Sized-related changes in winter condition of male calves in reindeer

Sammenhengen mellom størrelse og vinterkondisjon hos hankalver av reinsdyr

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Abstract: Size-related changes in body condition of free-ranging male calves of semi-domesticated reindeer were studied in northern Finland from October 1983 to February 1984. In October-November, back fat depth or muscle fat percent correlated positively with the body size (=back length). In January, the highest means especially for muscle fat percent were found among medium-sized calves. Carcass weight and weight/back length ratio correlated positively with size, excluding February sample, where correlation for carcass weight was non-significant and for weight/back length ratio negative. Weight in the autumn correlated negatively with weight in February. Therefore, normalizing selection for body size (working against small and large phenotypes) is expected to occur in late winter. Small calves may be at greater mortality risk because of lower initial body reserves. Large calves commonly disperse during the rutting season and they may suffer most from increased food competition later in winter. Using of medium-sized calves for breeding might be the safest policy on ranges characterized by short food supply and difficult snow conditions.

Key words: condition, fat, mortality, normalizing selection, stabilizing selection, weight

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Helle, T., Pulliainen, E. ja **Aspi, J.** 1987. Koon vaikutus poron urosvasojen talviseen kuntoon.

Tiivistelmä: Koon vaikutusta vapaana laiduntavien poron urosvasojen kuntoon tutkittiin Pohjois-Suomessa loka-helmikuussa talvella 1983-84. Loka-marraskuussa selkärasvan paksuus tai lihaksen rasvaprosentti riippui vasan koosta (=selän pituus). Tammikuussa sen sijaan lihaksen rasvaprosentti oli korkein keskikokoisilla vasoilla. Ruhopaino sekä ruhopaino/selän pituus oli yleensä riippuvainen koosta. Helmikuussa ruhopainon riippuvuus koosta ei ollut enää tilastollisesti merkitsevä, ja koon ja ruhopainon/selänpituuden välinen korrelaatio oli negatiivinen. Eniten painoa menettivät (%) loka-helmikuun välillä suurikokoisimmat vasat. Havainnot viittaavat siihen, että talvella esiintyvä kuolleisuus on normalisoivaa koon suhteen (karsii pieniä ja suuria fenotyyppejä). Pienten vasojen kuolleisuusriski on suuri alunperinkin vähäisen varastoravinnon vuoksi. Suuret vasat puolestaan erkaantuvat usein emistään jo rykimäaikana, ja joutuvat kärsimään eniten talven mittaan kiristyvästä ravintokilpailusta. Niukoilla laitumilla siitokseen on turvallisinta säästää keskikokoisia vasoja.

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Sammendrag: Størrelses-relaterte forandringer i kroppskondisjon hos fritt beitende han-kalver av semidomestiserte rein er studert i Nord-Finland fra oktober 1983 til februar 1984. I oktober - november korrellerte tykkelsen av ryggfettet eller muskelfett-prosenten positivt med kroppsstørrelsen (= rygglengden). I januar ble de høyeste middelverdier, særlig for muskelfett-prosenten, funnet hos kalver av middels størrelse. Skrott-vekter og vekt/rygglengde-forholdet korrellerte positivt med kroppsstørrelse bortsett fra februar-prøvene, der korrellasjonen for skrott-vekt var ikke-signifikant og for vekt/rygglengde-forholdet var negativt. Vekt om høsten korrellerte negativt med vekt i februar. Derfor ventes et normaliserende utvalg for kroppsvekt (som arbeider mot små og store fenotyper) å skje på senvinteren. Små kalver er utsatt for større dødsrisiko på grunn av lavere kroppsreserver. Store kalver streifer vanligvis under brunsttiden og kan komme til å lide under økt næringskonkurranse på senvinteren. Bruk av middels store kalver i avlen kan være den sikreste metode på beiter som karakteriseres av dårlige næringstilgang og vanskelige snøforhold.

