot days in the worst insect season (20.6.–10.7.) and the PTM index (total precipitation x mean May temperature) and PHJJ index (total precipitation x number of hot days of June and July).

Statistical methods

The differences in carcass weights of the calves between the years, months and pasture regions were tested by means of one-way ANOVA, the weight differences between the months and pasture regions being tested one year at a time. The dependences of calf production and carcass weights of the calves on reindeer densities and the measures and indices representing weather and snow conditions were calculated by simple regression, and the coincident effects of the we-

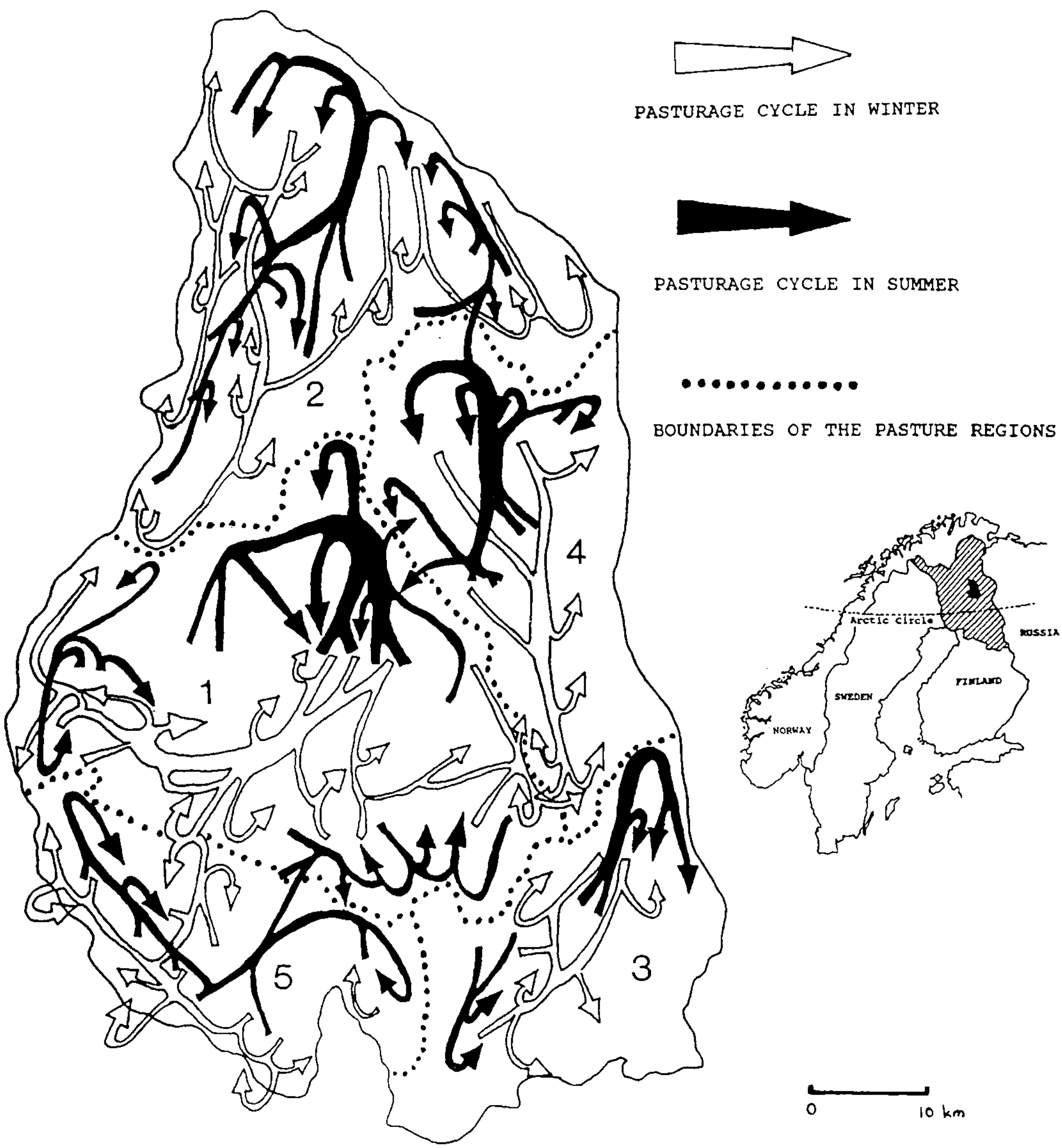

Fig. 1. Location of the Oraniemi co-operative in the reindeer herding area of Finland and the yearly pasturage cycle of reindeer in the Oraniemi district during the 1980's. Pasture regions: 1) Keskikaira, 2) Koitelainen, 3) Vasaniemi, 4) Voutavaara, 5) Ala-Kitinen.

