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The size of the winter home range of female roe deer *Capreolus capreolus* was studied in Sweden in a boreal area, Grimsö, and in a boreo-nemoral area, Bogesund. The home range size of each roe deer was based on 48-72 radio-locations collected from late January to early March. The average size of the winter home range was similar in the two areas, i.e. about 60 ha. No significant differences were found between home range sizes based on minimum convex polygon and harmonic mean 95%. The mean size of core areas (harmonic mean 50%) differed significantly between study areas. Snow depth was identified as an important factor influencing the size of home ranges. In the boreal forest, snow cover lowered the availability of the main food for the roe deer, i.e. dwarf-shrubs, resulting in roe deer concentrating around artificial feeding sites.

Key words: roe deer, Capreolus capreolus, home range size, boreal forest, boreo-nemoral forest, snow, artificial feeding

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The home range size of deer is affected by several factors, some of which show considerable spatial and temporal variation (Beier & McCullough 1989). Roe deer *Capreolus capreolus* occupy the smallest home ranges among Cervideae in northern Europe (Putman 1988). However, large intraspecific variation is found in home range size, related to differences in environmental conditions. Home range size seems to be related to habitat productivity as well as to habitat fragmentation (e.g. Thor 1990, Andersen et al. 1995). Studies in England have shown a correlation between home range size and nitrogen value of the vegetation (Johnson 1982). Visibility within the home range may also influence its size (Cibien & Sempéré 1989, Andersen et al. 1995). Furthermore, factors directly or indirectly influencing resource availability also affect home range size. It is generally accepted that, regardless of species, the average size of a home range decreases as population density increases (Sanderson 1966), as has been demonstrated for roe deer (Ellenberg 1978, Vincent et al. 1983). Resource availability may decrease with increasing population density, thereby increasing competition between animals and causing solitary deer such as roe deer to explore smaller areas.

In alpine and boreal environments, snow is the main factor affecting habitat utilisation by deer in winter, by decreasing food availability and, to some extent, by limiting mobility (e.g. Thor 1990, Pauley et al. 1993, Schmidt 1993).

Finally, artificial feeding during winter, which is a common management practice for roe deer in Sweden, influences the movements of the animals and their strategy of energy conservation, consequently affecting the size of the winter home range (Cederlund 1981, Schmidt 1993). When snow is deep, roe deer may restrict their movements, but increase the size of their home range in order to include artificial feeding sites situated near settlements (Cederlund 1982). Artificial forage has a higher nutritive value than dwarf-shrubs, and the access to the feeding sites is probably limited by their distribution and competition between animals.

The objectives of this study were to examine factors influencing the size of the winter home range of roe deer. Comparisons were made between two forest areas in central Sweden differing in roe deer density, resource availability and snow cover. We predicted that: 1) Home range size is larger in a boreal area than in a boreo-nemoral area, because the former is poorer in food resources, and because the roe deer population is less numerous than in the boreo-nemoral area; 2) Roe deer feed mainly on dwarf-shrubs in snow-free conditions, and on dwarf-shrubs and artificial forage if dwarf-shrub availability is restricted by snow cover. Thus, when food availability is restricted due to snow depth, the roe deer concentrate around feeding sites.

Study areas and methods

Radio-tracking was conducted in two study areas: Bogesund (1,400 ha; ca 15 m a.s.l.; 59°23'N, 18°15'E) located within the boreo-nemoral region, only 15 km north of Stockholm, and Grimsö (1,900 ha; ca 100 m a.s.l.; 59°43'N, 15°13'E) situated on the southern fringe of the taiga. In both areas, the forest (80% of the study areas) is dominated by Norway spruce *Picea abies* and Scots pine *Pinus sylvestris*. The landscape at Bogesund is typical of the southern coniferous zone, with oak *Quercus robur* in mixed and deciduous forests intermixed with rocky outcrops and agricultural land. On the other hand, Grimsö is characterised by an abundance of large mires (Table 1).

A vegetation survey made after snow-melt showed that the proportion of the ground covered with vegetation (excluding mosses and lichens) was 12.7% at Grimsö and 14.3% at Bogesund (Guillet 1994). Dwarf-shrubs constituted 55% of the total plant cover at Grimsö and 31% at Bogesund. Cover of trees and shrubs (parts of vegetation < 1.5 m) at Bogesund was twice that at Grimsö.