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Introduction

Natural selection tends to promote traits that increase survival and reproduction. In the reindeer (*Rangifer tarandus* L.), both characteristics are often related to body weight. In winter, low quality and reduced availability of food results in a negative energy and nutritive balance. Survival may be influenced not only by food availability but also by body condition as the animal enters the winter (Reimers 1977, 1982). Ringberg et al. (1980) and Reimers and Ringberg (1983) showed that in reindeer the amount of stored fat deposits is dependent on body weight. Calves, having the smallest body fat reserves, suffer most from winter starvation, but even among them, high body weight in the autumn improves maintenance of body condition during the winter (Varo 1972).

Reindeer are polygynous breeders and so the male reproductive success might be expected to be related to body weight (Bergerud 1974, Clutton-Brock et al. 1980). Among females, body weight influences conception rate (Varo 1972, Lenvik 1977), the calf's birth weight and its survival (Vostrajakov 1971, Varo 1972, Haukioja and Salovaara 1978, Eloranta and Nieminen 1985). However, among females the association between weight and reproductive success is obviously less pronounced than among males. According to a current theory on parental investment, females of polygynous mammals should invest heavily on their male offsprings before weaning, since the final body size of males is dependent on early growth rates (Clutton-Brock et al. 1982, Skogland 1986).

In the contemporary management of semi-domesticated reindeer, rapid growth and large final body size have been the basic goals in practical reindeer breeding (Varo 1972). However, conventional knowledge of reindeer owners in Finnish Lapland postulates that the largest as well as the smallest male calves are most prone to winter mortality. This is partly in contradiction to the scientific arguments presented directly above, and hints for normalizing selection for body size. Normalizing selection refers to the situation where the fitness of individual phenotypes depends inversely on the extent to which the phenotype differs from a central optimum (Mather 1953). Normalizing selection has been shown to operate on a number of characters in a variety of species, including body size in sparrows (*Passer domesticus* L.) (Bumpus 1896; see also Johnston and Fleischer 1981, Lande and Arnold 1983) and moles (*Talpa europea* L.) (Stein 1950, 1951) in harsh winter conditions.

In this paper we will test whether the smallest and largest male calves lose their body reserves by midwinter faster than do the medium-sized ones. The parabolic relationship between the size and condition indices can be considered as indirect evidence of normalizing selection for body size under the most demanding conditions in late winter. If that is true, heavy maternal investment on male offspring, resulting in a high body weight in the autumn, becomes questionable, and also new selection criteria in practical reindeer breeding are needed.

Material and methods

The diets, range conditions, herding practices, and animal densities of Finnish semi-domesticated reindeer are described in detail by Helle and Saastamoinen (1979), Pulliainen and Siivonen (1980) and Mattila (1981).

Monitoring changes in body condition over the whole slaughtering period within one herding association was impossible. The southern herding associations held most of their round-ups from October to December and the northern ones from December to February. As a result, samples were collected from the 7 herding associations depicted in Fig. 1.

In the round-ups sampled in this study, the harvesting rate of male calves ranged between 80 and 95%. Slaughtered calves were sexed and dressed at the slaughter site and marked with a numbered tag for later identification. Condition measurements were taken from randomly selected carcasses at Poro ja Riista slaughterhouse in Rovaniemi. The following body characteristics were measured.

1. Back length was measured from the front edge of scapula to the base of the tail from a hanging carcass.
2. Chest girth. Sternum opened by the saw was replaced before measuring.
3. The sum measure is the sum of back length and chest girth, and normally correlates well with body weight (Varo 1972).
4. Carcass weight to the nearest kg. Carcass weight was live weight minus blood, head, lower legs, viscera and skin.
5. Back fat. Measured according to Riney (1955).
6. Muscle fat. A piece of muscle from Musculus extensor carpi radialis was removed from the foreleg, and the fat content was determined using petroleum benzene - chloroform as a solvent.

A total of 272 male calves was studied between 13 October 1983 and 2 February 1984.