ather measures and indices on carcass weights by multiple regression. Monthly changes in mean carcass weight were calculated for each year and used to assess the average trend in carcass weights upon slaughtering over the period 1974–87. Simple correlations were used to assess the dependences between the weather measures. Only linear dependences were tested.

Results

The reindeer pasturage cycle

The Oraniemi area has traditionally been divided into five pasture regions, Keskikaira, Koitelainen, Vasaniemi, Voutavaara and Ala-Kitinen. Determining the exact borders between these regions was partly a question of interpretation, but the distinctions between them were real. This was because some of the reindeer were occasionally taken temporarily to another region by the herdes and some did not themselves follow the main pasturage cycles. Excluding the first mentioned cases in which the herders had a direct effect on the movements of the reindeer, at least 75% of all the later observations of the marked reindeer were made within the pasture regions in which they had been marked. Thus the majority of the reindeer stayed in the same regions year after year. The older females seemed to be more faithful to their home range than the younger ones, as the majority of the marked animals which wandered exceptionally far were the younger ones. The annual home range of the reindeer varied between 300 and 600 km² in the different pasture regions when estimated on the basis of observations of marked reindeer and knowledge of the movements of reindeer herds (Fig. 1).

Reindeer densities and the extent of the pastures

There were quite large differences in reindeer densities and in the extents of the pasture types between the pasture regions of Oraniemi. The highest densities were observed in the Voutavaara and Keskikaira regions and the lowest in the Koitelainen and Ala-Kitinen regions in the herding years 1984–87, while the greatest differences in the proportions of the pasture types between the pasture regions were found in the arboreal lichen pastures, which ranged from 5% to 21% of the total area of the pasture regions. The Koitelainen region had the largest arboreal and summer pasture areas in proportion to total area, while the Voutavaara and Vasaniemi regions had the greatest lichen pasture areas. The Keskikaira region had a plentiful supply of autumn pastures (Table 1 and Fig. 2).

Factors influencing calf production and carcass weights

Calf production in the herding years 1965–87 in the whole Oraniemi district varied from 15 to 74 calves/100 females. The lowest calf-% (under

Table 1. Total areas and areas of reindeer pastures (km²) (% in brackets) in the whole Oraniemi district and its pasture regions separately in 1986. Ranges of the average reindeer densities for the different pasture types, calf-% and mean carcass weights of the calves in the herding years 1984–87.

	Oraniemi	Keskikaira	Koitelainen	Vasaniemi	Voutavaara	Ala-Kitinen
total area (km²)	4082 (100)	1230 (100)	1030 (100)	673 (100)	645 (100)	504 (100)
lichen pastures (km²)	478 (12)	126 (10)	63 (6)	112 (16(	105 (16)	72 (14)
arboreal lic. pastures (km²)	464 (11)	59 (21)	219 (21)	47 (7)	62 (10)	77 (15)
summer pastures (km²)	656 (16)	186 (15)	217 (21)	93 (14)	70 (11)	90 (18)
autumn pastures (km²)	320 (8)	145 (12)	39 (4)	66 (10)	34 (5)	35 (7)
all pastures (km²)	1918 (47)	517 (42)	538 (52)	318 (47)	271 (42)	274 (54)
reind./km²	1.9- 2.2	2.3- 2.5	0.7- 1.4	1.4- 1.5	2.7- 3.3	0.9- 1.7
reind./km² in lichen pasture	10.8-11.8	31.0-34.8	12.0-12.9	5.5- 5.9	7.6-14.8	3.9- 7.4
reind./km² in arb. lic. pasture	11.1-12.2	32.5-37.2	2.2- 4.3	13.2-15.6	20.4-21.8	5.7- 6.9
reind./km² in summer pasture	11.6-13.5	14.9-16.7	3.3-6.6	9.9-11.1	24.8-30.5	4.9- 9.4
reind./km² in autumn pasture	23.9-27.7	19.0-21.3	18.2-36.9	13.9-15.6	51.2-62.7	12.6-24.3
reind./km² in all pastures	4.0- 4.6	5.4- 6.0	1.3- 2.6	2.9- 3.2	6.4- 7.9	1.6- 3.1
calf-%	43-68	43-58	49-69	34-67	42-67	49-69
carcass weight of calves (kg)	20.1-21.7	18.4-21.6	21.9-22.6	20.0-21.4	20.3-21.2	21.7-22.9