Snow covers the ground during a shorter period at Bogesund (January-March; SMHI 1994) than at Grimsö (December-April). Average snow depth reaches 30 cm in January at Grimsö, and 10 cm at Bogesund (long-term mean 1931-1960, Pershagen 1969). The winter of 1994 was fairly normal when considering snow conditions (SMHI 1994 and Table 2).

Table 1. Composition of the study areas (in %) according to land types and forest age classes (% of forest area).

Land type	Composition of study area: Bogesund	Grimsö
Forest	81	79
Mire	1	17
Rocky outcrop	8	2
Field	6	0
Pasture	4	2
Forest class		
Clear-cut	3	9
Young plantation	28	27
Pole-sized stand	23	32
Mature forest	46	32

Table 2. Snow depth (in cm) measured in five different habitat types at Bogesund and Grimsö, 1 February 1994.

Habitat	Snow depth: Bogesund	Grimsö
Open field	21	34
Clear-cut	18	49
Pine plantation	9	63
Pole-sized coniferous stand	10	25
Mature coniferous forest	9	20

Based on pellet-group surveys and the Petersen-Lincoln index, the winter density of roe deer was estimated at 8 animals/km^2 at Grimsö (G. Cederlund, pers. obs.) and 12 animals/km^2 at Bogesund (P. Kjellander, pers. comm.).

Because of trapping of roe deer, artificial food was provided in the two study areas. There were 17 feeding sites at Bogesund and eight at Grimsö. From November until late March, each site was provided with a weekly amount of 50 kg food.

From early January to early March, radio-tracking was conducted on 12 female roe deer at Bogesund; 10 females were radio-tracked at Grimsö from early January to mid-February. Portable radio-tracking equipment was used to locate the animals by triangulation from fixed points along roads or hills. Radio-collars weighed 200-250 g, and transmitters functioned in the 151 MHz range. The radio-tracking was done twice a day and two consecutive locations were separated by 12-13 hour periods to minimise dependence. The tracking was delayed one hour every day in order for the whole 24-hour period to have been covered at least twice by the end of the study period. Does were located 48-72 times each, resulting in a total of 490 locations at Grimsö and 752 at Bogesund. A mean deviation between actual and observed positions of about 50 m within 1 km of a target collar was indicated in 10 non-systematic tests. Locations with error polygons larger than one hectare were excluded.

We first estimated the size of the home range using three methods: 1) the harmonic mean method (Dixon & Chapman 1980) encompassing the 95% isopleth based on a grid system of 100 × 100 m, 2) an adaptive kernel method encompassing the 95% isopleth with a smoothing parameter of five chosen subjectively (Worton 1989), and 3) the minimum convex polygon method. The home range as estimated by the minimum convex polygon was similar in size to that estimated by the harmonic mean

Table 3. Mean size (± SD) of home ranges and core areas (in ha) among female roe deer at Bogesund (N=12) and Grimsö (N=10). The t-test was used to compare means within each column.

	Home range				Core area	
	Minimum convex polygon		Harmonic mean 95%		Harmonic mean 50%	
Study area	Mean	SD	Mean	SD	Mean	SD
Bogesund	57	13	59	14	12	3
Grimsö	59	30	68	26	9	3
t	0.25		1.02		2.81	
p <	0.80		0.30		0.02	

95% (Guillet 1994). The home range as estimated by the kernel method was similar in size to that estimated by the harmonic mean method (unpaired T-test with unequal variances; Bogesund: 70 and 59 ha, respectively, t = 1.76, df = 22, P = 0.0922; Grimsö: 85 and 68 ha, respectively, t = 1.03, df = 20, P = 0.3172). We therefore chose to use the harmonic mean measure of the home range in our study, because the method is simpler than the kernel method and also allows studies of home range utilisation (*cf.* Guillet et al. 1995, Guillet et al. in prep.), and the minimum convex polygon estimation in order to facilitate comparison with other home range studies.

The 50% harmonic mean isopleth was found to be suitable to delimit the core area (Harris et al. 1990, Guillet 1994).

