

Movements and home range dynamics of Roe Deer, *Capreolus capreolus* L. in southeastern Norway

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Thirty-three Roe deer were radio-collared on a winter feeding site near the coast in SE Norway during 1984—87. Nineteen of the animals remained year-round within 2 km of the feeding site. The others migrated an average of 8 km to their summer ranges, but generally returned to the feeding site each fall. During summer bucks defended territories averaging 34.8 ha. Related does appeared to stay in groups with home ranges adjacent to each other and there was an extensive overlap in area use within a group, but less so between groups. Average home range size of does was 38.4 ha. Home ranges of mothers and daughters tended to separate as the daughters grew older. Most migrating animals moved to the east and had summer ranges in the interior, where winter death rate was expected to be high. Apparently migrating animals were most likely to find unoccupied territories in this area.

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INTRODUCTION

Territoriality and home range use in Roe deer *Capreolus capreolus* (L.) are well documented through studies in continental Europe and Denmark (Kurt 1968, Bramley 1970, Strandgaard 1972). Studies have been conducted in one area in Sweden (Cederlund 1983), while in Norway no information is available on social organization of wild Roe deer. Sizes of territories and home ranges appear to vary between areas in relation to habitat quality (Bobek 1977), and this may also be the case in Norway.

During winter Roe deer do not defend territories but tend to congregate in larger groups (Strandgaard 1972, Cederlund 1981). Migrations between summer and winter ranges appear related to snow depth and variations in the availability of forage (Formozov 1946, Schloeth 1972, Robin 1975). In the Kalö area of Denmark, where snow covers the ground only during short periods each winter, Roe deer do not migrate. In mid-Sweden Roe deer are stationary during winters of moderate snow depth, but during win-

ters of heavy snow some animals travel to artificial feeding sites (Cederlund 1981). In Norway, congregations of Roe deer at artificial feeding sites occur regularly during winter, but it is not known whether these animals have been recruited from the immediate vicinity of the feeding site or have undertaken long-distance migrations.

Here we report the first extensive study of Roe deer in Norway using radiocollared animals. Roe deer were trapped and radiocollared at an over-wintering area where they had been fed by local farmers for many years. This area was a 50 ha forest/pasture range with several feeding sites. Radiocollared animals were followed over a 4-year period, and we investigated occurrence, timing and extent of migration, as well as social organization of stationary animals during summer.

STUDY AREA AND METHODS

The study was conducted in the forests of the Norwegian Agricultural University at Ås (59° 40' N, 10° 47' E), about 15 km from the coast. The forests are interspersed with grain fields and pastures (see Selås et al. (1991), for a detailed description of the study area). The

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study area is located within the area of the densest Roe deer population in Norway, with an estimated minimum of 10 animals km⁻² (Bjar and Selås 1987).

Thirty-three Roe deer (14 bucks and 19 does) were radiocollared during the winters of 1984–87. The transmitters, 150 MHz were moulded with a battery in a epoxy resin and attached to PVC collars. The entire assembly weighed 250–300 g. Animal positions were determined by triangulation, using a handheld antenna and a compass. Compass bearings were taken from at least three positions at a distance of 50–100 m. Accuracy of the bearings was accepted when the longest diagonal of the error polygons did not exceed 20 m (Kenward 1987). Twenty-one Roe deer stayed year-round within 2 km of the winter feeding site: they were defined as stationary and followed from 1 to 4 years. They were plotted on average every second day throughout the summers of the study period. During 1986 and 1987 the animals were plotted once every hour for 15 24-hour periods throughout the summers. During the 4-year study we obtained 4460 map positions.

Boundaries of home ranges for separate years and animals were determined according to the method of Harvey and Barbour (1965), as modified by Wegge and Larsen (1987). The minimum number of positions needed to obtain a reliable estimate of home range size was based on the method of Kenward (1987). Thirty positions, regarded as the standard for interspecific as well as intraspecific comparisons by Kenward (1987), were also found well suited for this study.