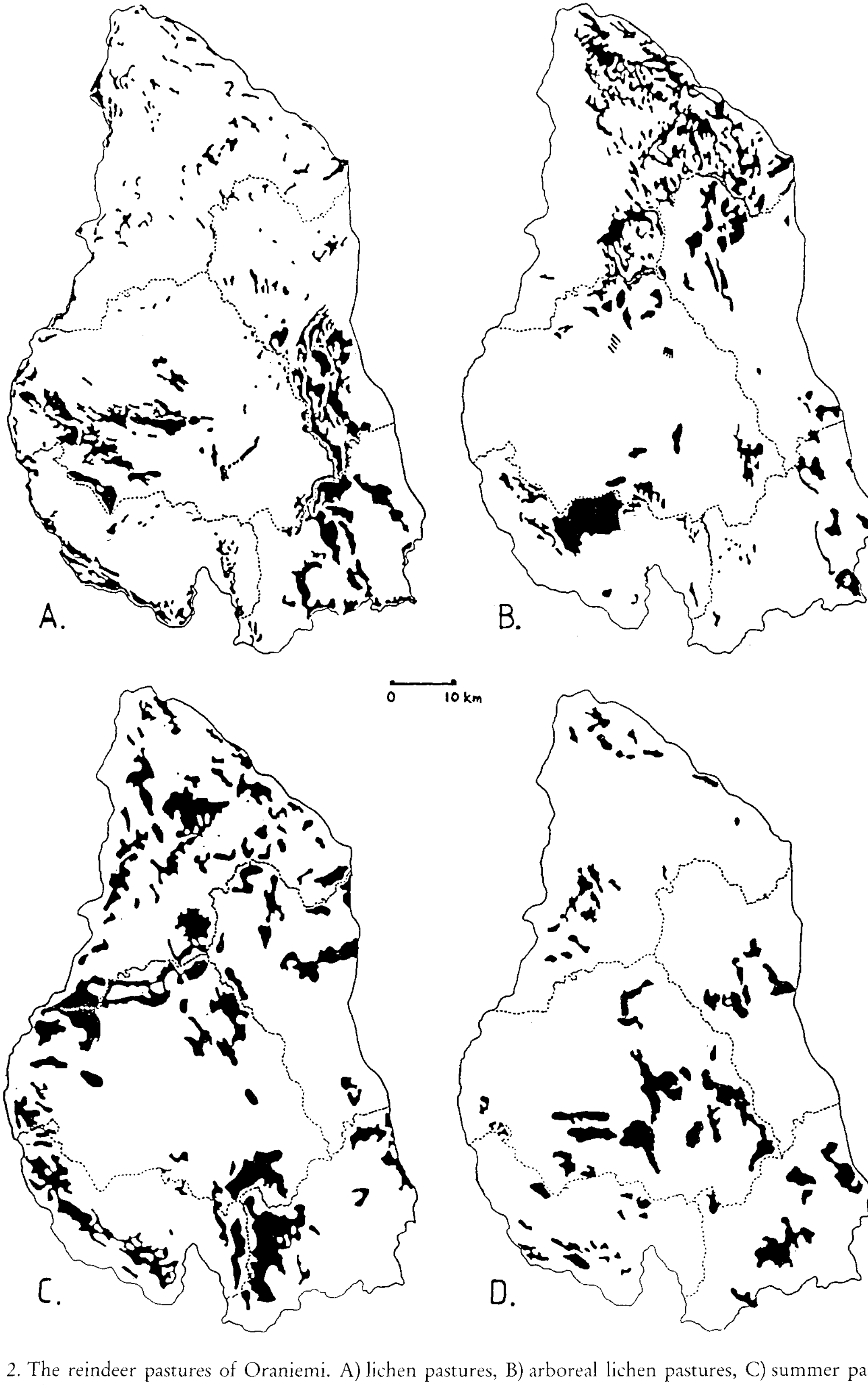

Fig. 2. The reindeer pastures of Oraniemi. A) lichen pastures, B) arboreal lichen pastures, C) summer pastures, D) autumn pastures.