The effect of artificial feeding was compared between the two study areas by calculating preference indices for concentric zones spaced 50 m around feeding sites. Preference index (PI) =

$$\frac{\text{observed number of locations in the zone}}{\text{number of locations as expected by a random distribution in the home range}}$$

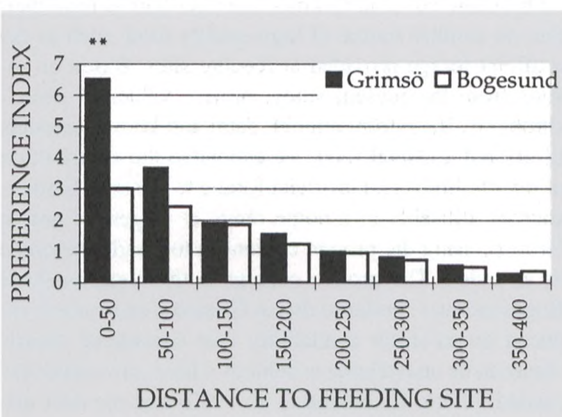

Figure 1. Home range utilisation by roe deer in relation to the distance (in metres) to artificial feeding sites at Grimsö and at Bogesund; ** indicates significant difference between the two study areas, P < 0.01.

with preference when PI > 1 and avoidance when PI < 1.

A χ^2-test was used to determine if feeding sites influenced home range utilisation. A χ^2-test associated with the Neu et al. (1974) method was used to compare home range utilisation between the two study areas.

Results

The mean size of the winter home range estimated either by the harmonic mean or by the minimum convex polygon method did not differ significantly between the two study areas (Table 3).

The mean core area was 41% larger at Bogesund than at Grimsö. The home range of roe deer contained, on average, 1.9 core areas at Bogesund and 1.2 at Grimsö (t = 1.96; df = 20; P > 0.05).

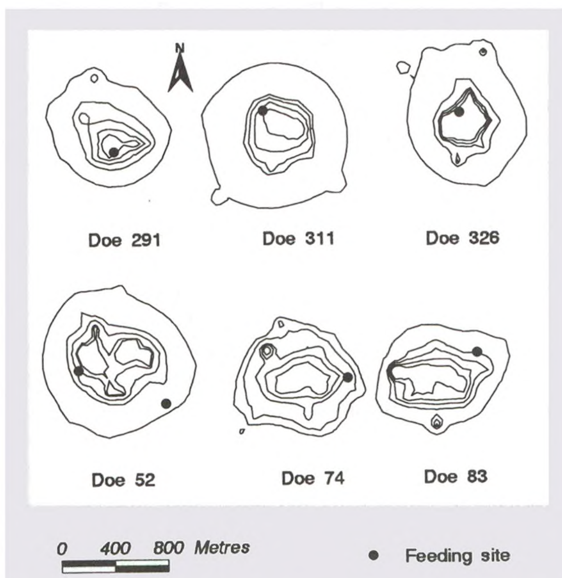

Figure 2. Use of winter home range by roe deer and position of feeding sites: three examples from Grimsö (doe nos 291, 311 and 326) and from Bogesund (doe nos 52, 74 and 83). Areas are delimited by harmonic mean calculation for 95, 80, 65, 50 and 35% of the locations, respectively

Feeding sites influenced home range use in both study areas (Bogesund: $\chi^2 = 79$; df = 8; $P < 0.0001$; Grimsö: $\chi^2 = 103$; df = 8; $P < 0.0001$). Use of the area up to 50 m from artificial feeding sites was twice as high at Grimsö than at Bogesund ($P < 0.01$; Fig. 1). However, the effect of feeding sites on the use of the whole home range did not differ significantly between the two study areas ($\chi^2 = 11$; df = 8; $P > 0.20$). In the 12 home ranges at Bogesund 16 feeding sites were included, but only three of them were included in core areas. On the other hand, 9 out of 10 feeding sites present in the 10 home ranges at Grimsö were included in core areas and six of 10 were located within the 35% harmonic mean isopleth (Fig. 2). The concentration of locations around the feeding site at Grimsö was confirmed by the small size of the core area (see Table 3).

Discussion

The average size of the winter home range among female roe deer at Bogesund in the boreo-nemoral zone was similar (about 60 ha) to that at Grimsö in the boreal zone. Fairly similar sizes were found in other European studies: the winter home range of female roe deer was 58 ha in a forest habitat in France (population density 6 animals/km^2; Vincent et al. 1983). The winter home range of adult does varied between 39 and 59 ha on an island mainly composed of open land in Norway (concave polygon; 10 to 40 animals/km^2; Andersen et al. 1995). Annual home ranges at Kalø in Denmark were 29 ha in a forest habitat and 58 ha in a habitat composed of open land and forest (20 animals/km^2; Jeppesen 1990). In a coniferous forest in Great Britain, does with access to fields occupied average home ranges of 114 ha in winter (minimum convex polygon; 60 ha as estimated with the harmonic mean 95% isopleth; 9 animals/km^2; Chapman et al. 1993).