RESULTS

More does (13) than bucks (6) were stationary (migrated less than 2 km), but the difference was not significant ($\chi^2 = 2.16$, $p = 0.142$). Migrating 1-year-old animals stayed in the winter area until late May/early June, while older animals left during late April/early May (Fig. 1). There was a tendency for bucks to leave earlier as they grew older. All bucks captured by us during their first winter migrated during the following spring, e.g. as one-year-olds. Four animals, one 1-year old and three 2-years-old dispersed (did not return).

Prior to their final fall migration 1-year-old bucks usually made short excursions out-

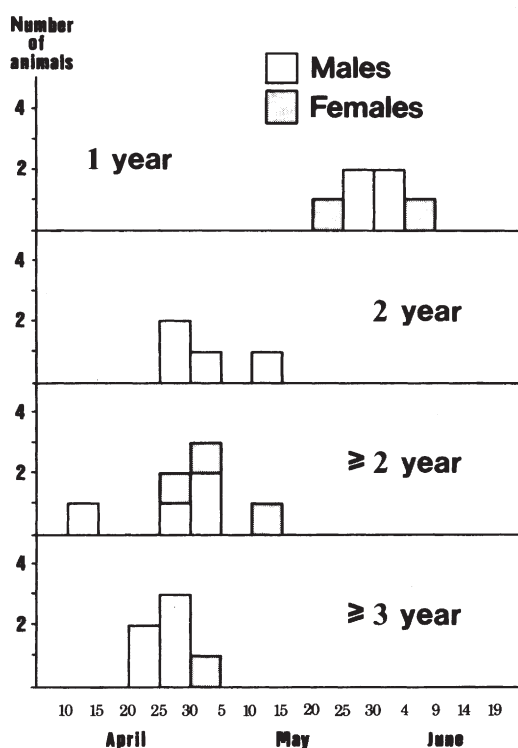


Fig. 1. Dates of departure from winter range for male and female Roe deer at Ås, Norway.

side their home range. These excursions lasted from one to several days and were in the general direction of their winter range.

Both sexes used approximately the same ranges each summer. No animals migrated to the west (towards the coast), and only one to the northwest; most animals had their summer ranges to the east or southeast (towards the interior) (Fig. 2). The average distance between summer and winter ranges was 8.2 km. Does generally migrated longer distances ($\bar{x} = 10.6 \text{ km} \pm \text{Se} = 9.1$) than bucks ($\bar{x} = 6.6 \text{ km} \pm \text{SE} = 3.9$), but the difference was not significant (Mann-Whitney U-test, $p > 0.1$). The longest migration (25 km) was by a 1-year-old doe that never returned to the winter area. Also a 2-year-old buck left the winter area the spring after he was captured and never returned. Two bucks radio-collared as yearlings returned after their first migration, but left the winter area permanently when they were 2 years old. The other migrating animals returned to the winter area each fall, usually during October or November.

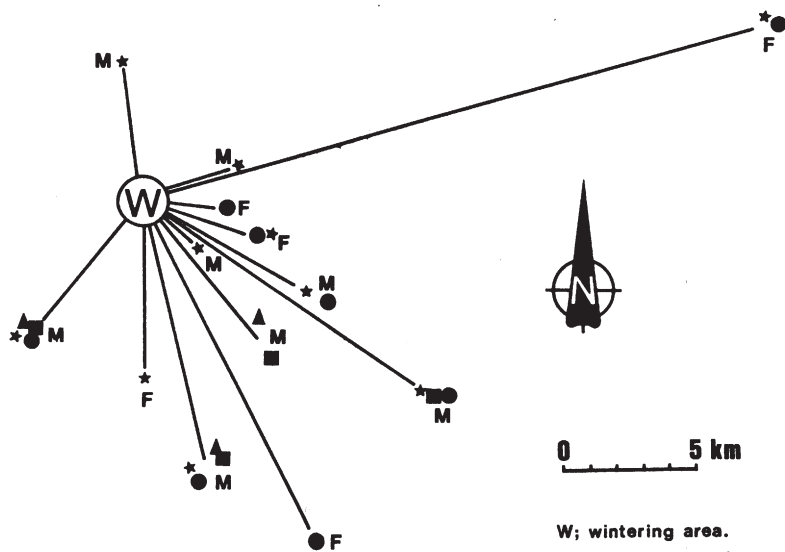


Fig. 2. Distance of migration and location of summer ranges of Roe deer in relation to a winter feeding area at Ås.