Table 2. Mean carcass weights of calves. $\bar{x} \pm SE$ (N), in the pasture regions and in the whole district of Oraniemi in the herding years 1974–87. The significances of the weight differences between the pasture regions (P_1 values) and of the weight differences between the herding years in the whole Oraniemi district (P_2 value) in 1974–87 are indicated (one-way ANOVA, F-test).

Herding year	Keskikaira	Koitelainen	Vasaniemi	Voutavaara	Ala-Kitinen	P_1 values	Oraniemi
1974 - 75	16.4±0.4 (91)	18.6±0.7 (20)	16.9±0.5 (29)	17.9±0.4 (57)	14.9±0.6 (33)	P<0.001	16.8±0.2 (230)
1975 - 76	19.8±0.3 (15)	20.7±0.4 (68)	20.9±0.5 (59)	20.8±0.3 (141)	22.2±0.4 (68)	P<0.001	20.7±0.2 (494)
1976 - 77	21.9±0.3 (137)	22.6±0.4 (52)	22.3±0.4 (66)	21.9±0.2 (175)	21.0±0.4 (47)	NS	22.0±0.1 (477)
1977 - 78	17.5±0.6 (38)	20.2±1.6 (5)	18.3±0.3 (113)	20.0±0.5 (65)	19.8±0.4 (32)	P<0.001	18.8±0.2 (253)
1978 - 79	19.9±0.2 (169)	23.2±0.8 (25)	21.1±0.4 (54)	19.7±0.3 (87)	19.8±0.5 (30)	P<0.001	20.3±0.2 (365)
1979 - 80	22.6±0.2 (308)	20.9±0.7 (20)	22.6±0.2 (143)	21.9±0.3 (104)	22.1±0.3 (92)	P<0.05	22.4±0.1 (667)
1980 - 81	20.6±0.2 (204)	21.7±0.3 (63)	20.6±0.4 (67)	20.1±0.2 (165)	20.2±0.6 (26)	P<0.01	20.5±0.1 (525)
1981 - 82	21.0±0.2 (310)	21.5±0.3 (56)	20.5±0.4 (83)	20.5±0.2 (197)	20.9±0.5 (50)	NS	20.8±0.1 (696)
1982 - 83	22.7±0.2 (282)	23.6±0.4 (75)	23.0±0.3 (129)	23.9±0.2 (257)	23.5±0.5 (46)	P<0.001	23.2±0.1 (789)
1983 - 84	20.7±0.2 (352)	23.6±0.6 (27)	20.5±0.3 (108)	22.1±0.2 (177)	21.2±0.4 (45)	P<0.001	21.2±0.1 (709)
1984 - 85	18.4±0.1 (433)	22.2±0.3 (170)	20.0±0.2 (149)	20.5±0.2 (423)	21.7±0.3 (111)	P<0.001	20.1±0.1 (1286)
1985 - 86	19.2±0.2 (331)	21.9±0.2 (191)	20.7±0.3 (111)	20.3±0.3 (251)	21.7±0.3 (102)	P<0.001	20.4±0.1 (986)
1986 - 87	21.6±0.1 (699)	22.6±0.2 (288)	21.4±0.2 (214)	21.2±0.1 (574)	22.9±0.3 (117)	P<0.001	21.7±0.1 (1892)
							$P_2 < 0.001$

30%) was recorded in the mid-1960's, the early 1970's and the herding year 1977–78, while the highest calf-% were reached in the herding years 1968–67, 1970–71 and 1986–87 (over 65%). Throughout the 1980 the calf-% was over 40%. There were very significant differences in the carcass weights of the calves over the period 1974–87 ($P < 0.001$), the mean weights for these years varying from 16.8 to 23.2 kg (Table 2).