Ellenberg (1978) showed that home range size decreased when population density increased. When roe deer density was about 3 animals/km^2 in 1975-77 at Grimsö, Cederlund (1982) found a home range of 108 ha for female roe deer during the entire winter, compared with 59 ha in the winter of 1993-94 when roe deer density was 8 animals/km^2. Although we did not follow the roe deer during the entire winter in 1994, the larger home range size in 1975-77 indicates a negative correlation between population density and home range size. However, considering only the roe deer population, home range size was supposed to be larger at Grimsö than at Bogesund, the latter area having the highest population density, which contradicts the general relationship.

Thus, population density of roe deer alone cannot explain home range size. Abundance and distribution of resources certainly play an important role as well. Regarding vegetation cover, the two study areas were fairly similar after the winter. However, food was generally more available at Bogesund than at Grimsö. The thin snow covering the ground at Bogesund for two months probably did not affect food availability. In contrast, snow was rather deep in some forest stands at Grimsö. Cederlund (1982) found that female roe deer responded to increasing snow depth by reducing their daily range, while males covered a similar range. This was supported by Thor (1990), who suggested that it is crucial for the roe deer to move as little as possible in severe snow conditions, because of energetic aspects. Thus, it was not surprising to find the does concentrating in small core areas at Grimsö, while core areas were larger at Bogesund.

In both study areas, the deer were influenced by the artificial feeding (see Fig. 1). All the home ranges of radio-tracked female roe deer included at least one feeding site, possibly being a result of the regular distribution of feeding sites over the areas. Our data could not be used to confirm that establishment of home range borders depended on location of feeding sites, mainly because the radio-tracked does had been trapped using such trap-feeding sites.

Roe deer are particularly selective towards high-quality food (Drodz & Osiecki 1973, Hofmann 1989, Holand 1992). Reduced access to high-quality food during severe winter conditions may cause high mortality from emaciation (Borg 1970, Holand 1994). The quality of artificial forage provided at feeding sites was higher than that of any forest plant. This may explain why areas around feeding sites were frequented more by roe deer than the rest of their home ranges, both at Bogesund and at Grimsö. But use of the first 50 m from feeding sites was considerably higher at Grimsö than at Bogesund, in spite of high trap density at Bogesund. Considering that availability of the main food for the roe deer, dwarf-shrubs, was affected by snow cover at Grimsö, roe deer had to base their diet on another source of high-quality food, such as the artificial forage provided at feeding sites. Based on results from the present study, protein values of dwarf-shrubs (R. Bergström unpubl. data) and known amounts of offered artificial food, we estimated the contribution of dwarf-shrubs and artificial forage to the total food resources utilisable in a home range at Bogesund and at Grimsö, using the protein content in tonnes/home range as an index. The protein content in the home range at Bogesund was similar to that at Grimsö if snow cover reduced dwarf-shrub availability (we considered dwarf-shrubs to be unavailable in habitats where snow depth exceeded 50 cm; Cederlund et al. 1980) and roe deer utilised artificial feeding. A concentration around feeding sites resulted in roe deer having less need to explore further areas at Grimsö. Consequently, home range and core area were smaller compared with winters with 'natural' resources available at Grimsö, while at Bogesund use of the home range was less affected by artificial feeding.

In conclusion, we believe that the ultimate factor influencing the size of the winter home range among female roe deer was snow depth. Snow conditions at Grimsö reduced mobility and food availability, thus increasing the attraction of roe deer to artificial feeding sites. This hypothesis could be tested, for example, by conducting experiments comparing situations with and without supplemental feeding for the roe deer in neighbouring areas where the other factors, population density and snow depth, could be controlled.

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References

Andersen, R., Linnell, J. & Aanes, R. 1995: Rådyr i kulturlandskapet. Slutrapport. - Norwegian Institute for Nature Research, Fagrapport 10: 1-80. (In Norwegian).

Beier, P. & McCullough, D.R. 1989: Factors influencing white-tailed deer activity patterns and habitat use. - Wildlife Monographs 109: 1- 51.

Borg, K. 1970: On mortality and reproduction of roe deer in Sweden during the period 1948-1969. - Viltrevy 7: 121-129.

Cederlund, G. 1981: Some aspects of roe deer (Capreolus capreolus L.) winter ecology in Sweden. - PhD Thesis, University of Stockholm, Sweden, 194 pp.

