

MALE AND FEMALE SPATIAL BEHAVIOUR OF ROE DEER IN A MOUNTAINOUS HABITAT DURING PRE-RUTTING AND RUTTING PERIOD

Rossi I.*, Lamberti P.*, Mauri L.***, Apollonio M.**(*)

* Dipartimento di Etologia, Ecologia, Evoluzione, Università degli Studi di Pisa, via A. Volta 6, I-56126 Pisa (Italy).

** Dipartimento di Zoologia e Antropologia Biologica, Università degli Studi di Sassari, Via Muroni 25, I-07100 Sassari (Italy).

Abstract - During pre-rutting and rutting period, spacing behaviour of male and female roe deer *Capreolus capreolus* (Linnaeus, 1758) was studied in a wooded and mountainous habitat, in the Casentinesi Forest National Park, Italy. Data were collected using radio-tracking techniques from March to August 1997. Bimonthly and monthly home ranges and bimonthly home range overlaps of both sexes were analysed. Variations in bimonthly home range sizes did not show significant differences between sexes during pre-rutting and rutting period. Different social factors seemed to influence the ranging behaviour of both sexes in this mountainous habitat. Male use of space varied in relation to the age classes of animals, especially during the pre-rutting period, when yearlings were not able to establish a territory. Female ranging movements were linked to the births timing and to two different spacing strategies during the rutting period. Home ranges sizes of females were significantly lower than those of males in May and in July. Significant changes in home range sizes were also found between prime age males and both roaming and stationary females.

Key-words: Roe deer, *Capreolus capreolus*, home range, radio-tracking, forest habitat.

J. Mt. Ecol., 6: 1 - 6

1. Introduction

In roe deer (*Capreolus capreolus*) the mating system can affect considerably spatial behaviour, as in most ungulate species. During pre-rutting and rutting period, in fact, we can find in both sexes different individual mating strategies and various factors determining home range sizes. Summer home ranges of females are of the same size order as coexisting male territories and the spacing systems of the two sexes are independent of each other during the rutting season, which means that one male territory might overlap several female ranges and vice versa (Strandgaard, 1972; Liberg *et al.*, 1998).

The biological cycle of roe deer is characterised by different important events in spring and in the summer period, such as territoriality for male and the end of gestation and births for females. Age is an important correlate of male mating success and, during the territorial and rutting period, different use of space between prime age and yearling males emerged in many roe deer studies

(Strandgaard, 1972; Bideau *et al.*, 1983; Fruzinsky *et al.*, 1983; Vincent *et al.*, 1995; Danilkin & Hewison, 1996; Johansson, 1996; Hewison *et al.*, 1998; Liberg *et al.*, 1998). Yearling males commonly present wider ranging movements, while prime age ones show a greater spatial stability, even though also prime age males can follow non-territorial strategies (Johansson & Liberg, 1996; Hewison *et al.*, 1998; Liberg *et al.*, 1998). Female spatial behaviour, instead, is influenced by the high costs of gestation and lactation, and is limited by the care for the new-borns in May and June (Danilkin & Hewison, 1996; Tufto *et al.*, 1996; Hewison *et al.*, 1998; Lamberti *et al.*, 2001).

Even though male and female spatial behaviour has long been a subject of interest, few data are available on the differences between the sexes. Furthermore, only a few studies have concentrated on mountain-dwelling roe deer (Thor, 1990).

In the present study, we analysed spatial behaviour in a free ranging population of roe deer, living in a mountainous and wooded

(*) Corresponding author: marcoapo@discau.unipi.it

habitat, in order to assess differences in home range sizes between males and females. Bimonthly and monthly home range sizes of both sexes were investigated during pre-rutting and rutting period of one year.

