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Variations in body measurements of wild and semi-domestic reindeer (Rangifer tarandus) in Fennoscandia

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The morphometric variation in seven body characters of 204 adult female reindeer from various wild and semi-domestic populations in Fennoscandia was investigated by multivariate analysis. The wild mountain reindeer (*Rangifer tarandus tarandus* L.) from southern Norway have smaller bodies than those of the Kola Peninsula, a difference that can hardly be due to nutritional factors alone. The wild forest reindeer (*Rangifer tarandus fennicus* Lönn.) differs from both of these in several body measurements and ratios. It has significantly longer legs, both relatively and absolutely, than the wild Norwegian mountain reindeer and semi-domestic animals studied. The Finnish semi-domestic reindeer is in most respects identical with the wild mountain reindeer of southern Norway, which bears out early records claiming the western origin of the present Finnish semi-domestic reindeer. The gene flow from the wild forest reindeer to the semi-domestic forest type appears virtually to have ceased in the southeastern herding co-operatives.

It is concluded that the long legs of the wild forest reindeer are an important adaption to taiga conditions, where the snow cover is usually deep and soft. The mountain types have evolved in areas with hard-packed tundra snow, and consequently the semi-domestic reindeer have difficulty in surviving in coniferous forests, especially in winters with deep, soft snow.

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1. Introduction

Body measurements and ratios are useful taxonomic criteria and are used in *Rangifer* systematics (Banfield 1961). With the exception of the works of Herre (1955) in Finnmark, northernmost Norway, and Vostrjakov (1971) in the Soviet Union, only a few body measurements have been presented for the reindeer populations in Fennoscandia. However, it has long been known that the various populations differ in body characters. In both wild and semi-domestic stocks in Finland and Sweden the differences are clearest between the mountain and forest reindeer forms (Lönnberg 1909, Klemola 1928, Itkonen 1948).

This paper presents data on the body characters of the present Finnish semi-domestic reindeer and the wild populations living in Fennoscandia. The aim of the study was to elucidate the origin and genetic structure of the Finnish semi-domestic reindeer. In addition, the material provided an opportunity to examine the morphological differences between various populations with relation to some external environmental factors, especially snow characteristics.

2. Present reindeer populations in Fennoscandia

The present distribution of the wild and semi-domestic reindeer populations in Fennoscandia is shown in Fig. 1.

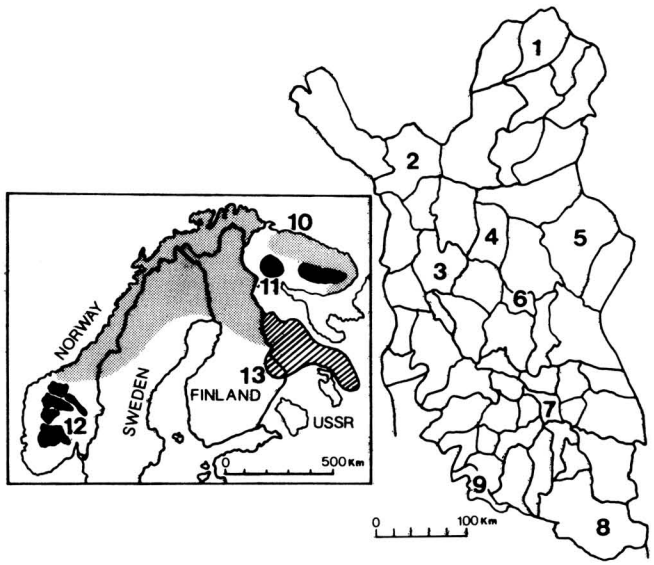

Fig. 1. The present distribution of semi-domestic and wild reindeer in Fennoscandia and the study populations. The figure on the left shows the management area of semi-domestic reindeer (stippled), the populations of the semi-domestic (10) and wild mountain reindeer (11) in the Kola Peninsula and in Norway (12), and the distribution (hatched) of the wild forest reindeer in eastern Finland and in the Soviet Union (13). The Finnish reindeer management area (on the right) shows the herding co-operatives investigated in the study (1 = Utsjoki, Kaldoaivi; 2 = Enontekiö, Näkkälä; 3 = Kittilä, Alakylä; 4 = Sodankylä, Sattasniemi; 5 = Savukoski, Kemin-Sompio; 6 = Pelkosenniemi, Pyhäjärvi; 7 = Posio, Livo; 8 = Hyrynsalmi, Halla; 9 = Ylikiiminki, Kiiminki).