Results

Back lenght was selected as the principal size character, since it showed smallest variation between study populations (Table 1). Back length was not dependent on gross density of summer herd ($r = -0.126$, $df = 7$, $p > 0.05$), and male calves are known to show little or no skeletal growth (total length and lower jaw) after October despite *ad libitum* feeding conditions (Ryg and Jacobsen 1981). Within the samples, back lengbts were normally distributed with the exception in Muotkatunturi where they were significantly skewed to the left ($p < 0.05$); this suggests that large calves were left alive, and therefore care should be taken when interpreting the data from Muotkatunturi.

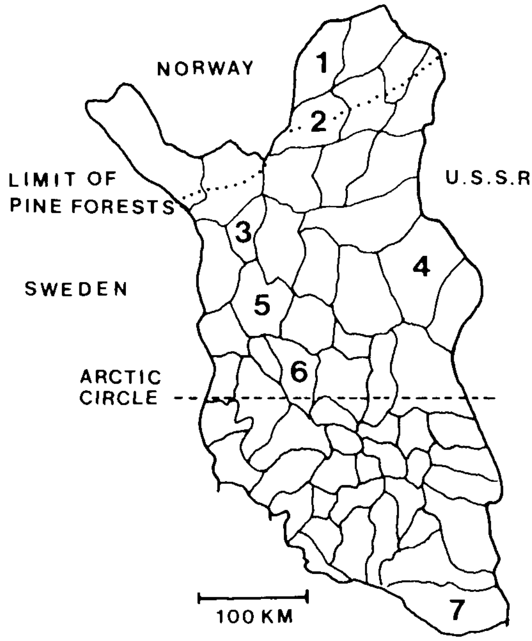


Fig. 1. The Finnish reindeer management area and study herding associations. 1 Paistunturi, 2 Muotkatunturi, 3 Kyrö, 4 Kemin-Sompio, 5 Alakylä, 6 Poikajärvi and 7 Halla.

Condition indices are plotted against back length in Fig. 2. Correlation matrix for the entire data set is taken from Poikajärvi (16 October 1983) and Kemin-Sompio (2 February 1984) and given in Tables 2 and 3 respectively.

Fat indices

The means for back fat depth and percent of calves without back fat for the herds linearly declined with the sampling date; the r-values were -0.955 and -0.920 respectively ($df = 7$, $p < 0.001$). Back fat depth correlated positively with back length in 3 samples in October and November (Fig. 2A), but muscle fat only in Alakylä in late October (Fig. 2B). Most

Table 1. Gross densities of summer herd and measurements (mean ± S.D.) of body characters and fat indices for male calves. Sampling locations are presented in Fig. 1.

Location	Density ind./km²	Date	N	Back length cm	Back fat mm	Muscle fat %	Chest girth cm	Sum measure cm	Carcass weight kg	Weight/back length
Poikajärvi	2.7	13.10.83	24	64.4±3.5	12.3±6.5	—	79.0±4.6	143.4±6.6	21.8±3.2	—
Poikajärvi	2.7	16.10.83	28	63.5±3.8	8.6±4.2	3.1±1.8	75.6±5.0	139.5±8.7	20.4±3.3	0.320±0.039
Alakylä	2.7	27.10.83	37	67.3±2.8	9.9±4.4	4.2±2.1	80.8±2.6	148.2±4.9	23.9±2.8	0.356±0.031
Alakylä	2.7	3.11.83	30	66.2±3.1	11.0±6.4	4.4±1.8	78.9±4.2	145.2±6.8	22.0±3.0	0.335±0.031
Paistunturi	5.8	13.12.83	28	64.3±2.5	3.0±2.8	—	75.9±4.2	140.3±6.0	16.8±2.6	0.262±0.037
Kyrö	2.7	5. 1.84	47	65.6±3.0	2.2±4.2	3.9±3.9	79.8±3.6	145.4±6.1	21.4±3.2	0.324±0.033
Halla	1.0	19. 1.84	28	64.1±3.1	0.7±0.9	3.7±0.9	77.9±3.9	142.2±5.9	20.5±2.7	0.322±0.035
Muotkatunturi	2.7	20. 1.84	26	64.9±2.8	2.0±2.6	3.1±2.1	—	—	20.1±2.9	0.309±0.030
Kemin-Sompio	3.5	2. 2.84	24	63.3±3.0	0.4±0.8	1.4±1.1	72.1±4.1	135.4±6.4	18.3±2.7	0.289±0.036

intracellular muscle fat is structural, and therefore it is less affected by moderate changes in condition than back fat (Fig. 3).

