ACTA THERIOLOGICA
Vol. 28, 16: 243—258, 1983

Habitat, Density and Spatial Structure of the Forest Roe Deer Population[1]

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Fruziński B., Łabudzki L. & Wlazełko M., 1982: Habitat, density and spatial structure of the forest roe deer population. Acta theriol., 28, 16: 243—258 [With 7 Tables & 1 Fig.]

During the study period (1973—1980) variations were found in population density from 20.8 individuals per 100 ha to 10.4/100 ha. The most important cause of variations in numbers consisted in winter weather conditions. The roe deer *Capreolus capreolus* (Linnaeus, 1758) preferred the parts of tree stands in which the coniferous species *Pinus silvestris* predominated (average 16.1 individuals per 100 ha), to tree stands in which *Quercus sessilis* predominated (14.1 individuals/100 ha). Maximum population density was found in the older plantations (21.7 individuals) and thickets (20.9 individuals). The average size of the territory of bucks, depending on the calculation method used, was: 9 ha for the minimum polygon, 10.3 for the convex polygon, and 52.3 ha for the elliptic area of probable activity. Average size of does' home ranges was respectively: 12.2 ha, 15.2 ha and 77 ha. 84.2% of all marked bucks were observed at a distance of up to 1 km from the capture site, 47% of these within a radius of 0.5 km. The corresponding figures for does were 54% and 33.3%. Migrations to the furthest distances (2.3 km for bucks and 5.2 km for does) were undertaken by the youngest individuals, caught and marked as fawns.

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1. INTRODUCTION

The roe deer is a species eurybiotic to a very great degree. It currently occurs in different types of forest habitats, in typically cultivated landscapes and also in extensive open fields, or large stretches of meadows (Pielowski, 1970). Population density is most often uneven, depending on the character of the habitat and also on geographical situation. Although a very numerous and also widespread species, at the same time it creates considerable difficulties as to method in ecological studies. This applies primarily to a forest habitat, in which roe deer take advantage of any form of shelter (undergrowth, herb layer vegetation) thus making opportunities for direct observation very limited.

The studies were aimed at describing the density and spatial structure of a roe deer population in wooded land. Examination was made

[1] Badania prowadzone w ramach problemu MR.II.15 koordynowanego przez Instytut Ekologii PAN.

of the relation between density and the character of the biotope and age of the tree stand. An attempt was made at defining the size of the territory of males and home range of females, and also the extent of local movements by individuals in the population.

2. STUDY AREA

The studies were carried out in the "Zielonka" Experimental Game Research Centre of the Poznań Academy of Agriculture, which includes a fairly dense stretch of wooded land 7,944 ha in extent known as the "Zielonka Forest", situated about 30 km in a N—E direction from Poznań, in the Wielkopolsko-Kujawy Lowland Region, which is a slightly undulating plain formed during the second Frankfurt glaciation period. The frontal moraine raised area and several narrow glacial valleys with lakes contribute to the physiographical variety of the area.

The surface of the study areas is formed of leached type soils consisting of loose sand and slightly clayey glacial accumulation. These soils have only faintly marked morphological characteristics and determine the direction of the development of plant successions. Only a small part of the area is covered by fen type soils — peat, muds and boggy soils (Mucha & Margowski, 1957).

The tree stands of the Centre are situated in an area in which the mean annual precipitation is the lowest in Poland (508 mm). Average annual temperature is +8.6°C. The growing period with temperatures above +5°C lasts about 220 days. The weather conditions in summer are formed by the continental climate, but in winter by the oceanic climate, which moderates extreme temperatures. There is no marked harmful factory air pollution, as is shown by the state of health of tree stands.

Descriptions of the succession sequence of the flora points to deterioration in the biotope as the level of ground water falls. Oak woods thus change into mixed coniferous woods, and further deterioration in soil conditions will lead to formation of a fresh coniferous forest biotope. The predominating biotopes are mixed fresh coniferous forest and fresh coniferous forest.

The tree stands of the Centre are situated in the spruce-less belt, beyond the natural range of firs, within the limits of the scattered range of beech. The species forming the tree stands are pine (*Pinus silvestris*) and oak (*Quercus sessilis*). Pine woods are in the decided majority and occupy 85.2% of the total wooded area. The majority of pine woods consists almost solely of pine, with a slight proportion of oak and single specimens of birch, spruce, beech and larch. Mixed oak and pine stands also occur, and only occasionally unmixed oak woods (about 10% of the area) and alder. Several years ago many species of trees and bushes not indigenous to the area were introduced, but they are not of a wood- or biotope-forming character, with the exception of *Padus racemosa*, which in places of its numerous occurrence forms shady brushwood over stretches several hectares in extent (Nowaczyk, 1964).