2.1. Wild Fennoscandian mountain reindeer (Rangifer tarandus tarandus L.)

The wild Fennoscandian mountain reindeer is descended from the European prehistoric reindeer, which arrived in Fennoscandia during the wide interstadial of 35 000—40 000 years ago and survived the later cold period on the Norwegian coast (Siivonen 1975). Its original post-glacial range consisted of the entire mountain system from Stavanger Fjord to North Cape, including the mountains of western Sweden, Northern Finland and the Kola Peninsula (Lönnberg 1909, Jacobi 1931, Banfield 1961).

At present wild mountain reindeer are to be found in two distinct main populations. Reimers (1975) reports that the total population living in southern Norway is about 25 000 animals. In the Kola Peninsula the wild mountain reindeer occurs in two subpopulations, together consisting of about 20 000 individuals (Semenov-Tian-Shanskii 1975). According to Banfield (1961), these are identical in skull dimensions with the Norwegian wild mountain reindeer. In Finnish Lapland the wild mountain reindeer was largely wiped out during the 19th century, the last individuals of disappearing at the beginning of the 20th century (Itkonen 1948).

The ecology of the wild mountain reindeer has been investigated in southern Norway by several authors, including Skogland (1974, 1975) and in the Kola Peninsula by Semenov-Tian-Shanskii (1975, 1980).

2.2. Wild forest reindeer (Rangifer tarandus fennicus Lönn.)

The wild forest reindeer reached Fennoscandia from the east or south-east after the last glaciation, but its earlier history is not known in detail (Heptner 1966, Siivonen 1975). Originally it was distributed in Europe throughout almost the whole coniferous forest belt (Banfield 1961, Montonen 1974). Because of over-hunting the number of animals declined and its area of distribution became more restricted over the years. The wild forest reindeer survived in Soviet Karelia, and has spread from there since the 1950s to some areas in eastern Finland (Marvin 1959, Kauko 1961, Segal 1962, Komulainen 1972, Vanninen 1972). Nowadays this population totals 5 000—6 500 individuals, of which the animals in northern Soviet Karelia have interbred with semi-domestic reindeer (Danilov et al. 1978, Sulkava 1980). Taxonomic studies on the wild forest reindeer occurring in Kuhmo, eastern Finland, indicate their racial purity (Siivonen 1972, 1975, Nieminen 1977, 1980). The present status of other European wild forest reindeer populations in the Soviet Union mentioned by Heptner (1966) is unknown. For basic information on the ecology and behaviour of the wild forest reindeer the reader is referred to papers by Marvin (1959), Montonen (1974) and Helle (1980).

2.3. Semi-domestic reindeer (Rangifer tarandus tarandus L.)

In Fennoscandia the old records mention reindeer husbandry for the first time at the end of the 9th century in Norway (Banfield 1961). However, the custom is probably at least 2000 years old (e.g. Itkonen 1948). Extensive reindeer husbandry as practised by Lappish reindeer nomads began in the Middle Ages in the mountains of Scandinavia (Hultblad 1968).

In the 16th and 17th centuries reindeer were reared in eastern Fennoscandia in three apparently relatively distinct main areas. In the 16th century, according to Itkonen (1948), the monastery of Petsamo owned reindeer, and so obviously did the local Scolt Lapps in the Kola Peninsula. In the 17th century Lapps in Tornio Lapland, which included western Finnish Lapland and the present commune of Utsjoki, owned a total of 1 600 reindeer. This reindeer husbandry was characterized by seasonal

migrations between the winter ranges and the coast of the Arctic Ocean.

The third area included several regions in central and northern Finland, where reindeer were introduced from Tornio Lapland early in the 17th century (Itkonen 1948). Attempts to introduce reindeer into central Finland were unsuccessful, and the southern limit of the Finnish reindeer management area as it is at present was established during the 18th century (Alaruikka 1971).