M = male, F = female, each letter represents an individual animal.

W; wintering area.

Summer ranges; ▲ 1984, ■ 1985, ● 1986, ★ 1987.

There was no clear relation between age/sex and date of return, but there was a tendency for older bucks to return later than younger animals.

The average size of home ranges of bucks ($\bar{x} = 34.8$ ha, \pm SE = 9.9 range 18.8—50.5 ha) was slightly smaller than that of does ($\bar{x} = 38.4$ ha, \pm SE = 27.0, range 8.8—90.9 ha) but not significantly so (Mann-Whitney U-test, $p > 0.1$) (Figs. 3 and 4). Older does had smaller average home ranges ($N = 6$, $\bar{x} = 26.6$ ha, \pm SE = 19.7) than one-year-old does ($N = 5$, $\bar{x} = 47.8$ ha, \pm SE = 29.8), but the difference was not significant (Mann-Whitney U-test, $p > 0.1$), nor was there any significant difference in size of home range between one yearling buck (no. 257, fig. 3) and adult bucks.

Generally, home ranges of different bucks did not overlap (Fig. 2). However, twice during the summer of 1986, one buck no. 066, moved into the home range of another buck no. 256 (Fig. 3). During the first visit no. 256 used a border area of his home range and the two animals did not appear to have contact. The second time when no. 066 trespassed, no. 256 was ill and dying. Although some change of home range borders occurred, bucks generally used the same area each summer. The year after no. 256 died, buck no. 257 took over his home range, maintaining approximately the same borders (Fig. 3). When no. 066 died his home range was shared by buck no. 257 (neighbour), and a new buck that moved in (no. 055). The home range of no. 055 consisted of two separate areas approxi-

mately 1 km apart (Fig. 3). He was located twice as he moved between his home ranges. As the summer progressed movement between the two areas decreased.

Home ranges of does were not evenly spaced over the study area but occurred in groups. Within groups home ranges overlapped extensively, but there was less overlap between groups (Fig. 4). Group A consisted of no. 384, her daughter, no. 106, and possibly no. 286. An old doe (no. 046), her daughter (no. 026), and possibly her daughters, no. 356 and no. 476, made up group B. Group C consisted of no. 236, no. 486 and group D of no. 346, no. 316, no. 196 and possibly no. 223. Each group used approximately the same area during the summers of the study period. There were also unmarked does in the area, but little is known of their use of the area. Some animals died in the course of the study (Fig. 4).

During the first three years of the study we recorded 11 excursions by does, of 1 km or more, outside their home ranges. Five of these were by yearlings around the time of calving, four were during August by older does that apparently were chased by bucks during the rut, one was in June and one in September.

The home range use of no. 046 and her daughter, no. 026, illustrate the development of home range use between related animals. The daughter used the same home range as her mother during her second summer (1985), but usually stayed some distance