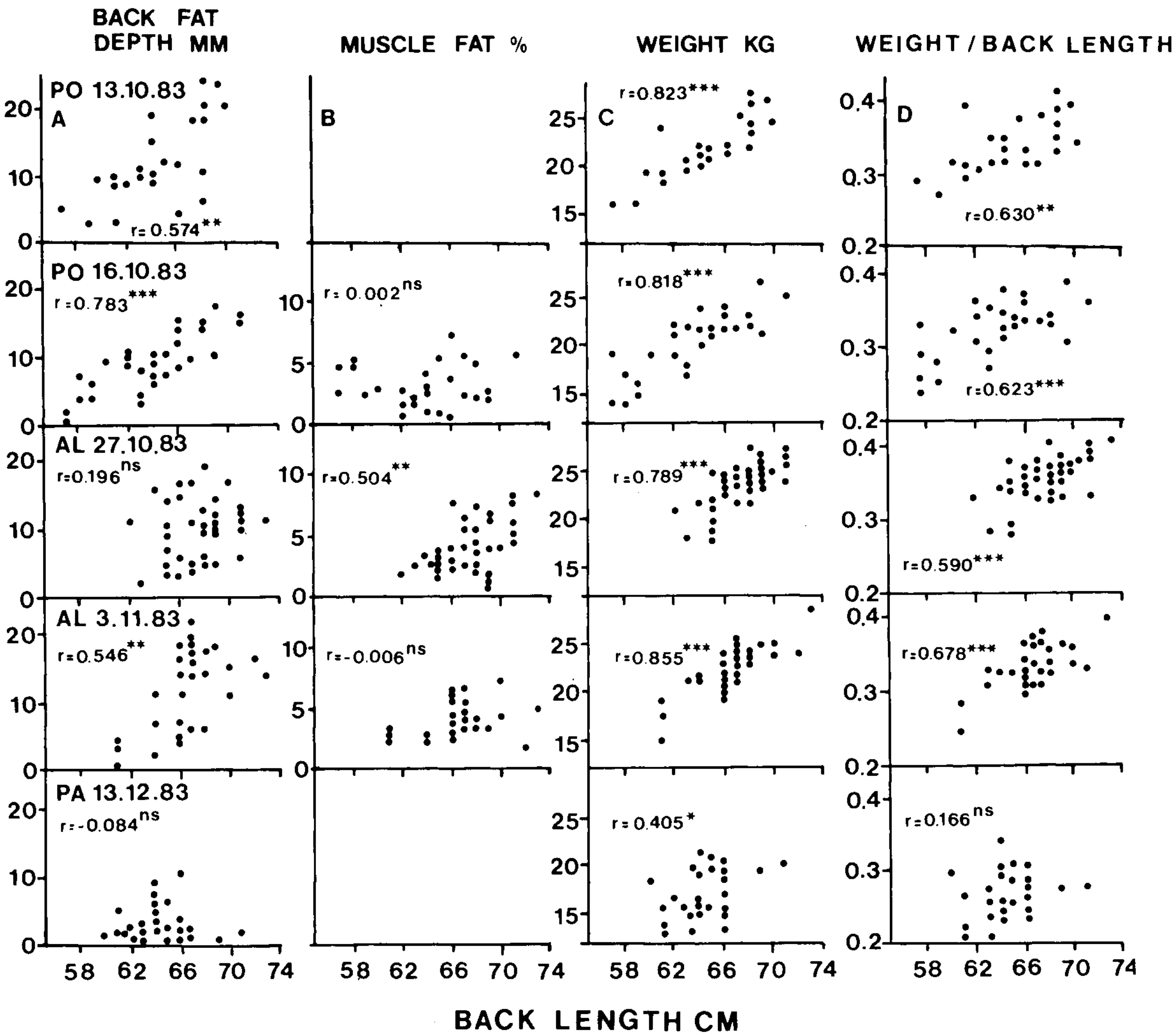
The parabolic relationships between the size and fat indices were typical to Kyrö, Halla and Kemin-Sompio. Analyses of variance revealed (Table 4) that in Kyrö medium-sized calves had significantly higher muscle fat percent than large calves as relative sizes were used. In Halla, the differences between medium-sized calves and small or large calves were significant for both fat indices in several instances irrespective of whether the classification was based on absolute or relative sizes. In Kemin-Sompio the variation in fat indices was clearly smaller, and the differences were not significant.