2. Study area

The study was carried out in the Casentinesi Forest National Park (36,426 ha), in central Italy. Data were collected in an intensive study area of about 5000 ha, located on the Tuscan slope of the Appennines, in Arezzo Province (43°48'N, 11°49'E), ranging in altitude from 400 to 1520 m a.s.l. The climate is temperate with a mean annual temperature of 8°C. Snow normally occurs during the period October-April, with a mean annual snow cover of 20 days below 1000 m a.s.l, and 90 days above 1000 m a.s.l. Mean annual precipitation is around 1680 mm. Most of the area is forested (95%) and is dominated by *Quercus*, *Castanea*, *Tilia* and *Acer* (>90%) below 900 m a.s.l.. Above 900 m a.s.l. the area is covered by *Fagus* and *Abies* (> 90%). In this area roe deer population lives in the presence of three other ungulate species: red deer (*Cervus elaphus*), fallow deer (*Dama dama*), and wild boar (*Sus scrofa*). Roe deer density was estimated in 10 deer per km² by drive censuses in forest habitats (Arezzo Province, unpubl. data). Natural predators of roe deer, wolf (*Canis lupus*) and fox (*Vulpes vulpes*), are present and hunting is not permitted.

3. Methods

Data were collected on ten males and ten females using radio-tracking techniques, during the pre-rutting (March-June) and rutting (July-August) period in 1997. Roe deer were captured with dropnets and equipped with radiocollar transmitters (Televilt TSX, 151 MHz), at different times from March 1994 to March 1997. At the moment of capture, the age of each roe deer was estimated on the basis of tooth eruption and wear (Hewison *et al.*, 1999). Animals were divided into four age classes: fawns (from zero to one year), yearlings

(from one to two years), prime age (from two to seven years) and old (more than seven years). Our sample consisted of seven prime age males and three yearlings and of seven prime age females and three old ones. Twenty-four radiofixes, one for each hour of the day, were collected every month for each animal (144 fixes for each animal), with at least a 12-h. interval between two consecutive fixes to avoid autocorrelation (Van Winkle, 1975). Televilt RX-81 and RX-8910-HE receivers with a 4-element Yagi antenna and triangulation (Heezen & Tester, 1967; Kenward, 1987) were used to obtain radiofixes. Minimum Convex Polygon (MCP-95%) (Mohr, 1947) and Kernel methods (Kernel-95%) (Worton, 1989; Harris *et al.*, 1990) were used to estimate home range sizes. The Range V software package was used for data analysis (Kenward & Hodder, 1996). Bimonthly and monthly home range sizes of both sexes were calculated and the overlap percentages of bimonthly home ranges determined. For statistical analysis, we considered separately male and female data. Non-parametric Friedman tests were used to test variation during pre-rutting and rutting periods and Wilcoxon tests to compare a specific month (April) with other ones (March, May, June, July and August) when significant variation was found. Differences between sexes were analysed with Mann-Whitney U-tests. Data of prime age males were also considered separately from those of yearlings, as well as the two categories of females with different spatial behaviour (*i.e.* stationary and roaming females, Lamberti *et al.*, 2001), and possible differences were analysed with Mann-Whitney U-tests. In all tests significance was set at $p < 0.05$ and was accordingly corrected, using the Sequential Bonferroni Method (Rice, 1989), for Wilcoxon tests.

4. Results

During territorial and rutting period, no significant differences were found between all male and female home range sizes in March-

	Female		Male	
	MCP-95%	Kernel-95%	MCP-95%	Kernel-95%
March-April	68 ± 53	92 ± 79	46 ± 15	65 ± 31
May-June	44 ± 34	54 ± 48	85 ± 121	91 ± 94
July-August	93 ± 157	87 ± 98	54 ± 40	71 ± 44

Tab. 1 - Bimonthly average (\pm SD) home range size (ha) of radio-collared roe deer in the Casentinesi Forest from March to August 1997 using the Minimum Convex Polygon method with 95 % of fixes estimated (MCP-95%) and the Kernel method with a 95% isoline (Kernel-95%).