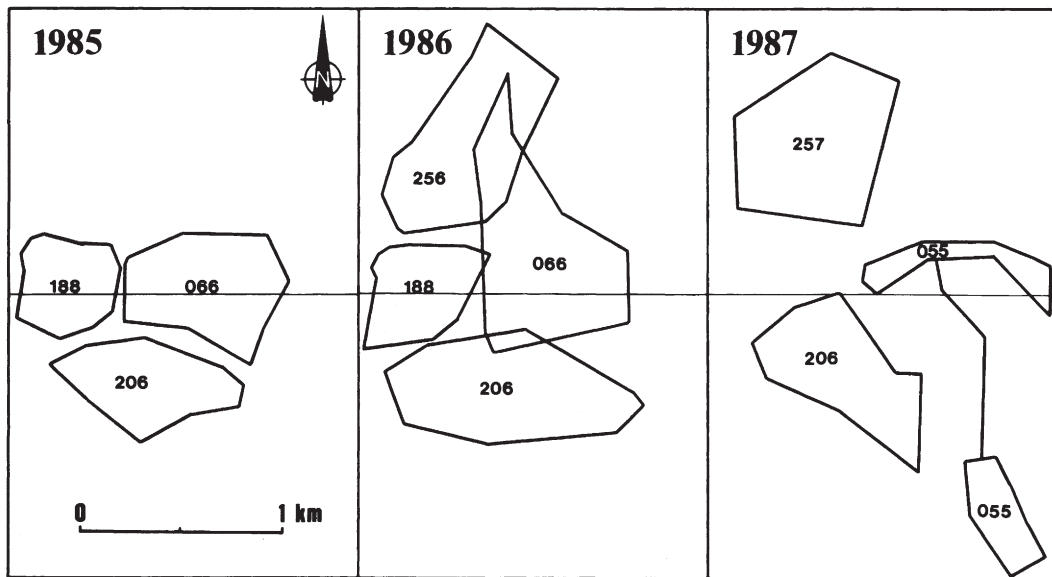


Fig. 3. Summer territories of Roe deer¹ bucks during May–September 1985–87 at Ås.

¹Nos. 256 and 066 died in August 1986 and January 1987, respectively. No. 188 lost its collar during 1986, but probably stayed in the area during the summer of 1987. No other bucks were recorded in the area during 1986–87. The northern border of the maps is identical each year.

away. Particularly during early summer, when the mother had new fawns, the distance between the animals was several hundred meters. Later, from September and through the fall, the daughter usually stayed together with her mother and the new fawns and this continued in 1986 until both had fawns and generally stayed well apart. The next summer they used adjacent but separate home ranges throughout the summer (Fig. 4). During 1984 and 1985 the mother (no. 046) gave birth within the richest part of the home range, but stayed out of this area the following two summers. In 1987 the area was occupied by a new collared doe (no. 236), which may also have used this area in 1986 and prevented no. 046 from using it.

Pregnant does decreased their home range as the date of calving approached. The first 2 weeks after giving birth the does stayed within small, well defined areas. As the summer progressed their home ranges increased again (Fig. 5). Two does (no. 026 and no. 346) left the calving area 14 and 20 days, respectively, after their fawns were born and did not return to this part of their home range during the rest of the summer. Also other does with fawns

made generally little use of the area where their fawns were born after mid summer. Does without fawns also changed their pattern of home range use as the summer progressed, but there was not the reduction in area use observed in does with fawns.

Distance between positions of bucks recorded at 1-hour intervals showed the lowest value during May ($130 \text{ m} \pm \text{SE} = 31$) and early July ($91 \text{ m} \pm \text{SE} = 33$) and a peak in June ($153 \text{ m} \pm \text{SE} = 35$) and August ($188 \text{ m} \pm \text{SE} = 38$). Only the values from August were significantly different from the May/June values (Mann-Whitney U-test, $p < 0.05$). The distance moved between 1-hour intervals was generally shorter for does, on the average $55 \text{ m} (\pm \text{SE} = 14)$ for the summer as a whole, increasing slightly from spring to fall but with no marked peaks.

DISCUSSION

Throughout Europe, Roe deer bucks have been shown to defend territories, while does, particularly related ones, have overlapping home ranges (Henning 1962, Bramley 1970, Strandgaard 1972, Ellenberg 1979, Loudon