According to taxonomic studies based on skull measurements, the Finnish semi-domestic reindeer population is today genetically homogeneous and identical with the wild Norwegian mountain reindeer, but differs clearly from the wild forest reindeer (Siivonen 1972, 1975, Nieminen 1977, 1980). In this paper the semi-domestic reindeer living in the coniferous forest area is called the semi-domestic forest reindeer in spite of its mountain origin.

The semi-domestic tundra reindeer was introduced into the Kola Peninsula by Komis during the last decades of the 19th century (Semenov-Tian-Shanskii 1975). It originates from the tundra of Malozemelskaja beside the Pechora River (Heptner 1966). In the Kola Peninsula reindeer of this type have interbred with the local semi-domestic reindeer, called skolt reindeer. These animals were introduced later to the shore of the White Sea (Sablina 1960) and some individuals were brought into Finland for experimental breeding (Valmari & Perttunen 1977).

Information of the habits of semi-domestic reindeer has been provided by Itkonen (1948), Alaruikka (1964), Sulkava & Helle (1975) and Pulliainen & Siivonen (1980) in Finland, by Skuncke (1969) in Sweden and by Skjenneberg (1965) in Norway.

3. Material and methods

Animals. Altogether 204 reindeer were measured during autumn and winter in the present study. Only adult females 4 years old or older were used in the study. Their age was determined from the eruption and wear of the teeth (see Banfield 1954, Miller 1974). The material consisted of 180 (living) semi-domestic reindeer from 9 different herding co-operatives ('*paliskunta*' in Finnish) in Finland, 7 (living) semi-domestic reindeer and 5 (living) wild mountain reindeer from the Kola Peninsula, the Soviet Union, 5 (freshly killed) wild mountain reindeer from the Snøhetta area, Norway, and 7 (5 living, 2 dead) wild forest reindeer from Kuhmo, eastern Finland (see Fig. 1).

Body measurements. On each of the reindeer the seven characters were measured to the nearest millimetre with a steel metric rule or callipers (Fig. 2).

Statistical analysis. Multivariate analyses were used to determine how the reindeer groups are related when all seven body characters are considered simultaneously. Principal component and factor analyses were used initially to examine reindeer of unknown provenance. Discriminant analysis was then used for discrimination between samples (see Atchley & Bryant 1975, Kendall 1975). All computations were made with the statistical Data Processing System Survo/71, at the University of Tampere, Finland.

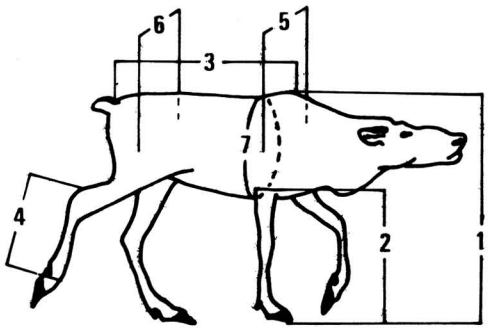

Fig. 2. Body characters taken in the present study. 1 = shoulder height (maximal height from ground to spinous processes of vertebrae), 2 = foreleg length (from ground to end of radio-ulna), 3 = back length (along back from first spinous process to base of tail), 4 = tarsal length, from heel (fibulare) to end of metatarsal, 5 = chest width (at the forelegs), 6 = pelvis width (at the hind legs), 7 = chest circumference (just behind front legs).

4. Results

Measurements of the body characters for different reindeer groups are given in Table 1.

4.1. Principal component and factor analyses

In the calculation of a matrix of correlation coefficients, which is the fundamental matrix used in these analyses, most of the seven body characters were found to be highly correlated (Table 2). The first component and the first factor accounted for 58.4 and 81.2 % of the variation, respectively, and gave a positive weighting to all the characters, and they were clearly measures of body size (characters 1, 2, 3 and 7, see Table 3 and Fig. 2). The second component and second factor accounted for a further 16.9 and 16.3 % of the variation, respectively, giving the greatest weightings to shoulder height, foreleg length and tarsal length (characters 1, 2 and 4). They were clearly measures of body height. The third component and factor accounted for a subsequent 12.2 and 2.5 % of the variation, respectively, giving the greatest weightings mainly to width measurements, and they were therefore measures of body width. The size of the eingenvalues indicates (Table 3) that these three were the only significant components and factors, containing 87.5 and 100 % of the total variation described by the seven characters. Within each sample the body measurements of individuals tended to yield similar component and factor values, indicating

Table 1. Measurements (cm, mean and *SE*) of the body characters for adult female reindeer. For further information on the body characters see Fig. 2.