The complete clearing method is used for the treestands there, although in a small percentage of the deciduous forests focus clearing is used. Both the species composition of the treestands and the way in which they are utilized create favourable conditions for development of ground vegetation, which determines the natural food resources for herbivores. There are particularly good food and shelter conditions in the relatively large area of plantations and thickets (Table 1). An additional habitat advantage in this respect is the higher than average proportion of surface ecotones in the experimental woods of the Academy of Agriculture (these woods form about 30% of the total area of the Centre), due to the considerable number of experimental plots in different sectors (Nowaczyk, 1964).

The percentage of forest-field boundaries is 70.2%. The structure of agricultural

Table 1

Distribution of forest and age classes of stands at Zielonka.

Age classes (years)								
Ia		Ib	II	III	IV	V	VI	Total
a_1 (1—5)	a_2 (6—10)	(11—20)	(21—40)	(41—60)	(61—80)	(81—100)	(100)	
% ha	% ha	% ha	% ha	% ha	% ha	% ha	% ha	% ha
Fresh coniferous forest								
16.5	16.1	15.5	12.4	8.1	9.8	10.6	1.2	10.6
94.9	93.0	148.0	131.5	100.7	113.2	100.3	9.8	791.4
Moist coniferous forest								
	0.1	0.1	0.2					0.08
	0.8	1.9	2.4	0.8				5.9
Boggy coniferous forest								
		0.2						0.04
		3.1						3.1
Mixed fresh coniferous forest								
53.5	56.0	60.0	63.5	45.6	51.2	49.5	33.0	52.1
307.4	322.2	573.7	677.1	656.6	592.0	481.3	274.4	3884.7
Mixed moist coniferous forest								
	0.5	0.5	0.7	1.6	0.8			0.6
	2.9	4.5	8.5	19.5	5.8	1.0	0.3	42.5
Mixed deciduous forest								
29.1	24.9	20.0	19.8	38.0	35.0	32.0	54.5	31.5
168,5	143.9	186.9	210.8	471.1	401.3	311.2	452.6	2346.3
Fresh deciduous forest								
0.7	1.2	1.9	1.0	2.0	1.9	7.5	11.3	3.4
4.4	7.2	19.8	10.9	25.3	22.3	70.9	94.2	255.0
Moist deciduous forest								
								0.01
		0.8						0.8
Alderwood								
0.4	1.2	1.8	2.4	4.7	1.3	0.4		1.7
2.6	7.0	18.1	25.2	58.1	15.4	2.5		128.9
Total								
100	100	100	100	100	100	100	100	100
577.8	577.0	956.8	1066.4	1332.1	1150.0	967.2	831.3	7458.6

crops in fields adjoining treestands is determined by the low fertility of these soils (classes V and VI). It must however be emphasized that there is rational and intensive cultivation of soils near tree stands.

3. STUDY METHODS

There are considerable difficulties of a technical and methodical nature in establishing the numbers or population density of roe deer in wooded areas. On this account a fairly variable study technique was used. A map was prepared of tree stands and 19 sample areas were marked out, distributed evenly over the whole area (although taking into consideration the situation of enclaves of fields and meadows). The total area over which drives were carried out was 767.71 ha, which constituted almost exactly 10% of the whole of the wooded land of the Centre. The extent of one drive varied from 15 to 68 ha. These differences were due to the principles of the chosen method, since endeavour was made to mark out sample areas as uniform as possible, in which one age class of treestand only was represented (*e.g.* plantation, thicket, pole-sized stand) or one or two biotopic types of forest similar to each other. This made it possible to examine the density of the roe deer there depending on the age structure of the tree stand and the biotopic type of the wood. Two basic types of biotope were distinguished, namely pine forest (fresh coniferous, mixed moist coniferous) with decided predominance of pine in species composition of the tree stands, and mixed deciduous forest, with a considerable proportion of oak and slight admixture of pine. It proved possible to determine biotope differentiation in 19 marked out areas (which most often covered whole forest sectors, sometimes part of them or uniform parts of treestands in 100% of cases). Fresh and mixed moist coniferous forests covered 58% of the sample areas, and mixed deciduous forests — 42%.

The distribution of age classes over the sample areas was less even. The development stages of the tree stand were represented there as follows: young plantations — about 12%, thickets — 23%, pole-sized stands — 25% and older tree stands 40%, which approximately corresponds to their representation over the whole wooded area.

Complete age range was obtained in 13 areas, while in 6 it was impossible to avoid partial mixing of two or even 3 age classes. In some areas where there were 2 different age classes of treestand, additional observers were stationed on the boundary between marked-out areas.

About 80 persons (observers and beaters) took part each time in the drives, using the method for carrying out drives after Pucek *et al.* (1975). From 1973—1980 drives covered all 19 experimental plots, took place every year during the spring period from 16—23 March (133 trials).