At least significant differences in carcass weights ($P < 0.05$) were observed between the pasture regions in 11 out of the 13 years over the period 1974–87 (Table 2). The lightest calves tended to be in the Keskikaira region and the heaviest in the Koitelainen region. At least significant differences in carcass weights ($P < 0.05$) between the slaughtering months were observed in every one of the 13 years (Table 3). The carcass weights of the calves upon slaughter rose on average from September to the end of November and the beginning of December and then fell rapidly until March (Fig. 3).

The more than trebled reindeer density in Oraniemi over the period 1965–87 had no statistically significant detrimental effect on calf production. On the contrary, it seemed that the calf-% rose in response to increased reindeer density ($r^2 = 0.24$, $P = 0.02$, $N = 22$). There was a slight positive dependence between reindeer density and the carcass weight of the calves in 1974–87 ($r^2 = 0.10$, $P = 0.30$, $N = 13$).

The annual variations in calf production in 1974–87 were explained best by snow accumulation in the previous winter (total of the mean snow depths for the winter months) and the number of days for which the ground was covered by snow in the previous May, but these relationships were not statistically significant ($r^2 = 0.13$, $P = 0.11$, $N = 21$ and $r^2 = 0.14$, $P = 0.09$, $N = 22$). A deep snow cover in winter and its persistence in spring were factors the most predictive of low calf production, however. The relationships between calf-% and the

Table 3. Mean monthly carcass weights of calves upon slaughter, $\bar{x} \pm SE$ (N), in Oraniemi in the herding year 1974–87. The significances of the weight differences are indicated as P value (one-way ANOVA, F-test).

Herding year	Slaughtering month							
	September	October	November	December	January	February	March	P value
1974-75	14.6±0.6 (28)	16.6±0.4 (61)	15.8±1.0 (11)	17.2±1.1 (11)	17.7±0.3 (114)	14.0±0.8 (5)	–	P<0.001
1975-76	20.2±0.5 (36)	19.8±0.4 (137)	–	–	22.0±0.2 (173)	20.1±0.2 (148)	–	P<0.001
1976-77	–	22.0±0.2 (184)	21.6±0.5 (16)	22.3±0.2 (179)	21.1±0.3 (98)	–	–	P<0.01
1977-78	15.0±1.3 (11)	19.0±0.3 (147)	–	19.6±1.0 (8)	19.2±0.4 (79)	16.8±0.9 (8)	–	P<0.001
1978-79	21.1±0.6 (30)	20.4±0.3 (167)	21.0±0.7 (27)	–	20.8±0.5 (38)	19.7±0.4 (62)	19.1±0.5 (45)	P<0.05
1979-80	–	22.4±0.2 (316)	22.7±0.2 (251)	21.8±0.4 (79)	20.8±0.6 (21)	–	–	P<0.01
1980-81	21.1±0.8 (30)	20.8±0.2 (205)	24.3±1.8 (3)	21.2±0.5 (37)	20.1±0.2 (213)	20.5±0.4 (37)	–	P<0.01
1981-82	19.9±0.3 (139)	21.2±0.2 (318)	21.7±0.4 (75)	21.8±0.4 (49)	19.9±0.3 (108)	22.1±0.5 (7)	–	P<0.001
1982-83	22.3±0.2 (143)	23.9±0.2 (219)	24.8±0.3 (144)	23.1±0.5 (35)	22.6±0.2 (173)	21.6±0.4 (56)	20.9±0.6 (19)	P<0.001
1983-84	19.7±0.4 (96)	22.1±0.2 (265)	22.0±0.4 (61)	–	20.5±0.2 (244)	21.4±0.4 (43)	–	P<0.001
1984-85	20.5±0.2 (185)	19.4±0.1 (652)	21.3±0.2 (243)	21.3±0.5 (67)	19.7±0.3 (130)	17.1±0.8 (9)	–	P<0.001
1985-86	18.8±0.3 (106)	20.2±0.1 (583)	22.3±0.3 (125)	21.5±0.4 (61)	21.5±0.3 (91)	16.5±0.6 (20)	–	P<0.001
1986-87	21.4±0.1 (473)	22.0±0.1 (596)	22.2±0.2 (367)	22.9±0.2 (163)	20.1±0.2 (210)	19.5±0.4 (29)	20.5±0.4 (54)	P<0.001

other weather measures and indices were even weaker.