Table 2. Coefficients of correlation between the body characters and fat measurements in Poikajärvi on 16 October 1983. NS not siginficant, *** p<0.001.

	1	2	3	4	5	6	7
1. Back length	—						
2. Back fat	0.783***	—					
3. Muscle fat	—0.002NS	0.109NS	—				
4. Chest girth	0.823***	0.808***	—0.152NS	—			
5. Sum measure	0.925***	0.829***	—0.080NS	0.938***	—		
6. Weight	0.818***	0.766***	—0.111NS	0.850***	0.846***	—	
7. Weight/back length	0.623***	0.643***	—0.123NS	0.751***	0.694***	0.955***	—

Table 3. Coefficient of correlation between the body characters and fat measurements in Kemin-Sompio on 2 February 1984. NS not significant, * p <0.05, *** p<0.001.

	1	2	3	4	5	6	7
1. Back length	—						
2. Back fat	—0.119NS	—					
3. Muscle fat	0.118NS	0.229NS	—				
4. Chest girth	0.558**	0.033NS	—0.101NS	—			
5. Sum measure	0.821***	—0.066NS	—0.073NS	0.919***	—		
6. Weight	—0.187NS	—0.271NS	0.036NS	—0.219NS	—0.219NS	—	
7. Weight/back length	—0.455***	—0.210NS	—0.010NS	—0.396NS	0.948***	—0.466*	—



Weight

The mean weights (including all male calves slaughtered) from October or November (Muotkatunturi) were inversely correlated with gross density of summer herd (Table 1) (r = —0.809, df = 5, $p < 0.05$); statistics from Kemin-Sompio were not available, and therefore the mean weight from the previous year (20.0 kg) was used (Helle et al. 1983). The positive correlation between back length and carcass weight was significant for the all samples except that from Kemin-Sompio in February (Fig. 2C). The r-values were inversely related to mean carcass weight (r = —0.714, df = 7, $p < 0.05$) suggesting that differences in capacity to maintain body weight were associated with range conditions.

The present material permits only an indirect analysis of size-related differences in weight gain from autumn to mid-winter. We assumed that the condition of Kemin-Sompio calves in October was similar to that found in Poikajärvi on 16. October. This assumption leans on similar back lengths (Table 1) and nearly identical mean weights (Poikajärvi 20.4 kg, Table 1, Kemin-Sompio 20.0 kg). With this assumption the calculated weight loss correlated positively with autumn weight, and the effect of autumn weight was highly significant. (Interaction term in a 2-way ANOVA F = 8.58, $p < 0.001$) (Table 5).

Weight/back length ratio correlated closely with carcass weight (r = 0.986, df = 7, $p < 0.001$), and in 5 samples between October to