In order to determine the size of the territories of males and the home ranges of females, local movements and the use made by roe deer of different parts of the biotope as feeding grounds, the following ways of obtaining information were employed:

— direct observations of individuals from permanent raised observation posts,
— transecting line on permanent observation routes,
— data from experimental drives,
— observation record cards during individual hunting, on which the time and place of observations of each marked individual encountered were entered.

On a selected part of the hunting area (730 ha wooded land) as from 1973 organized captures of roe deer were made, using nets. Each individual caught was marked by means of a leather collar carrying an enamel plate, fastened on the animal's neck. Strandgaard (1972) successfully used this method in his studies on the roe deer. In place of the enamel number plate leather ones were also used on which numbers had been affixed using reflecting plastic but without much success, since they were not resistant to wear or the effect of other external conditions. Captures were made in February and March from 1973—1977.

In all 84 roe deer: 39 males and 45 females were caught and marked. All observations of marked individuals were entered on an accurate map of the area, scale 1 : 1000.

The size of bucks' territories and does' home ranges was calculated comparatively by means of two methods, *i.e.* the minimum polygon and convex polygon, taken after Stickel (1954) and Southwood (1966), in accordance with the equation:

$$A = \frac{1}{2} \sum_{i=1}^{n} (x_i y_{i+1} - x_i + 1 y_i)$$

where A — size of territory or home range, n — number of observations, i — successive observations, x and y — co-ordinates of the observation point.

The size of coordinates was given in hectometres. The above calculations were made solely for individuals, the localization of which had been determined at least 5 times (min. 5 — max. 15 observations), those in the case of bucks applying only to the period of their territorial behaviour (April — Sept.), whereas the period for does covered the whole year. The results obtained were compared with the method proposed by Jenrich & Turner (1969) for calculating the elliptic area of probable activity.

The use made by roe deer of certain parts of a tree stand as feeding places was defined by means of direct observation of feeding individuals in the early morning and evening hours, until dusk fell. Three permanent routes (transecting lines) were set up, the total length of which was 12 km. The proportion of young plantations, timber stands and wood-field boundaries was equal. As from the beginning of March 1976 to the end of February 1977, 81 regular inspections (every 4—5 days, morning and evening) were made of the routes in question. The combined observation time was about 320 hours, during which 938 roe deer were observed.

Analogical observations were made from March to the end of May 1977 (302 observed roe deer) and from October to the end of December 1977 — 273 roe deer observed.

4. RESULTS

4.1. Population Density

Over the course of 8 years fairly distinct variation was observed in the spring population density of roe deer, from 20.8 individuals per 100 ha of wooded area in 1975 to 10.4 individuals in the spring of 1979 (Fig. 1). The cause of the greatest decrease in density undoubtedly consists in severe and snowy winters bringing about considerable natural mortality. Mortality, usually low, of less than 10% of the autumn head of roe deer (Fruziński & Łabudzki, 1963), increases under conditions of long-lasting snow cover.

As from 1975 to the spring of 1979 there was a distinct tendency to decrease in the spring population density. During this period maximum decrease in density was observed, both as the effect of the late winter of 1976/77, and the long-lasting snowfall in March (by 4.6 individuals/

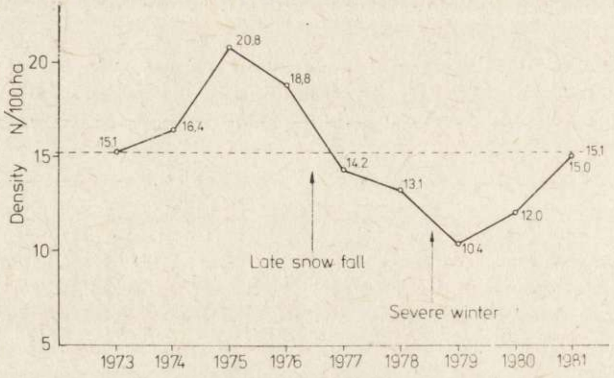

Fig. 1. The density of the roe deer population at Zielonka in 1973—1981.

100 ha) and also the exceptionally severe and snowy winter of 1978/79 (by 2.7 individuals/100 ha) (Fig. 1). As from the spring of 1980 a renewed increase in population density was observed, which in 1981 reached the value attained 8 years previously, at the same time being the average population density in the given period (Fig. 1).

Coniferous forests proved to be more attractive to roe deer than deciduous woods, as is shown by differences in population density (Table 2). On an average these differences are statistically significant for an 8-year period, as shown by the analysis of variance made ($P<0.05$): the value of the lowest significant difference *(NIR*, expressed by the quotient of estimated error and degrees of freedom for error) was 1.74. The most highly statistically significant differences in the spring population density in coniferous and deciduous forests was thus observed during the period 1973—1976, with a simultaneous fairly high total population density (Table 2). Differences in density not statistically

Table 2

Roe deer population density in two types of habitats.