The measures which showed a significant relationship with the mean carcass weights of the calves in 1974–87 were precipitation (mm) in May ($r^2=0.33$, $P=0.04$, $N=13$) and total precipitation (mm) in summer, i.e. June, July and August ($r^2=0.33$, $P=0.04$, $N=13$). The greater the precipitation was in May the heavier were the calves at the next slaughter, and the greater the precipitation was in summer the lighter were the calves. There was only a slight positive dependence between mean temperature (°C) in May and mean carcass weights ($r^2=0.09$, $P=0.31$, $N=13$). The dependence between the number of hot days in summer and the mean carcass weights was negative but slight ($r^2=0.11$, $P=0.27$, $N=13$), as was that between the number of hot days in the worst insect season and mean carcass weights ($r^2=0.01$, $P=0.74$, $N=13$).

The slight negative dependence was observed between snow accumulation in the previous winter and the carcass weights ($r^2=0.14$, $P=0.20$, $N=13$) as was also observed between the numbers of days for which the ground was covered by snow in the previous May and carcass weights ($r^2=0.13$, $P=0.14$, $N=13$).

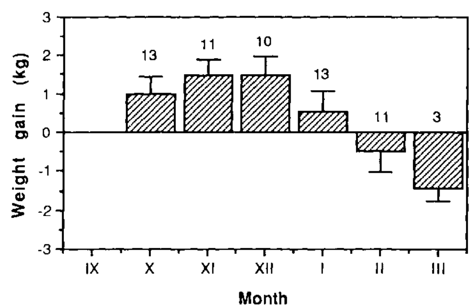

Fig. 3. Changes in mean monthly carcass weights of calves ($\bar{x}$ □SE) from the 0-level of September in Oraniemi in the herding years 1974–87. The numbers above the columns indicate the number of years' results which were used to calculate the weight changes.

A statistically significant positive dependence was observed in the herding years 1974–87 between the PTM index (see methods) and the mean carcass weights of the calves (r^2=0.41, P=0.02, N=13). The dependence between the PHJJ index and the mean carcass weights was also significant but negative (r^2=0.49, P=0.008, N=13). There was no correlation between precipitation and mean temperature in May (r=–0.15, P=0.62, N=13), nor was the correlation between total precipitation and the number of hot days in June and July significant in the years 1974–87 (r=–0.16, P=0.61, N=13).

The coincident effects of precipitation and mean temperature in May on the carcass weights of the calves were also statistically significant when calculated by multiple regression (r^2=0.49, P=0.03, N=13). In the same way, the coincident effects of total precipitation and number of hot days in June and July on the weights were almost significant (r^2=0.43, P=0.06, N=13). All of this can be interpreted as indicating that the carcass weights of the calves were greater following a warm rainy May and lower following a warm rainy June and July. In all, 68% of the variation in carcass weights in 1974–87 could be explained by these two indices together (r^2=0.68, P=0.004, N=13).

The different reindeer densities had no statistical effect on calf production in the five pasture regions over the period 1984–87 (e.g. regression between reindeer density/km² and calf-% for the pasture regions: (r^2=0.003, P=0.85, N=13), but high densities in the pasture regions were associated with lower carcass weights of the calves. The clearest relationship emerged between reindeer densities on the arboreal lichen pastures and the mean carcass weights of the calves, but high densities on lichen pastures and on all reindeer pastures were also associated with lower carcass weights (Fig. 4 and 5). The dependence between reindeer densities on the summer pastures and carcass weights was also negative, but slight (r^2=0.19, P=0.10, N=15), as was that between reindeer density over the total areas of the pasture regions and carcass weights (r^2=0.21, P=0.09, N=15).