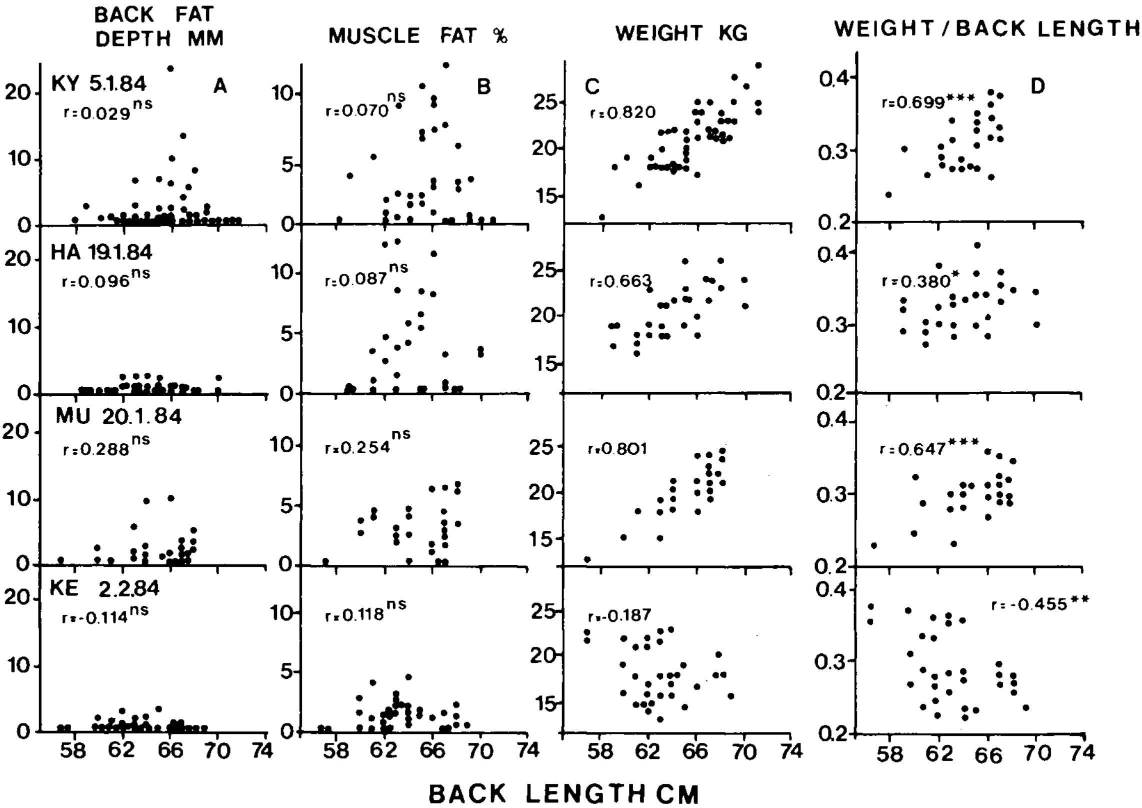


Fig. 2. Relationship between back length and back fat depth (A), muscle fat % (B), carcass weight (C) and weight/back length ratio (D). Locations: Po Poikajärvi, Al Alakylä, Pa Paistunturi, Ky Kyrö, Ha Halla, Mu Muotkatunturi and Ke Kemin-Sompio (see Fig. 1). *** p<0.001, ** p<0.01, * p<0.05, ns non-significant.

January also with back fat depth. The correlation between back length and weight/back length ratio was positive in 8 samples, whilst in the last sample from Kemin-Sompio it was negative (Fig. 2D).

Correlations between body measures and weight

In reindeer breeding, selection has subjected to weight, but in practice weight has commonly been replaced by more convinient sum measure (Varo 1972) or chest girth (Aarak and Lenvik 1980). In this study, these provided quite reliable estimates on body weight in October and November; the r-values ranged for the sum measure between 0.793 and 0.938 (p < 0.001)

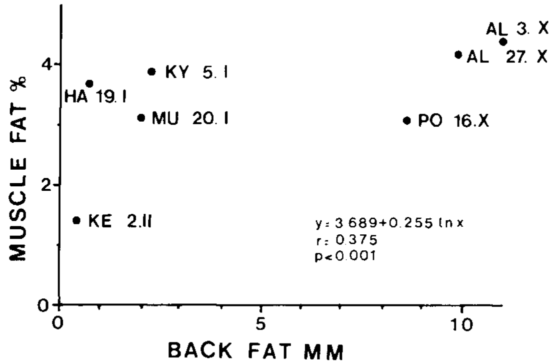


Fig. 3. Relationship between back fat depth and muscle fat percent. The regression has been calculated from the original data. See Fig. 1 for abbreviations.

and for chest girth between 0.788 and 0.871 ($p < 0.001$). However, the correlations weakened with the progress of the winter, and in early February they were nonsignificant and slightly negative (Fig. 4).