Year	Coniferous forest	Decidous forest	Difference	Total on the study area
1973	16.9	13.6	3.3[1]	15.2
1974	18.8	14.0	4.8[1]	16.4
1975	22.7	18.9	3.8[1]	20.8
1976	19.8	17.9	2.1[1]	18.8
1977	14.7	13.7	1.0	14.2
1978	13.6	12.6	1.0	13.1
1979	11.1	9.7	1.4	10.4
1980	13.1	10.9	2.2[1]	12.0
Avg.	16.1	14.1	2.0[1]	15.1

[1] The differences are statistically significant, *NIR* (smallest essential difference)=1.74

significant occurred from 1977—1979, during the phase of population decrease due to severe winters.

In respect of age differentiation it was the older plantations and thickets which proved most attractive to roe deer during the study period, average density being respectively: 21.7 and 20.9 individuals/100 ha. Far lower density was found in the pole-sized stands (15.6 individual/100 ha), and lowest — 9.4 individual/100 ha — in timber stands (Table 3). Population density in age classes of tree stand exhibits statistically significant differences ($P<0.05$). On an average over the study period it was only differences in population density in plantations and thickets which were not significant, but were highly significant between the youngest age classes and between timber stands and pole-sized stands ($NIR=5.44$). In some years differences in density, even in the same age classes of tree stands, are frequently considerable (Table 3).

Table 3

Population density in different age classes of stands.

Year	Young plantations	Thickets	Pole-sized stands	Timber stands
1974	34.1	19.0	17.6	9.3
1975	32.0	26.4	23.8	12.7
1976	13.4	30.7	15.5	15.4
1977	16.5	20.1	14.5	10.0
1978	13.8	18.2	13.4	9.7
1979	18.6	16.2	11.9	3.6
1980	23.7	16.2	12.9	5.3
Avg.	21.7	20.9	15.6[1]	9.4[1]

[1] The differences are statistically significant, *NIR* (smallest essential difference) = 5.44

The differences were analyzed in this connection only in relation to the average values for the whole study period (Table 3), assuming that with necessarily small study areas, weather conditions at least might affect results in different years. The possibility of this kind of error was to a great extent eliminated by the calculated (from the study period) sample area, which was respectively: 677 ha for plantations, 1253 ha for thickets, 1341 ha for pole-sized stands and as much as 2100 ha for timber stands.

4.2. Utilization of Different Types of Daytime Feeding Places

The use made of different parts of the forest biotope as feeding places reveals considerable seasonal variations. During the period March—July the roe deer fairly evenly utilize different types of feeding places, frequently also moving into fields near tree stands where they fed on winter cereals (in early spring) and serradilla and fodder lupin (in summer). During the period September—December there was a distinct and systematic decrease in intensity of feeding on field crops, and it was not until towards the end of the winter period that this increased.

In summer and autumn (July—September) roe deer most often fed on forest plantations and in tree stands of the older age classes (Table 4). The degree of attractiveness of older oak tree stands clearly

Table 4

Distribution of the number and percentage of roe deer observed on the different types of the feeding areas.

Months, year	Hours of observations	Total no. of animals observed	% of roe deer observed: Arable lands	Young forest plantations	Ground cover in stands	Ground cover under oaks
III. 1976	22	63	34.9	14.3	23.8	27.0
IV, 1976	24	61	34.4	41.0	24.6	
V, 1976	24	60	20.0	45.0	35.0	
VI, 1976	23	57	15.8	47.4	36.8	
VII, 1976	28	75	28.0	37.3	34.7	
VIII, 1976	31	108	16.7	44.4	38.9	
IX, 1976	23	78	12.8	50.0	37.2	
X, 1976	23	93	6.5	51.6	10.7	31.2
XI, 1976	28	90	3.3	40.0	13.3	43.4
XII, 1976	32	82	3.7	29.3	8.5	58.5
I, 1977	29	81	7.4	25.9	11.1	55.6
II, 1977	33	90	11.1	20.0	12.2	56.7
Total, Avg.	320	938	15.0	37.3	23.3	24.4

Table 5

The comparison of the utilization of the feeding areas types by the roe deer (%) in spring and autumn.

Feeding place	Spring (III—V)			Autumn (X—XII)			Total number of observ.
	1976	1977	Avg.	1976	1977	Avg.	
Arable lands	29.9	23.2	25.7	4.5	56.0	30.6	290
Young forest plantations	33.1	27.5	29.7	40.8	30.0	35.3	334
Ground cover in stands	27.7	22.8	24.7	10.9	14.0	12.5	185
Ground cover under oaks	9.3	26.5	19.9	43.8		21.6	213
Total							1024

depends on good seed years (abundance of acorns, *e.g.* in 1976). On an average over the yearly cycle (37.3%) and in both seasons of the year (35%), plantations are most often used as feeding places (Tables 4, 5).