April (Mann-Whitney U-test: $U = 45$, $N_1 = 10$, $N_2 = 10$, $p = 0.705$, MCP-95%; $U = 47$, $N_1 = 10$, $N_2 = 10$, $p = 0.821$, Kernel-95%), May-June (Mann-Whitney U-test: $U = 38$, $N_1 = 10$, $N_2 = 10$, $p = 0.364$, MCP-95%; $U = 35$, $N_1 = 10$, $N_2 = 10$, $p = 0.257$, Kernel-95%) and July-August (Mann-Whitney U-test: $U = 50$, $N_1 = 10$, $N_2 = 10$, $p = 1.000$, MCP-95%; $U = 42$, $N_1 = 10$, $N_2 = 10$, $p = 0.545$, Kernel-95%) (Tab. 1). MCP bimonthly home range sizes were the largest for males and the smallest for females in May-June (Tab. 1). The same result was found using the Kernel method. The highest standard deviation values of bimonthly home range sizes were seen in May-June for males and in July-August for females, with both methods (Tab. 1). Male monthly home ranges varied significantly during pre-rutting and

rutting period (Friedman test: Chi-square = 13.31, $df = 5$, $N = 10$, $p = 0.021$, MCP-95%; Chi-square = 13.43, $df = 5$, $N = 10$, $p = 0.020$, Kernel-95%) and April values were significantly lower compared to those of March (Wilcoxon test: $T = 0$, $N = 10$, $p < 0.05$, MCP-95%; $T = 2$, $N = 10$, $p < 0.05$, Kernel-95%), May (Wilcoxon test: $T = 3$, $N = 10$, $p < 0.05$, MCP-95%), and July (Wilcoxon test: $T = 3$, $N = 10$, $p < 0.05$, Kernel-95%) (Fig. 1).

A comparison between sexes showed that male monthly home ranges were significantly larger than those of female in May (Mann-Whitney U-test: $U = 23$, $N_1 = 10$, $N_2 = 10$, $p = 0.041$, Kernel-95%) and in July (Mann-Whitney U-test: $U = 20$, $N_1 = 10$, $N_2 = 10$, $p = 0.023$, Kernel-95%) (Fig. 1). Also stationary females monthly home range sizes were significantly

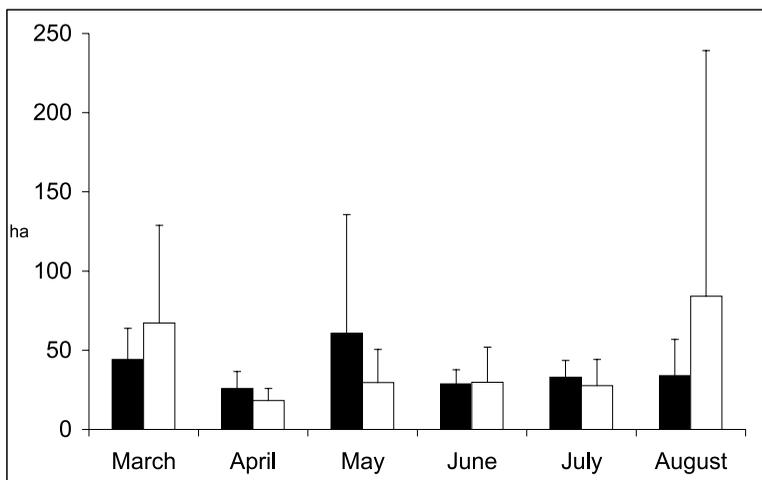


Fig. 1 - Monthly average (\pm SD) home range size (ha) estimated by the Minimum Convex Polygon method with 95% of fixes for all female and male radio-collared roe deer from March to August 1997 in the Casentinesi Forest (■: males, □: females).

	Female				Male			
	Stationary		Roaming		Prime age		Yearling	
	MCP-95%	Kern-95%	MCP-95%	Kern-95%	MCP-95%	Kern-95%	MCP-95%	Kern-95%
March	41 ± 38	44 ± 33	94 ± 73	177 ± 135	34 ± 13	47 ± 50	68 ± 6	130 ± 15
April	16 ± 6	19 ± 6	20 ± 9	36 ± 29	24 ± 10	32 ± 18	29 ± 13	37 ± 17
May	21 ± 8	26 ± 9	38 ± 27	56 ± 57	29 ± 11	40 ± 15	134 ± 115	194 ± 196
June	26 ± 15	43 ± 38	34 ± 29	31 ± 21	27 ± 9	44 ± 16	32 ± 11	64 ± 51
July	21 ± 6	29 ± 17	34 ± 22	40 ± 27	32 ± 11	63 ± 34	35 ± 10	62 ± 14
August	28 ± 8	42 ± 14	140 ± 215	263 ± 432	29 ± 18	52 ± 52	45 ± 34	41 ± 10