Discussion

Size-related changes in body condition

For practical reasons the sampling in this study had to be completed by the beginning of February, leaving the harshest winter months still ahead. However, the parabolic relationships between the size and fat indices and greatest weight loss among large calves found in January and February support the hypothesis on normalizing selection for body size later in winter.

Small calves would be at greater risk because of lower initial reserves at the onset of winter. Some large calves, instead, reach sexual maturity already in their first autumn, and this results in a deterioration of body condition (Zhigunov 1968). In our study, however, even large calves were able to maintain body condition until early November, at least, when the actual rutting season was over (Helle 1980). Thus the loss of body reserves observed in mid-winter should be related to factors other than possible rutting activity exhibited by the calves themselves.

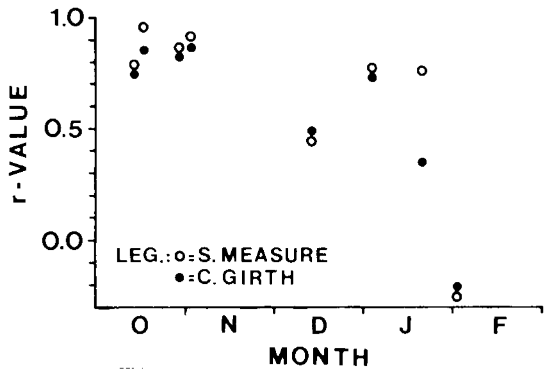


Fig. 4. The r-values between sum measure and carcass weight and chest girth and carcass weight in male calves from October to February.

Espmark (1964) reported that the dominant stag behaves aggressively towards the largest male calves during the rutting season and may chase them away from the harem (Skjenneberg 1965, see also Clutton-Brock et al. 1979). Skogland (1986) reported that large male calves are weaned earlier and disperse earlier than smaller ones. However, in mid-winter food competition becomes harder with increasing snow depth (Helle 1984), which might explain why large calves without maternal support in feeding (including assistance in cratering and occupation of the feeding hole) had to catabolize body reserves at a faster rate.

Table 4. Fat indices in absolute (A) and relative size-classes (according to back length) of male calves in Kyrö, Halla and Kemin-Sompio. Significance of difference was tested by 1 way ANOVA, or, if the other value was 0, by t-test.

	Kyrö					Halla					Kemin-Sompio				
Size (A)	N	Back fat mm	P	Muscle fat %	P	N	Back fat mm	P	Muscle fat %	P	N	Back fat mm	P	Muscle fat %	P
Small (≤61 cm)	4	1.0±1.4		2.6±5.8		7	0.1±0.4		1.4±1.4		8	0.3±0.7		1.4±1.4	
			>0.1		>0.1			<0.05		<0.05			>0.1		>0.1
Medium (62 - 67 cm)	22	3.2±5.8		4.7±4.4		17	1.0±0.9		5.1±4.6		20	0.4±0.9		1.6±1.1	
			>0.1		<0.1			>0.1		<0.1			>0.1		>0.1
Large (≥68 cm)	9	0.6±0.8		2.1±2.2		4	0.7±1.0		0.9±1.7		5	0.0±0.0		1.1±0.7	
	Kyrö					Halla					Kemin-Sompio				
Size (B)	N	Back fat mm	P	Muscle fat %	P	N	Back fat mm	P	Muscle fat %	P	N	Back fat mm	p	Muscle fat %	p
Small (lower quartile)	8	1.6±2.4		3.2±3.3		7	0.1±0.4		1.4±1.9		8	0.3±0.7		1.4±1.4	
			>0.1		>0.1			<0.05		<0.01			>0.1		>0.1
Medium (medium fractile)	18	3.6±6.1		5.5±4.3		14	1.0±1.0		6.2±4.5		17	0.5±0.4		1.8±1.1	
			<0.1		<0.01			>0.1		<0.01			>0.1		<0.1
Large (upper quartile)	9	0.4±0.9		1.4±1.5		7	0.6±0.8		1.5±1.5		8	0.0±0.0		0.9±0.7	

Table 5. Carcass weights (kg, mean ± S.D.) of male calves in different size classes (based on back length) in October and February.