4.3. Size of Bucks' Territories

The average size of a buck's territory during the period from March—September, depending on the method accepted for mapping results of field observations, was: 9 ha in the case of the minimum polygon and 10.3 ha for the convex polygon. With Jenrich and Turner's method (1969), the area of probable activity was on an average 52.3 ha. Data, as yet unfortunately scanty, do not permit of defining correlations

Table 6

Territories (males) and home ranges (females) sizes estimation.

No. of deer	Age, approx.	Date and place of marking	Observations No.	Observations Year	Observations Period	Area size, ha A	Area size, ha B	Area size, ha C
	Males							
13	5—6	29.II.1976, 159g	15	1976	4.VII.—15.IX	8.7	10.6	30.0
				1977	5.V.—26.VII			
30	5—6	8.III.1975, 161a	5	1976	29.III.—18.VIII	8.4	11.6	24.4
A24	5—6	5.III.1972, 159f	10	1973	3.III.—21.VIII	8.4	11.6	34.0
10	2—3	6.III.1976, 1401	8	1976	21.V.—20.X	5.5	7.9	34.7
B15	4—5	4.III.1973, 159a	11	1974	4.VI.—19.IX	6.4	6.4	35.5
				1976	18.V.—30.X			
19	2—3	16.II.1975, 137d	6	1976	24.II.—8.IX	6.3	7.5	38.0
BO4	4—5	11.III.1973, 163a	6	1974	8.VI.—23.VIII	8.6	9.2	50.0
A23	2	26.II.1972, 160c	6	1974	4.IV.—28.VIII	9.3	10.7	61.3
O7	2	6.III.1976, 96a	5	1976	7.IV.—27.X	9.8	9.8	67.7
20	2—3	6.III.1976, 96f	8	1976	4.VII.—28.VIII	15.5	16.4	71.5
				1977	5.III.—4.VII			
21	2	20.II.1976, 159g	5	1977	3.IV.—10.VIII	11.3	11.3	80.5
14	4—5	16.II.1976, 137d	6	1976	28.II.—25.IX	13.5	17.1	100.6
Avg.						9.0	10.3	52.3
	Females							
B17	3—4	6.III.1977, 159g	7	1977	21.IV.—9.IX	3.3	3.3	16.1
BO6	2—3	25.II.1973, 137a	8	1976	22.II.—12.IX	5.9	6.8	28.4
28	6—7	8.III.1975, 95a	8	1976	13.III.—22.XI	3.2	4.8	34.0
33	1—2	11.III.1978, 137d	5	1979	8.VII.—10.IX	5.5	6.0	44.0
A13	2—3	11.III.1978, 118a	6	1973	9.IV.—8.VIII	7.9	8.5	49.8
O4	1	4.II.1974, 26a	5	1979	15.V.—17.VII	6.6	6.6	51.9
				1980	28.IV.—4.VII			
BO8	4—5	10.III.1973, 159g	5	1974	25.V.—15.VIII	4.6	4.6	52.5
A29	4—5	22.II.1974, 137d	9	1976	6.V.—16.XII	16.7	20.4	79.8
				1977	20.III.—23.VII			
BO5	2	4.III.1973, 160b	5	1973	16.VI.24.IX	9.5	12.4	100.5
17	3—4	6.III.1976, 96a	9	1977	15.V.—16.X	19.5	26.2	112.4
BO3	3—4	3.III.1973, 26a	5	1973	23.VI.—28.XII	12.1	18.0	117.4
22	6—7	8.III.1975, 95a	11	1976	20.VII.—18.XII	51.3	64.6	237.0
				1977	7.II.—17.VII			
Avg.						12.2	15.2	77.0

A — minimum polygon, B — convex polygon, C — elliptic area of probable activity.

between the size of territories and population density in different years (Table 6).

4.4. Size of the Home Ranges of Does

The existence of does' home ranges, despite the absence of manifestations of territorial behaviour, is not open to doubt. Calculation made for 12 females of the average size of the home range showed that this is more extensive than the territory of bucks, depending on the calculation method used, was 12.2 ha or 15.2 ha, but as much as 77 ha in the case of theoretically calculated area of probable activity (Table 6).

4.5. Movements of Individuals in the Population

The movements of individuals in a population are not usually over any great distance, and the territorial distribution of the population pointed to distinct stability.

A greater degree of settled residence is exhibited by males. Almost half of the individually marked bucks (47%) were observed within a radius of up to 0.5 km from the place of their capture (Table 7). 84% of all bucks observed were found at a maximum distance of up to 1 km from their place of capture and marking. Only a small number of individuals had moved further away. The maximum distance from the place of capture (2.3 km) was found for buck 09, marked when a fawn.