Tab. 2 - Monthly average (±SD) home range size (ha) of radio-collared roe deer in the Casentinesi Forest from March to August 1997 using the Minimum Convex Polygon method with 95 % of fixes estimated (MCP-95%) and the Kernel method with a 95% isoline (Kernel-95%).

lower than prime age male ones in May (Mann-Whitney U-test: $U = 4$, $N_1 = 7$, $N_2 = 5$, $p = 0.028$, Kernel-95%) and in July (Mann-Whitney U-test: $U = 5$, $N_1 = 7$, $N_2 = 5$, $p = 0.042$, Kernel-95%) (Tab. 2).

Different male spatial behaviours seemed to be related to age. Monthly home range sizes of male yearlings were significantly larger than those of prime age males in March (Mann-Whitney U-test: $U = 0$, $N_1 = 3$, $N_2 = 7$, $p = 0.017$, MCP-95% and Kernel-95%) and in May (Mann-Whitney U-test: $U = 0$, $N_1 = 3$, $N_2 = 7$, $p = 0.017$, MCP-95% and Kernel-95%) (Tab. 2).

Monthly home ranges of roaming females were significantly larger than those of prime age

males ones in March-April (Mann-Whitney U-test, $U = 4$, $N_1 = 5$, $N_2 = 7$, $p = 0.028$, Kernel-95%) (Fig. 2). In March and, mainly, in August, roaming females showed high mean monthly home range sizes with high standard deviations values (Tab. 2). No significant differences were found in overlap percentages (always higher than 50%) at bimonthly home ranges between prime age males and females (Mann-Whitney U-test, $U = 29$, $N_1 = 7$, $N_2 = 10$, $p = 0.558$, May-June on March-April) (Mann-Whitney U-test, $U = 33$, $N_1 = 7$, $N_2 = 10$, $p = 0.845$, July-August on May-June) (Mann-Whitney U-test, $U = 27.5$, $N_1 = 7$, $N_2 = 10$, $p = 0.464$, July-August on March-April).

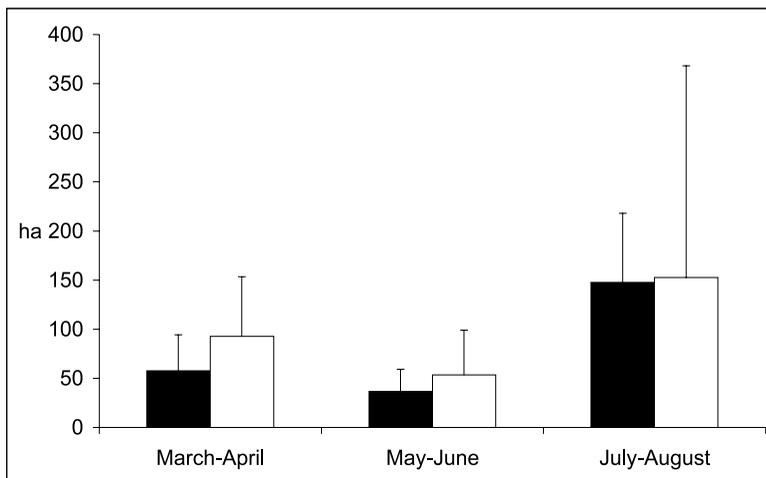


Fig. 2 – Bimonthly average (±SD) home range size (ha) estimated by the Minimum Convex Polygon method with 95% of fixes (MCP-95%) for roaming female and prime age male radio-collared roe deer from March to August 1997 in the Casentinesi Forest (■: prime age males, □: roaming females).