	N	1. Shoulder height	2. Foreleg length	3. Back length	4. Tarsal length	5. Chest width	6. Pelvis width	7. Chest circumference
Semi-domestic reindeer								
Finland								
1. Utsjoki, Kaldoaivi	15	92.1±0.5	55.5±0.3	86.1±0.6	35.1±0.1	21.2±0.3	22.7±0.1	105.7±0.8
2. Enontekiö, Näkkälä	21	91.1±0.7	56.8±0.3	89.0±0.9	35.6±0.2	22.4±0.3	26.2±0.3	107.0±1.0
3. Kittilä, Alakylä	31	88.7±0.4	56.7±0.4	88.7±0.4	34.5±0.2	22.6±0.3	25.3±0.3	103.5±0.7
4. Sodankylä, Sattasniemi	10	89.1±0.7	56.7±0.4	89.3±0.9	35.6±0.3	20.0±0.5	25.1±0.6	102.9±1.1
5. Savukoski, Kemin-Sompio	35	92.8±0.4	57.7±0.2	84.6±0.5	35.2±0.2	20.0±0.2	25.6±0.2	103.0±0.5
6. Pelkosenniemi, Pyhäjärvi	15	92.3±1.1	57.9±0.4	91.9±0.7	35.5±0.3	22.1±0.2	26.4±0.4	108.7±0.8
7. Posio, Livo	12	89.6±0.7	57.1±0.6	91.7±1.9	34.8±0.2	21.0±0.5	26.5±0.8	104.6±1.2
8. Hyrynsalmi, Halla	33	92.7±0.5	59.7±0.2	89.1±0.7	36.0±0.1	21.1±0.2	25.8±0.3	103.8±0.5
9. Ylikiiminki, Kiiminki	8	91.5±0.3	56.7±0.4	85.1±0.4	35.1±0.2	19.7±0.1	23.2±0.2	100.6±0.6
U.S.S.R.								
10. Kola Peninsula	7	94.4±0.9	59.7±0.7	93.0±1.2	36.7±0.3	21.4±0.5	27.4±0.3	110.0±1.2
Wild Reindeer								
11. Wild mountain reindeer, Kola Peninsula, U.S.S.R.	5	101.2±1.9	64.4±0.6	96.6±1.9	39.8±0.6	22.4±0.7	26.9±0.6	113.8±1.3
12. Wild mountain reindeer, Snøhetta, Norway	5	90.0±1.4	57.2±0.3	87.2±1.6	34.7±0.3	19.5±0.3	26.1±0.8	99.4±0.6
13. Wild forest reindeer, Kuhmo, Finland	7	104.8±1.6	68.3±0.7	87.2±1.1	41.7±0.7	19.8±0.2	22.0±0.3	109.3±1.7

Table 2. Coefficients of correlation between the seven body characters of the reindeer (N = 204). For explanation see Fig. 2. (NS, not significant, *** $P < 0.001$).

	1.	2.	3.	4.	5.	6.	7.
1. Shoulder height	—						
2. Foreleg length	0.704***	—					
3. Back length	0.297***	0.327***	—				
4. Tarsal length	0.609***	0.734***	0.334***	—			
5. Chest width	0.056 NS	0.037 NS	0.385***	0.071 NS	—		
6. Pelvis width	0.072 NS	0.075 NS	0.358***	0.068 NS	0.432***	—	
7. Chest circumference	0.478***	0.372***	0.379***	0.425***	0.473***	0.290***	—

Table 3. The principal components and factors for the seven body characters of the reindeer (N = 204).

	Principal components			Factors		
	1	2	3	1	2	3
Eigenvalue	4288	1243	891	3505	705	161
Trace %	58.4	75.3	87.5	81.2	97.5	100.0
Body character						
1. Shoulder height	24.7	26.3	−7.2	24.9	18.0	−4.3
2. Foreleg length	14.2	10.8	−8.0	15.4	11.6	−5.1
3. Back length	43.3	−19.7	−14.0	36.1	−10.5	−6.0
4. Tarsal length	8.2	5.1	−2.1	9.1	5.5	−2.2
5. Chest width	7.5	−3.7	6.4	7.8	−7.7	5.7
6. Pelvis width	8.8	−1.9	0.2	9.0	−3.6	−3.3
7. Chest circumference	37.5	1.5	23.1	33.4	−6.2	5.8

that the samples were sufficiently homogeneous for multiple discriminant analysis.