Movements of does were far more often observed and in this case also, however, 54% of the does were observed at distances of up to 1 km from the place of capture, 33% of which at distances up to 0.5 km. In extreme cases the distance over which they moved exceeded even 5 km in a straight line (Table 7). The animal marked B29 caught 27.2.1977, moved in the year following marking to a distance of about 5 km and ended its movement there. This doe was observed, together with its progeny, within an area not greater than about 15 ha (the number of observations being smaller than the number envisaged by the method made statistical calculation impossible) in successive years: 1978 (3.05), 1979 (27.1, 28.8), 1980 (10.5) and 1981 (10.8). In the case of other does also tendency to movements to greater distances occurred in individuals marked while still fawns (24, B11, B.14) or in individuals 1—2 years old (B29, B19).

5. DISCUSSION

Population density exhibits annual fluctuations connected with effective increase and natural mortality, and shooting. When pressure from shooting is moderate and relatively stable, the spring, that is, pre-reproduction population density is shaped chiefly by means of natural losses occurring primarily during the winter period. Natural mortality, usually not great, causes losses of 33—35% — of the autumn population numbers (Fruziński & Łabudzki, 1982) during frosty and snowy winters, and in consequence a decrease in spring population density (Fig. 1).

Table 7

Local movements of individuals.

No. of deer	Date and place marking	Observations		
		Nearest km	Farthest km	% of animals observed in a distance (from-to, km)
	Males			
B21	7.III.1976, 95a	0.1	0.3	
B25	7.III.1976, 118a		0.3	0—0.5 km
21	29.II.1976, 159g	0.2	0.3	47%
O7	6.III.1976, 96a	0.1	0.3	
BO4	11.III.1973, 163a	0.1	0.4	
B15	4.III.1973, 159a	0.1	0.4	
19	16.II.1976, 137d	0.2	0.4	
29	8.III.1975, 118a	0.2	0.4	
B34	27.II.1977, 96a	0.1	0.5	
14	16.II.1976, 137d	0.2	0.6	
20	6.III.1976, 96f	0.2	0.6	0.6—1 km
30	29.II.1976, 159g	0.1	0.7	37%
47	26.II.1978, 119a	0.5	0.7	
A24	5.III.1972, 159f	0.1	0.1	
A23	26.II.1972, 160c	0.3	0.8	
23	7.III.1976, 118d	0.8	1.0	
13	8.III.1975, 161f	0.9	1.3	above 1 km
10	6.III.1976, 140l	1.1	1.6	16%
09	16.II.1976, 137d		2.3	
	Females			
B17	6.III.1977, 159g	0.1	0.2	
A25	4.III.1972, 157b		0.2	0—0.5 km
12	6.III.1976, 96a	0.1	0.3	33%
A20	27.II.1972, 163a	0.2	0.4	
BO8	10.III.1973, 159a	0.1	0.4	
33	11.III.1978, 137b	0.1	0.5	
04	4.II.1974, 26a	0.1	0.5	
17	6.III.1976, 96a	0.1	0.6	0.6—1 km
BO5	4.III.1973, 160b	0.4	0.6	21%
A29	22.II.1974, 137d	0.1	0.6	
17	6.III.1976, 96f	0.2	0.6	
BO3	3.III.1973, 26a	0.3	0.8	
B26	6.III.1976, 96a	0.1	1.1	1.1—2.0 km
22	8.III.1975, 95a	0.3	1.3	8%
28	8.III.1975, 95a	1.2	2.1	2.1—3.0 km
B11	2.II.1974, 137a	0.2	2.2	21%
A13	11.III.1972, 118a		2.3	
A12	27.II.1972, 163a		2.5	
24	29.II.1976, 159g	1.8	2.6	
BO9	24.II.1973, 118a		3.4	above 3.1 km
B19	27.II.1977, 96a	0.2	4.8	17%
B14	4.III.1973, 159b		4.1	
B29	27.II.1977, 96b	0.3	5.2	

Population density is also conditioned by the habitat situation and to a certain extent by geographical situation. In Poland population density of roe deer in large stretches of wooded land is from about 2 individuals per 100 ha (in certain parts of the Białowieża Primeval Forest and Augustów Forest) to 15 individuals (Pucek *et al.*, 1975).

Average population density at Zielonka (15.1 individuals/100 ha) is thus maintained on a high level despite shooting, which annually accounts for about 17% of the spring numbers. Fairly numerous data on the density of roe deer in some European countries, *e.g.* in the German Democratic Republic — 2.5/100 ha (Stubbe & Passarge, 1979), German Federal Republic — 18 individuals/100 ha (Nüsslein, 1968), Czechoslovakia (Slovakia) about 4 individuals/100 ha (Hell, 1979) etc. have no comparative value, as they refer to total areas and not to given stretches of forest. The accurate data given by Strandgaard (1972), on the other hand, describe very small habitats. Even without the limits of one stretch of wooded land the population density of roe deer varied depending on biotopes, *i.e.* chiefly the species composition of the tree stand and its age structure.