Month	Small (≤61 cm)	N	Medium (62 - 67 cm)	N	Large (≥68 cm)	N
October	16.2±2.1	5	21.1±2.2	15	23.6±2.4	7
February	19.1±2.6	8	18.1±2.9	20	17.8±1.1	5
Weight gain %	+ 17.9		— 14.2		— 24.6	

Normalizing selection and maternal investment

The largest calves were probably born during the first half of the calving season to prime age females having a high body weight (Vostrjakov 1971, Varo 1972, Eloranta and Nieminen 1985). By contrast, the mothers of small-sized calves, are young or old, possess low body weight and gave birth in the latter half of the calving season.

In reindeer, dominant stags exceed mean values in both body size and antler size (Espmark 1964, Bergerud 1974, Prowse et al. 1980), and although it has never been formally demonstrated, they would be expected to be the most successful breeders. In polygynous species, there is normally strong selection for large body size and heavy maternal investment on males is expected (Trivers 1972, Trivers and Willard 1973, Reiter et al. 1978, Clutton-Brock et al. 1982). Indeed, male reindeer calves weigh more at birth (e.g. Varo 1964, Eloranta and Nieminen 1985), and during the first 3 weeks they suckle more than female calves (Kojola and Nieminen 1985). Unlike female calves, the growth rate of males during the first weeks is dependent on the females body weight (Aspi et al. in prep.).

These facts conflict with our hypothesis on normalizing selection for size. Why invest heavily on male offspring, if the result is useless or even detrimental? However, there exists evidence that total preweaning investment does not vary between sexes. If maternal investment favors male offspring, one would expect that females with male calf are in poorer condition in the autumn resulting in, at least, delayed estrus (for red deer (*Cervus elaphus*) see Guiness et al. 1978). Reindeer females clean their antlers before estrus, but the sex of the calf has no influence on the timing of antler cleaning or on the birth date of the next calf (Aspi et al. in prep.).

It is premature to say whether normalizing selection suggested in this study plays here any particular role from the evolutionary point of view. However, normalizing selection weakens the association between maternal investment and the reproductive success of the male offspring.

Practical remarks

The main aim in the management of semi-domesticated reindeer is meat production. This emphasizes the importance of rapid growth and the associated large final body size. The heritability (h_2) of weight is 0.60 in Finnish semi-domesticated reindeer (Varo 1972), indicating that growth rate can be improved by a sensible breeding program. According to Varo's (1972) original recommendations, selection of the males used in breeding should be made on the basis of the sum measure in yearlings, because these have already shown also their capacity to survive the winter. As a consequence of the rapid increase in the harvesting rate of male calves, however, selection is at present made at the age of 5 - 9 months. In the administration of reindeer herding, selection for large body size is still recommended, since Varo (1976) found a positive relationship between calf weight in the autumn and yearling weight (see also Røed 1986). However, Varo's study was carried out in artificial feeding conditions. In opposite to the present results, calves were able to maintain a nearly constant body weight throughout the winter. Therefore, in the beginning of the new growing season large calves weighed more than medium-sized or small calves, and a positive correlation between calf weight in autumn and yearling weight is understandable. In the present case the relationship would be positive if only skeletally large calves were capable to survive the winter and also compensate the weight loss caused by winter by faster growth in summer. That is not known, and therefore selection for medium-sized calves might be the best policy in areas characterized by short food supply and demanding snow conditions. Great variation in body condition in winter occurred even among medium-sized calves, which stresses the importance of more detailed studies on the selection criteria.

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