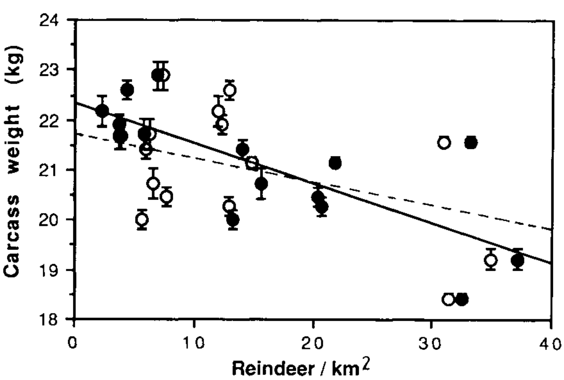

Fig. 4. Dependence of carcass weights of calves on reindeer density in arboreal lichen pastures (black circles, solid line: r^2=0.56, P=0.001, N=15, y=–0.08x+22.32) and in lichen pastures (open circles, fragmentary line: r^2=0.26, P=0.05, N=15, y=–0.06x+21.92) in Oraniemi. Each plot represents the mean carcass weight of the calves and reindeer density for the five pasture regions in the herding years 1984–87.

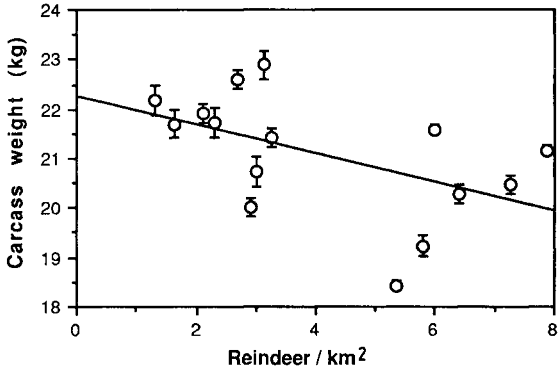

Fig. 5. Dependence of carcass weights of calves on reindeer density in all the reindeer pastures mapped (r^2=0.26, P=0.05, N=15, Y=–0.29x+22.27) in Oraniemi. Each plot represents the mean carcass weight of the calves and reindeer density for the five pasture regions in the herding years 1984–87.

Discussion

The movements of reindeer between pasture compartments are regulated largely by the quality and availability of food, which are in turn greatly affected by the phenology of the plants and the snow conditions (Skogland 1972, Sulkava & Helle 1975). Ontogenic experience has an important role in the home range behaviour of reindeer (Linkola 1972, Bergerud 1974), while their migration tendency emerges when they try to leave areas where food is difficult to obtain (Skuncke 1973). On the other hand, it is hypothesized by Helle (1981) that the migration tendency of Finnish semi-domestic reindeer may have been reduced by the old management practice of slaughtering animals which wandered too far from their own district. The small size of the co-operatives and the starionary behaviour of the reindeer have been among the factors leading to exhaustion of the pastures. Especially in the areas where winter pastures are scattered between the summer and autumn pastures, reindeer tended to trample their lichen fields during the snow free season.

Intense deterioration of the lichen pastures as a result of the increased number of reindeer has been evident almost throughout the reindeer herding area of Finland during recent times (Helle 1966, Krenlampi 1973, Kautto *et al.* 1986). At the same time, the major late winter pastures in the arboreal lichen forests have continued to be reduced by felling (Mattila & Helle 1978, Helle & Saastamoinen 1979, Nieminen 1988). Even the quantity of arboreal lichens in the forests has been observed to have declined (Kautto *et al.* f1986, Helle *et al.* 1990). In spite of all this alarming information about their pastures, reindeer stocks seem generally to have succeeded well in Oraniemi, as in the whole reindeer herding area of Finland.

The growth of reindeer stocks is based to a large extent on the commencement of the slaughtering of calves in the late 1960's, which markedly changed the structure of the stocks and thus improved their viability and yield (see Kojola *et al.* 1991). The decreases in reindeer stocks during the 1960's and 1970's are evidently linked to the unfavourable weather and snow conditions in several years (see Helle & Säntti 1982). With the favourable weather and snow conditions, intensified artifical feeding (Helle & Saastamoinen 1979, Nieminen 1988) and medical treatment against parasites (see Persen *et al.* 1982, Nordkvist *et al.* 1983, 1984) reindeer stocks showed rapid growth in the early 1980's. Furthermore, the availability of food for the reindeer in autumn and early winter has probably not declined, as the fellings will have increased the amounts of certain important fodder plants (e.g. *Deschampsia flexuosa*) (see e.g. Sulkava & Helle 1975).