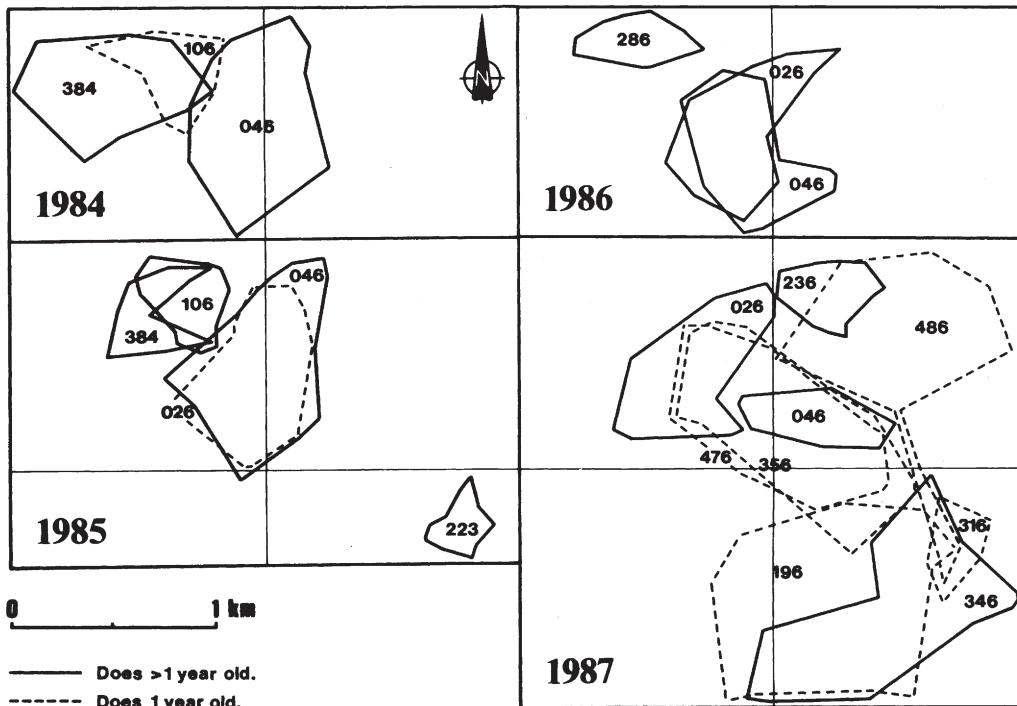


Fig. 4. Home range of Roe deer does¹ at Ås during summer (May–September) 1984–87.

¹The number of does studied increased from 3 in 1984 to 9 in 1987. Of these the following animals died in the course of the study: no. 384 during June 1985, no. 106 and no. 223 during the fall of 1985 and no. 286 during spring of 1987. The northern border of the maps is identical each year.

1982). Size of territories/home ranges appears closely related to the quality of the summer range (Bobek 1977). In coniferous forests of central Sweden, Cederlund (1983) found that bucks defend territories of on average 95 ha, nearly three times the size of buck territories on the coastal ranges of our Norwegian study areas, and farther to the south buck territories are generally smaller than in our area. Strandgaard (1972) reported 28 ha territories for bucks in deciduous forests of Denmark; in England territory sizes from 4 to 35 ha have been recorded (Loudon 1982), and Ellenberg found 10–12 ha in Germany. Some studies also report large variations in average territory size, e.g. from 8.5 ha to 128.5 ha in Poland (Bobek 1977), and from 18 ha to 80 ha in the southern Ural mountains (Sokolov and Danilkin 1980).

Several studies conclude that home ranges of does are smaller than the territories of bucks (Ellenberg 1978, Bobek 1977), but Fruzinski et al. (1983) found that does in

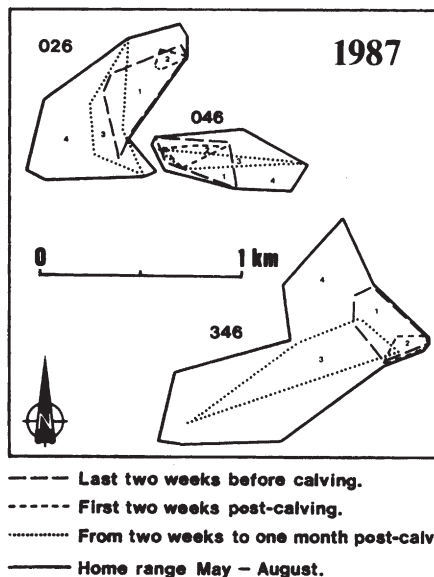


Fig. 5. Home range of 3 does and their fawns at Ås during the summer of 1987.