4.2. Discriminant analysis

Discriminant analysis indicated that the wild mountain reindeer living in the Kola Peninsula in the Soviet Union and in the Snøhetta area in Norway, and the wild forest reindeer of Kuhmo, in eastern Finland, are totally different in body characters (see Fig. 3). However, the wild mountain reindeer from Norway were very similar to the semi-domestic reindeer of Finland, especially to those belonging to the northern herding co-operatives of Utsjoki, Enontekiö and Kittilä. Small differences existed between the

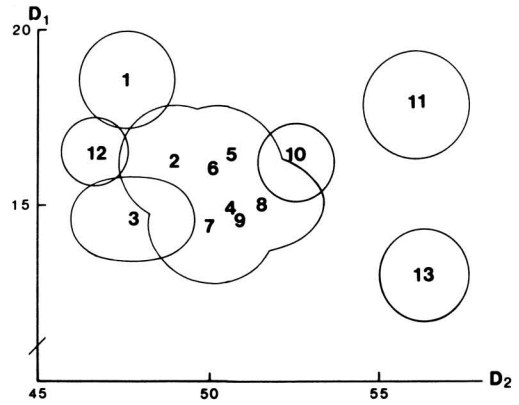

Fig. 3. Discriminant analysis for female reindeer bodies. D_1 and D_2 are discriminators ($x \pm SD$) of seven body characters in semi-domestic reindeer in Finland (1 = Utsjoki, 2 = Enontekiö, 3 = Kittilä, 4 = Sodankylä, 5 = Savukoski, 6 = Pelkosenniemi, 7 = Posio, 8 = Hyrynsalmi, 9 = Ylikiiminki), in semi-domestic (10) and wild mountain (11) reindeer in the Kola Peninsula, in wild mountain reindeer in Norway (12) and in wild forest reindeer in eastern Finland (13). For further information on the types of reindeer and body characters see Figs 1 and 2.

reindeer of the northern and southern herding co-operatives in Finland. The semi-domestic reindeer from the Kola Peninsula had body characters closely similar to the reindeer in the eastern herding co-operatives, e.g. to the reindeer of Savukoski.

4.3. Ratios of body characters

The shoulder height/foreleg length ratio for semi-domestic reindeer was highest in the hinds from Enontekiö (1.66) and lowest in the hinds from Hyrynsalmi (1.55) (Table 4). The foreleg length of the hinds from Hyrynsalmi was significantly ($P < 0.001$) longer than that of the hinds from Utsjoki (see Table 1). The ratios for shoulder height/foreleg length (mean 1.59) and shoulder height/back length (mean 1.03) of the semi-domestic reindeer from Finland were closely similar to those of the semi-domestic reindeer from the Kola Peninsula (1.58 and 1.02), and also to those of the wild mountain reindeer from the Kola Peninsula (1.57 and 1.05) and from Norway (1.57 and 1.03), but differed clearly from those of the wild forest reindeer from Finland (1.53 and 1.20, respectively). The foreleg length of the wild forest reindeer was slightly longer than that of the wild mountain reindeer from the Kola Peninsula, but significantly ($P < 0.001$) longer than that of the wild mountain reindeer from Norway and of the semi-domestic reindeer from the Kola Peninsula and from Finland.

5. Discussion

Many northern ungulates cannot realize their genotypic growth potential because of deficiencies in their diet (e.g. Severinghouse & Gottlieb 1959, Klein 1964, Suttie 1980). In consequence, genetic differences in body measurements are difficult to distinguish from those due to nutritional factors. In domestic ungulates the skeleton has a higher growth priority than muscle and fat tissues (Hammon 1944), and is therefore less affected by nutritional factors. In this respect, moreover, the different skeletal components show differences, and these correspond in the various species studied. For instance, in the domestic sheep and mule deer (*Odocoileus hemionus sitkensis*), the feet have a high growth priority (Palsson & Verges 1952, Klein 1964).