5. Discussion

Other studies showed no significant differences in home range sizes between male and female roe deer (Chapman *et al.*, 1993; Danilkin & Hewison, 1996; Liberg *et al.*, 1998; Mysterud, 1999). Also in our study area male bimonthly home range values were similar to those of females, even though differences in home range sizes between sexes were detected during the territorial and the rutting period. Both sexes presented significantly smaller home ranges in April, when males established territories, and when pregnant females reduced their home ranges because of the increase of resources availability (Lamberti *et al.*, 2001). However, a great individual variability was detected in male and female use of space, as seen in the high standard deviation values of bimonthly home range sizes.

Males showed large May-June home range sizes, especially in May and this was mostly determined by the yearling spatial behaviour. During the territorial period, in fact, home ranges of yearlings were generally larger than those of prime age males and, in our study area, this difference was significant in March and in May. Yearlings can adopt different ranging patterns: moving widely over the territories of several prime age males, or staying within the buffer zone between the territories of two neighbouring territorial males, or associating closely with a territorial male, because of their difficulties for establishing a territory (Bideau *et al.*, 1983; Danilkin & Hewison, 1996; Hewison *et al.*, 1998).

All roe deer females of our study area reduced their home range sizes during the birth period, in May-June. In roe deer, female mobility is limited by the presence of fawns (Danilkin & Hewison, 1996; Tufto *et al.*, 1996; Lamberti *et al.*, 2001), and the birth timing coincides also with the season of highest plant productivity (Chapman *et al.*, 1993; San José & Lovari, 1998; Lamberti *et al.*, 2001). In our study area females presented an increase of the home range sizes in July-August, and especially in August (Lamberti *et al.*, 2001). Two different

space use strategies were distinguishable during the reproductive period: stationary females showed small and stable home ranges, while roaming ones had significantly larger home ranges that influenced the higher values found for the whole female sample (Lamberti *et al.*, 2001). The different female spatial strategies, in the reproductive period, could be due to the increased opportunities for mate choice, as reported in other studies on female spatial behaviour (Danilkin & Hewison, 1996; San José & Lovari, 1998; Lamberti *et al.*, 2001).

During the pre-rutting and rutting periods home ranges sizes of females were significantly lower than those of males in May and in July. The same result was found from the comparison between stationary females and prime age males. This could be explained by the small and stable home range sizes of females during the birth and rutting periods. In the same time, prime age males may adopt a wide ranging behaviour in order to maximise reproductive success (Danilkin & Hewison, 1996; Liberg *et al.*, 1998).

Significantly different home range values between roaming females and prime age males were found instead in March-April, during the male territorial period, when prime age males often greatly reduced their home range sizes to establish their territories.

Also thanks to the fact that in spring and summer resources availability increases, reproduction and social behaviour become paramount in determining ranging patterns of both sexes (Hewison *et al.*, 1998). In our study area, male age and female spatial strategies were prime factors in determining the different use of space during pre-rutting and rutting period. Even when significant differences between sexes were not found, home range sizes showed different trends during pre-rutting and rutting period. Male use of space was influenced by age, especially during the territorial period, when yearlings were not able to establish a territory. Female ranging movements were linked to the births period, and then, during the rutting period, females

showed two different spatial strategies, possibly related to the increase of mate opportunities, as roaming females increased their home range sizes in August. Furthermore, significant differences were found between prime age males and the two groups of females when social factors, such as the female care for the new-borns and the territory establishment of prime age males, limited ranging movements.