forested habitats in Poland used larger areas than bucks over the summer (March—September). Cederlund (1983) showed that territory size may vary over the summer. Bucks used larger areas than does during spring (April—June), but during the rest of the summer (July—September) the territories of bucks and the home range of does were of equal size. The large buck territories during spring were associated with a peak in animal mobility. However, the period of highest mobility of the bucks in our area appears to be in August, but this is not associated with any expansion of territories. The difference could be related to animal density. The roe deer density in our area is 3—4 times higher than in the Swedish area (Cederlund 1983).

Bobek (1977) suggested that old deer have larger territories or home ranges than younger animals. Thus, lowering the mean age of the population, through increased hunting pressure should allow the establishment of a younger and denser population. Yearling animals in our study area did not use smaller areas than older ones, but data for bucks are limited to one animal. Cederlund (1983) found that two yearling bucks used areas of about the same size as older animals, and Loudon (1978) did not find any relationship between buck age and territory size. Data for Scandinavian populations are still too small to allow further conclusions, particularly since territory and home range size also vary with habitat quality and probably with other factors.

Strandgaard (1972) has shown that young bucks are driven from the summer range by older bucks when they reach maturity. In Denmark this happens when the bucks are either 1 or 2 years old. In our area none of the bucks, radio-collared during their first winter stayed within the home range of their mothers as 1-year-olds. Apparently they were forced to leave through competition with older bucks.

In spite of their group system, the number of does is also socially regulated, with the quality of the range as the ultimate limiting factor (Bobek 1977). In our study area does within groups overlapped considerably in area use during spring, but separated after the new fawns were borne. During the time of fawning does appear to be territorial and will tolerate neither other does nor their fawns of the previous year (Kurt 1968, Espmark 1969, Cederlund 1983). One-year-old does in our

area settled in marginal habitats, like territories bordering the territories of other does or forested islands within pastures and grain fields (Fig. 4).

The extensive spring migration by Roe deer from their winter feeding area shows that the number of animals using the area during winter was far higher than the carrying capacity of the area during summer. Migrating animals apparently learn the location of the winter feeding area when accompanying their mother during their first year. Winter migrations to man-made feeding sites appear to be easily establishable in Roe deer populations (Robin 1975, Cederlund 1981). The Roe deer's ability to find and utilize suitable winter ranges is probably a prerequisite for colonization of Scandinavian habitats with deep snow. It is well known that Roe deer having high altitude summer ranges with heavy snow accumulation migrate to lower areas during winter (Schloeth 1972). The Roe deer we studied migrated to their wintering area well in advance of a permanent snow cover. This could be an adaptation to avoid being caught by deep snows on their summer range.

Most of the Roe deer using the winter feeding site migrated to the interior instead of towards the coast. This is surprising, as the coast, with high winter temperatures and sparse snow cover appears well suited to Roe deer. A likely explanation is that the winter death rate of stationary animals is higher in the interior than in the coastal areas. Therefore migrating Roe deer may have a higher chance of finding unoccupied territories in the interior compared to coastal areas.

It is of interest that recoveries of tagged Swedish foxes also show migrations towards the interior and the north, away from the dense fox populations of the southern and coastal regions (Englund 1980, Lindström and Mörner 1985). This one-directional expansion has been put forward as the reason for the slow-down in the spread of sarcoptic mange (*Sarcoptes scabiei*) within fox populations of southern Sweden (Lindström and Mörner 1985).

A prerequisite for this hypothesis is that the animals acquire some knowledge of the high density areas. We have not recorded any extensive, random movements of Roe deer prior to their migration towards the interior. But animals could gain some knowledge of population density in neighbouring habitats

through the short excursions they appear to make as yearlings prior to their final movement from the winter range in spring, or possibly as calves accompanying old does on the summer excursions.

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