On the basis of these findings the most reliable body measurements for taxonomic use are those which primarily concern the parts of the skeleton that develop early, e.g. the length of the feet. In addition, the results of this study show that body ratios, such as shoulder height/foreleg length and shoulder height/back length are independent of body size and thus primarily of genetic origin.

Table 4. Ratios for shoulder height/foreleg length and shoulder height/back length in female reindeer.

	N	Shoulder/foreleg	Shoulder/back
Semi-domestic reindeer			
Finland			
1. Utsjoki, Kaldoaivi	15	1.66	1.07
2. Enontekiö, Näkkälä	21	1.60	1.02
3. Kittilä, Alakylä	31	1.56	1.00
4. Sodankylä, Sattasniemi	10	1.57	1.00
5. Savukoski, Kemin-Sompio	35	1.61	1.10
6. Pelkosenniemi, Pyhäjärvi	15	1.59	1.00
7. Posio, Livo	12	1.57	0.98
8. Hyrynsalmi, Halla	33	1.55	1.04
9. Ylikiiminki, Kiiminki	8	1.61	1.08
U.S.S.R.			
10. Kola Peninsula	7	1.58	1.02
Wild reindeer			
11. Wild mountain reindeer, Kola Peninsula, U.S.S.R.	5	1.57	1.05
12. Wild mountain reindeer, Snøhetta, Norway	5	1.57	1.03
13. Wild forest reindeer, Kuhmo, Finland	7	1.53	1.20

According to Lönnberg (1909) and Itkonen (1948), the Finnish and Swedish semi-domestic forest reindeer is descended from the wild forest reindeer. However, no historic sources support the contention that reindeer were herded on a large scale in the coniferous forest belt before the introduction of semi-domestic mountain reindeer in the beginning of 17th century (see Itkonen 1948). The skull dimensions show that at least the present Finnish semi-domestic reindeer population is genetically of pure mountain origin (Siivonen 1975, Nieminen 1977, 1980).

It is obvious, however, that the semi-domestic mountain reindeer introduced into the coniferous forest belt interbred there with the wild forest reindeer. In the 17th and 18th centuries the wild forest reindeer population was still extant in many places, whereas the numbers of semi-domestic animals remained low (e.g. Tegengren 1952, Alaruikka 1971). Because of their larger body size, compared to that of the semi-domestic reindeer, the males of the wild forest reindeer have apparently been successful in mating with female semi-domestic animals, hence the similarities in body size and structure between semi-domestic and wild forest reindeer. In fact, such hybrids are recognized nowadays in northern Soviet Karelia (Danilov et al. 1978). The genetic effects of the wild forest reindeer at population level may be expected to appear in Finland in Hyrynsalmi, for there the contacts between semi-domestic and wild forest reindeer have continued to some extent up to the present, almost without interruption.

In the northern part of the coniferous forest belt the semi-domestic forest reindeer, though rapidly disappearing, still occurred as a pure stock until the beginning of the 20th century (Itkonen 1948). The gene flow from the wild forest reindeer to the semi-domestic reindeer decreased with the decline of the wild population and ceased completely at the end of the 19th century (see e.g. Montonen 1974). Simultaneously many reindeer-keeping Lapps with their herds of mountain origin moved to the forest area (Itkonen 1948), increasing the genetic influence of mountain reindeer on the earlier local herds.

In addition, it may be conjectured that some behavioural features characteristic of wild forest reindeer have been actively selected against in the semi-domestic forest stocks. In contrast to the mountain reindeer, wild forest reindeer do not form large post-calving herds (Montonen 1974, Helle 1980). In semi-domestic herds such a habit would be unfavourable because it would hinder control of the movements of the animals and prevent them from going to the areas of neighbouring herding co-operatives.

This study shows that the wild mountain reindeer of the Kola Peninsula, although larger than the Norwegian wild mountain reindeer from Snøhetta and the Finnish semi-domestic reindeer, does not differ from these in body ratios. It is difficult to decide whether this difference is due to phenotypic or genotypic variation.