References

- BIDEAU E., VINCENT J. P., QUÈRÈ J. P. & ANGIBAULT J. M. (1983) - Occupation de l'espace chez le chevreuil (*Capreolus capreolus* L., 1789). Cas des males. *Acta Oecol., Oecol. Applic.*, 4: 163-184.
- CHAPMAN N. G., CLAYDON K., CLAYDON M., FORDE P. & 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. *J. Zool.*, London, 229: 623-640.
- DANILKIN A. & HEWISON A. J. (1996) - *Behavioural ecology of Siberian and European roe deer*. Chapman & Hall, London, 227 pp.
- FRUZINSKY B., LABUDZKI L. & WLAZELKO M. (1983) - Habitat, density and spatial structure of the forest roe deer population. *Acta Theriol.*, 28: 243-258.
- HARRIS S., CRESSWELL W. J., FORDE P., TREWHELLA W. J., WOOLARD T. & WRAY S. (1990) - Home range analysis using radio-tracking data, a review of problems and techniques particularly as applied to the study of mammals. *Mammal Rev.*, 20: 97-123.
- HEEZEN K. L. & TESTER J. R. (1967) - Evaluation of radio-tracking by triangulation with special reference to deer movements. *J. Wildl. Manage.*, 31: 124-141.
- HEWISON A. J., VINCENT J. P. & REBY D. (1998) - Social organisation of European roe deer. In: R. Andersen, P. Duncan & J. D. C. Linnell (Eds). *The European roe deer: the biology of success*. Scand. Univ. Press, Oslo, pp 189-219.
- HEWISON A. J., VINCENT J. P., ANGIBAULT J. M., DELORME D., VAN LAERE G. & GAILLARD J. M. (1999) - Test of estimation of age from tooth wear on roe deer of known age: variation within and among populations. *Can. J. Zool.*, 77: 58-67.
- JOHANSSON A. (1996) - Territory establishment and antler cycle in male roe deer. *Ethology*, 102: 549-559.
- JOHANSSON A. & LIBERG O. (1996) - Functional aspects of marking behaviour by male roe deer (*Capreolus capreolus*). *J. Mammal.*, 77(2): 558-567.
- KENWARD R. & HODDER K.H. (1996) - *Ranges V. An analysis system for biological location data*. Centre for Ecology and Hydrology, Wareham Dorset, UK, 69 pp.
- LAMBERTI P., ROSSI I., MAURI L. & APOLLONIO M. (2001) - Alternative use of space strategies of female roe deer (*Capreolus capreolus*) in a mountainous habitat. *Ital. J. Zool.*, 68: 69-73.
- LIBERG O., JOHANSSON A., ANDERSEN R. & LINNELL J. D. C. (1998) - The function of male territoriality. In: R. Andersen, P. Duncan & J. D. C. Linnell (Eds). *The European roe deer: the biology of success*. Scand. Univ. Press, Oslo, pp 221-256.
- MOHR C. O. (1947) - Table of equivalent populations of North America small mammals. *J. Midl. Nat.*, 37: 223-249.
- MYSTERUD A. (1999) - Seasonal migration pattern and home range of roe deer (*Capreolus capreolus*) in an altitudinal gradient in southern Norway. *J. Zool.*, London, 247: 479-486.
- RICE W. R. (1989) - Analyzing tables of statistical tests. *Evolution*, 43: 223-225.
- SAN JOSÈ C. & LOVARI S. (1998) - Ranging movements of female roe deer: do home-loving does roam to mate? *Ethology*, 104: 721-728.
- STRANDGAARD H. (1972) - The roe deer population at Kalø and the factors regulating its size. *Dan. Rev. Game Biol.*, 7: 1-205.
- THOR G. (1990) - How can does get more food than bucks? Habitat use of roe deer in the Bavarian Forest. *Proc. XIX Int. IUGB Congr.*, Trondheim, 19: 49-52.
- TUFTO J., ANDERSEN R. & LINNELL J. D. C. (1996) - Habitat use and ecological correlates of home range size in a small cervid: the roe deer. *J. Anim. Ecol.* 65: 715-724.
- VAN WINKLE W. (1975) - Comparison of several probabilistic home range models. *J. Wildl. Manage.*, 39: 118-123.
- VINCENT J. P., BIDEAU E., HEWISON A.J.M. & ANGIBAULT J.M. (1995) - The influence of increasing density on body weight, kid production, home range and winter grouping in roe deer (*Capreolus capreolus*). *J. Zool.*, London, 235: 455-467.
- WORTON B. J. (1989) - Kernel methods for estimating the utilization distribution in home range studies. *Ecology*, 70: 164-168.