Cederlund, G. 1982: Mobility response of roe deer (Capreolus capreolus L.) to snow depth in a boreal habitat. - Swedish Wildlife Research 12(2): 37-68.

Cederlund, G., Ljungkvist, H., Markgren, G. & Stålfelt, F. 1980: Foods of moose and roe deer at Grimsö in Central Sweden - Results of rumen content analysis. - Viltrevy 11(4): 168-247.

Cibien, C. & Sempéré, A. 1989: Food availability as a factor in habitat use by roe deer. - Acta Theriologica 34(7): 111-123.

Chapman, N.G., Claydon, K., Claydon, M., Forde, P.G. & Harris, S. 1993: Sympatric populations of muntjac (Muntiacus reevesi) and roe deer (Capreolus capreolus): a comparative analysis of their ranging behaviour, social organization and activity. - Journal of Zoology (London) 229: 623-640.

Dixon, K.R. & Chapman, J.A. 1980: Harmonic mean measure of animal activity areas. - Ecology 61: 1040-1044.

Drodz, A. & Osiecki, A. 1973: Intake and digestion of natural foods by roe deer. - Acta Theriologica 18: 81-91.

Ellenberg, H. 1978: Zur Populationsökologie des Rehes (Capreolus capreolus L., Cervidae) in Mitteleuropa. - Spixiana, Suppl. 2: 1-11. (In German).

Guillet, C. 1994: Winter home range and habitat use of roe deer in two forest environments of Sweden. - Mémoire de stage 3éme année Formation des Ingénieurs Forestiers de l'E.N.G.R.E.F., Nancy, France, 79 pp.

Guillet, C., Bergström, R., Cederlund, G., Bergström, J. & Ballon, P. 1995: Comparison of telemetry and pellet-group counts for determining habitat selectivity by roe deer (Capreolus capreolus) in winter. - Gibier Faune Sauvage, Game and Wildlife 12: 253-269.

Harris, S., Cresswell, P., Forde, P.G., Trewhella, W.J., Woollard, T. & Wray, S. 1990: Home-range analysis using radio-tracking data - a review of problems and techniques particularly applied to the study of mammals. - Mammal Review 20(2-3): 97-123.

Hofmann, R.R. 1989: Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. - Oecologia 78: 443-457.

Holand, O. 1992: Winter digestive strategy of a concentrate selector in Norway: the European roe deer. - Canadian Journal of Zoology 70: 1331-1335.

Holand, O. 1994: Seasonal dynamics of digestion in relation to diet quality and intake in European roe deer (Capreolus capreolus). - Oecologia 98: 274-279.

Jeppesen, J.L., 1990: Home range and movements of free-ranging roe deer (Capreolus capreolus) at Kalø. - Danish Review of Game Biology 14(1): 1-14.

Johnson, T. 1982: Habitat influences on roe deer. - Game Conservancy 13: 87-90.

Neu, C.W., Byers, C.R. & Peek, J.M. 1974: A technique for analysis of utilization-availability data. - Journal of Wildlife Management 38(3): 541-545.

Pauley, G.R., Peek, J.M. & Zager, P. 1993: Predicting white-tailed deer habitat use in Northern Idaho. - Journal of Wildlife Management 57(4): 904-913.

Pershagen, P. 1969: Snötäcket i Sverige 1931-1960. - Swedish Meteorological and Hydrological Institute, Meddelanden, Serie A, Nr 5, 154 pp. (In Swedish).

Putman, R. 1988: The natural history of deer. - Christopher Helm, London, 191 pp.

Sanderson, G.C. 1966: The study of mammal movements - a review. - Journal of Wildlife Management 30(1): 215-235.

Schmidt, K. 1993: Winter ecology of non-migratory Alpine red deer. - Oecologia 95: 226-233.

SMHI (Swedish Meteorological and Hydrological Institute) 1994: Väder och vatten. Monthly reports. (In Swedish).

Thor, G. 1990: How can does get more food than bucks? Habitat use of roe deer in the Bavarian forest. - In: Myrberget, S. (Ed.); Transactions of 19th I.U.G.B. Congress, Trondheim 1989 Vol.I: 49-52.

Vincent, J.P., Bideau, E., Quéré, J.P. & Angibault, J.M. 1983: Occupation de l'espace chez le chevreuil (Capreolus capreolus L.). II. Cas des femelles. - Acta Theriologica/Oecologica Applicata 4(4): 379-389. (In French).

Worton, B.J. 1989: Kernel methods for estimating the utilization distribution in home-range studies. - Ecology 70(1): 164-168.