In the majority of forests in Poland the density of roe deer is slightly higher in tree stands in which deciduous species predominate (Pucek *et al.*, 1975). At Zielonka, over an 8-year period, the average spring population density is higher in coniferous forests in which pine predominates in the species composition of the tree stand. Although the difference is only slight, it is statistically significant (Table 2), and it is certainly the better feeding conditions which account for this.

Distinct and statistically significant differences in the density of roe deer in different development stages of tree stands are undoubtedly due to the different shelter conditions. The decidedly maximum population density in older plantations and thickets shows clearly how important suitable shelter is, since this ensures safe living and feeding over the daily cycle. In by far the majority of forests in other parts of Poland density of roe deer was highest when the proportion of plantation in the age structure of treestands was maximum, 10.3—11.7% (Pucek *et al.*, 1975).

The degree to which roe deer use different parts of the forest biotope as feeding grounds varies seasonally, depending on the amount and accessibility of food. In small shelterbelts at Kalø roe deer made most intensive use of forest feeding places during the period from December—January and April—June (Strandgaard, 1972), whereas feeding in cultivated fields depended on the localization and structure of crops. The greatest attraction as a feeding place over the yearly cycle of forest plantations and herb layer under treestands at Zielonka is certainly due to some degree of stability in the food supply. Forest plantations continued to be attractive feeding places in the respective months on a similar level in different years (Table 5). Utilization of feeding places is thus an important, but clearly, varying, element of the population's spatial structure.

Territorial systems have a definitely seasonal aspect. The size of bucks' territories and does' home ranges depends on a large number of factors, such as the value of the biotope from the aspect of feeding place and shelter, climatic conditions and population density (Hell, 1979; Stubbe & Passarge, 1979). Many difficulties as regards method also arise as to correct definition of the size of territories and home ranges. Henning (1962) defines the size of territories of bucks 2 years old and older, as 8—12 ha, with very high population density (34 individuals/ 100 ha). In southern England the size of territories was about 10 ha, and in small woods 7.1—7.4 ha (Prior, 1968), in Denmark under similar conditions, 26—30 ha (Strandgaard, 1972). With population density similar to that found at Zielonka Kurt (1968) gives territory size for Switzerland as up to about 28 ha (with density of 20 individuals per 100 ha) and Mottl (1962) — 10.2—25.4 ha, depending on the season of the year (with density of 16 individuals per 100 ha). The majority of these data on European populations of roe deer do not, however, give exact details of the methods used for calculating territory size, and thus it is difficult to compare data. If we take as a basis territory size calculated by the convex polygon method (10.3 ha), in many cases these are nearly similar values. In view of the fact that the suitability of different methods for calculating territory size and shape is still open to discussion, with simultaneous constantly small numbers of field observations, we have given exact values for territories without attempting to give more detailed justification or recommendation of the given method used to calculate same. The method of defining the area of activity of elliptical shape would appear in particular to be debatable (Jenrich & Turner, 1969).

Many authors have drawn attention to the relation between territory and age of the given individual, but only Nikolandic (1968) gives definite data, according to which 2-year old bucks have the most extensive territories (77 ha) and adult individuals the smallest (45 ha). The scanty material does not permit of definite confirmation of this phenomenon, although data analyzed (Table 6) would appear to show that adult bucks do n fact have the smallest territories. Field observations have, however, shown that the boundaries of these territories are very actively defended by the owner and respected by its neighbours.

The size of the home ranges of does also depends on the season of the year. The absence of active protection of the boundaries of such ranges probably makes it possible for them to live in a larger space than is the case with bucks. According to Kurt (1968), the average size of a home range in the lowland regions of Switzerland is about 49 ha (from 3 to 180 ha). Strandgaard (1972) also states quite clearly that the size of the home range of a doe is far larger than the territory of bucks, since the home range is often common to a large number of does.

At Zielonka the average size of the home range, depending on the method used for its calculation, was: 12.2 ha (3.2 ha larger than the territory of bucks) or 15.2 ha (difference 4.9 ha) (Table 6). There is some degree of contradiction here with Mottl's data (1962), who gives the size of the home range of does as 10—22 ha and with Nikolandie (1968), who gives the average home range size for the roe deer as 37 ha (from 20 to 96 ha). This author and Kurt (1968) consider that it is the young 2-year does which have the largest home range. Some data from Zielonka also point to the existence of this regularity, since the largest home range was found for hinds 17 BO3 and 22, marked when 2—3 years old.