Birth weights of calves are greatly affected by the nutritional status of the females during the late stages in gestation (Thorne *et al.* 1976), and it is thus justified to assume that snow conditions in winter have an effect on the nutritional status of the females and thus on the birth weights of the calves, which should in turn be reflected in their autumn weights (see Eloranta & Nieminen 1985). It seems, however, that the yearly differences in carcass weights of calves are associated more clearly with the weather conditions in spring and early and mid-summer than with the snow conditions in winter. In other words, the calves are capable of compensating for a low birth weight by means of subsequent growth if the circumstances in spring and summer are favourable for weight gain.

By contrast, the calf-% reflects better the snow conditions in winter than the weather conditions later in spring or summer. The nutritional status of the reindeer females in scanty winter pastures seems already to be influenced by the depth of the snow cover and its persistence in spring, although these only indicate certain aspects of the pasturage conditions in winter, for one also needs information about the hardness and thickness of the ice and snow layers on the ground and within the snow bed. Such information was not available for the present analysis.

A warm, rainy May will probably cause rapid melting of snow and the early emergence of the green vegetation, and this will have its greatest effects in terms of improved condition of the females and increased milk production, which will in turn be reflected in the nutritional status and weight gain of the calves (Varo & Varo 1971). Rain and heat in June and July, on the other hand, will in themselves probably have little direct effect on the weight gain of the calves (see Yousef & Luick 1975), but rather their effects will be mediated via the earlier presence and greater abundance of blood-sucking insects, since there will then be plenthy of water available everywhere for their rapid reproduction and high temperatures to activate them (compare Helle & Tarvainen 1984). Conversely, however, there will probably not be a great number of biting insects about in a warm, dry summer.

When insect harrassment is at its peak the reindeer circulate nervously all the time and may form dense herds comprising thousands of animals (Baskin 1970), which will reduce the nuisance caused by the insects (Helle & Aspi 1983) but hampers feeding. The rapidly growing calves are not capable of compensating later for the losses of potential growth attributable to stress and feeding disturbances caused by insect harrassment in summer.

It has been observed experimentally that the natural trend in weight gain for reindeer calves can only partly be adjusted by supplementary feeding (Jacobsen *et al.* 1980), but the strength of this trend is greatly affected by the quality and quantity of the food available. For example, a steep rise and rapid fall in carcass weights of reindeer calves have been demonstrated in the central and southern parts of the reindeer herding district in Finland during autumn and winter, whereas no such a rapid change in weight was observed in the northern parts (Helle *et al.* 1983). These differences in weight gain are obviously connected with the areal differences in composition of nourishment. Anyway, from point of view of practical reindeer husbandry it would be useful for slaughtering to take place during the period when the body weights of the reindeer are highest.

Comparisons between separate reindeer populations in southern Norway have demonstrated a reduction in size and weight in relation to population density (Reimers *et al.* f1983, Skogland 1983, 1985, 1986). In areas containing abundant winter pastures of good quality the size of the reindeer depended first of all on their density in the summer pastures, whereas if winter pastures were in short supply or in poor condition, the size of the reindeer depended primarily on their density there. There were also fewer calves relative to the number of females in the dense populations than in the sparse ones. It has similarly been demonstrated in the reindeer herding area of Finland that the carcass weights of the calves depend on reindeer densities (Nieminen 1987) so that the herding districts in the northern part of the area, where densities were highest, had the lightest calves.

The results that emerged here show that the weights of reindeer calves in the central part of the herding area depend chiefly on reindeer densities in the winter pastures, especially the late winter pastures in the arboreal lichen forests. The condition of reindeer probably does not decline as quickly in late winter in those areas which have moderate arboreal lichen pastures. Any marked decline in the condition of the females before calving will be reflected in the birth weights of the calves (Thorne *et al.* 1976), and calves which are born light will also be light in autumn (Eloranta & Nieminen 1985). All the same, the present results suggest that, although the winter pastures seem to be the most limited resource, reindeer densities in the summer pastures are not entirely insignificant as far as the weight gain of the calves is concerned.

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