Of the populations sampled in this study, the wild mountain reindeer in Snøhetta and the semi-domestic reindeer in Enontekiö and Utsjoki have the most similar range conditions. These three areas all have vegetation of the alpine tundra type (Kalliola 1979) and are phenologically identical. Because of heavy grazing pressures the lichen biomasses of the prevailing alpine and subalpine heaths are low (Reimers 1975, Mattila 1980). The vegetation of the most favoured summer ranges consists mainly of the same species (e.g. Kalliola 1939, Skogland 1975). Thus no essential differences in the quality and quantity of the food are likely.

In the Kola Peninsula the ranges show greater diversity, including mountains and coniferous forests as well as open tundra (Semenov-Tian-Shanskii 1975). Later, however, Semenov-Tian-Shanskii (1980) reported that the ranges there were overgrazed because of the high population densities in the 1960s. The animals measured for this study have lived there or on the Finnish side of the frontier in range conditions similar to the local semi-domestic reindeer. Reindeer herders in Enontekiö and Inari told Itkonen (1948) that at the beginning of this century the wild reindeer were 13—30 cm taller than the semi-domestic ones. They also differed from the semi-domestic animals in having longer legs and a paler pelage. Compared with semi-domestic reindeer they had very little body fat. So it may be concluded that their large body size was not due to exceptionally good range conditions. Furthermore, the amount of body fat seems to be, in itself, a taxonomic character. In the Soviet Union, according to Formozov (1970), the fat reserves of reindeer are greater towards the north, being greatest in areas where the winter conditions are most extreme. Finally, the skolt reindeer, which originated from the local wild mountain reindeer in the Kola Peninsula (Semenov-Tian-Shanskii 1975), was known to be the largest of all the semi-domestic reindeer in northern Finland, Sweden and Norway (Itkonen 1948).

These results suggest that the Fennoscandian wild mountain reindeer can be divided into two

subpopulations, which differ genetically. Originally there must obviously have been a cline between the present western and eastern populations. This would support the hypothesis (Hultblad 1968) that the extensive reindeer husbandry in Fennoscandia was begun in the mountains of Scandinavia. Furthermore, the results indicate that the spread of reindeer husbandry from there was due to migration of reindeer-keeping Lapps and their animals into the area northeast of the mountains. In contrast to this general pattern Skolt Lapps domesticated their reindeer from local herds (Semenov-Tian-Shanskii 1975).

The characteristics of the snow cover have been commonly acknowledged to be a critical factor influencing the survival and thus the distribution of northern ungulates (Formozov 1946, Nasimovich 1955, Pruitt 1959). In the ranges of the Fennoscandian reindeer populations there occur two main types of snow accumulation. On open mountains and tundras the hard-packed but, in wind-swept areas, thin tundra snow predominates; in contrast, the coniferous forest belt, especially in eastern Fennoscandia, is characterized by the deep, soft taiga snow (see Pruitt 1970). In eastern Finland the average maximum snow depth exceeds 80 cm (Suomen Kartasto 1960).

The ability to move in snow depends not only on the snow characteristics, but also on the weight-load-on-track and length of leg of the animal. No comparative studies are available on the weight-load-on-track between the various reindeer populations. According to Banfield (1961), the hoof size in wild Fennoscandian mountain reindeer males is 60 × 60 mm and in wild forest reindeer males 110 × 95 mm, which may indicate a considerably lower weight-load-on-track in the wild forest reindeer. The mean lengths of the foreleg varied in the present material from 56 to 68 cm, the difference being greatest between the semi-domestic reindeer of Utsjoki area and the wild forest reindeer. According to Pruitt (1959, 1970), the arctic and subarctic reindeer and caribou populations studied hitherto in this respect, tend to avoid snow over 50—60 cm deep. It is well known to Finnish reindeer herders in forest areas that losses of animals are greatest in winters with deep, soft snow (e.g. Holster 1948). The difficulty of moving in such snow is considered to be partially due to the shortness of the legs (Siivonen 1974); moreover, as Pulliainen (1980) points out, this feature partially explains the vulnerability of semi-domestic reindeer to predation in taiga snow conditions.

In subspecies adapted to taiga areas the threshold of tolerance to deep snow is considerably higher than in open country forms. In Canadian woodland caribou (*Rangifer tarandus caribou* Gmelin) it is about 65 cm (Stardom 1975), which corresponds to the observations made in Finnish wild forest reindeer (Helle, unpubl.). Their ability to travel through deep, soft snow can be explained by their apparently low weight-load-on-track and long legs.

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