The size and range of movements undoubtedly form an important element of the spatial structure of the population. They certainly depend not only on population density, but also on the character of the habitat. They occur most intensively in overcrowded populations not used for hunting purposes, particularly if the population lives in small shelterbelts, round which intensive shooting takes place (Strandgaard, 1972). Mottl (1957), Raesfeld (1960), Rieck (1955, 1970), Myrberget (1973) and Blankenborn (1957) also indicate the important role played by movements for interchange of individuals and variations in population numbers.

Under the conditions at Zielonka, which is a large stretch of forest to some extent isolated from other such stretches, the range of movement is limited in comparison with data given by the authors referred to above. In our case also the furthest movements occurred in the case of young individuals, marked at the age of 8—10 months. Movements took place in spring, soon after marking, which is certainly connected with the search for territory or home range, although the presence of the youngest bucks is often tolerated by the owner of the territory, depending on their condition and behaviour (Strandgaard, 1972). More limited movement of males may be connected with their territorial behaviour in spring and summer. There are as far on data available on observations of marked individuals outside the Zielonka stretch of forest, although the lack of information cannot be taken solely to mean that no further movements took place at all.

Acknowledgements: Field work was carried out with considerable assistance from members of the Forestry Students Scientific Circle of the Academy of Agriculture in Poznań. The authors are also grateful to M. Franczak, M. Sc and K. Łagodziński for their contribution to the collection of study material.

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Accepted, March 21, 1983.

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BIOTOP, ZAGĘSZCZENIE I STRUKTURA PRZESTRZENNA POPULACJI SARNY LEŚNEJ

Streszczenie

Na podstawie badań przeprowadzonych w latach 1973—1980 w Łowieckim Ośrodku Doświadczalnym „Zielonka" (około 8000 ha powierzchni leśnej) określano zagęszczenie i organizację przestrzenną populacji sarny. Charakter biotopu wymagał zastosowania różnych metod badawczych, jak pędzenia próbne, transekt liniowy, czy wreszcie bezpośrednia obserwacja znakowanych indywidualnie osobników.

Stwierdzono zmienność zagęszczenia populacji od 20,8 osobnika na 100 ha do 10,4/100 ha (Ryc. 1). Najważniejszą przyczyną wahań liczebności były warunki atmosferyczne okresu zimowego. Wyższe zagęszczenie populacji (16,1 osobnika/100 ha) stwierdzono w drzewostanach o przewadze sosny w składzie gatunkowym, niż w drzewostanach liściastych i mieszanych o przewadze dębu (14,1 osobnika) (Tabela 2). Wyraźne, istotne pod względem statystycznym, różnice zagęszczenia populacji saren stwierdzono w poszczególnych stadiach rozwojowych drzewostanów. Zdecydowanie najwyższe zagęszczenie populacji w starszych uprawach (21,7 osobnika) i młodnikach (20,9 osobnika) (Tabela 3) świadczy o dużym znaczeniu warunków osłonowych.

Wykorzystanie przez sarny poszczególnych fragmentów biotopu jako żerowisk jest istotnym, lecz wyraźnie zmiennym elementem struktury przestrzennej populacji. Jedynie atrakcyjność upraw leśnych i runa w drzewostanach jako żerowisk utrzymuje się na zbliżonym poziomie w cyklu rocznym (średnio odpowiednio 37,3% i 23,3% obserwacji) w różnych latach, co świadczy o znacznej stabilności tego elementu bazy żerowej. W latach nasiennych dębu żołędzie stanowią podstawowy składnik żeru sarn aż do wiosny (w listopadzie 58,5% obserwacji) (Tabele 4 i 5).

Średnia wielkość terytorium kozłów, w zależności od zastosowanej metody kalkulacji wyniosła: 9 ha w przypadku wieloboku minimalnego (minimum polygon), 10,3 ha przy wieloboku wypukłym (convex polygon) i 52,3 ha w przypadku obszaru prawdopodobnej aktywności w kształcie elipsy (Tabela 6).

Średnia wielkość arealów osobniczych kóz wyniosła odpowiednio 12,2 ha, 15,2 ha oraz 77 ha (Tabela 7).

Układ terytorialny populacji nosi cechy wyraźnej stabilności, przy czym wyższy stopień osiadłości wykazały osobniki męskie: 84% wszystkich oznakowanych kozłów obserwowano w odległości do 1 km od miejsca odłowu, w tym aż 47% w promieniu do 0,5 km (Tabela 8). W przypadku kóz odpowiednio 54% i 33% (Tabela 9). Migracje na najdalsze odległości (2,3 km u kozłów i 5,2 km u kóz) podejmowały osobniki, najmłodsze, odłowione i oznakowane jako koźlęta.