DOI: 10.2478/v10083-012-0036-7

ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA

VOL. XXX (4) SECTIO EE 2012

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The body mass of the roe deer (*Capreolus capreolus* L.) in the foothills of the East Sudety Mountains

Masa tusz saren *(Capreolus capreolus L.)* na Pogórzu Wschodnio-Sudeckim

Summary. The aim of the study was to identify variation in the body mass of bucks and does of the roe deer shot in 2005–2011 in a hunting district at the border of Poland and the Czech Republic. The material comprised 334 bodies of hunted bucks (173 individuals) and does (161 individuals), which were weighed with 0.5 kg accuracy. Statistical analyses of this data showed that individuals of a gradually lower body mass have been hunted since 2007. The body mass of the bucks decreased during the seven years (2005–2011) of the study. The mean body mass of the population of bucks decreased by about 2.5 kg during five years (2007–2011). The decrease of the body mass of does was reflected by a 25% decrease of the mode value during seven years. This means a 5 kg decrease in the body mass of the most frequently hunted individuals. The proportion of individuals in a poor condition increased in the studied population. After the years when does of high body mass were hunted, the body mass of collected does became gradually lower. In 2011 the hunting of does increased by 94%, and of the bucks by 76%, in comparison with 2006. The mean body mass of individuals decreased by 12%. These figures reflect deterioration of the local population of the roe deer.

Key words: roe deer, body mass, habitat

INTRODUCTION

The roe deer inhabits ecosystems of both small woodlands and open arable fields, and is the most abundant eurybiotic species of game in Poland. In the 1980s in the foothills of the East Sudety Mountains, where the habitat conditions were exceptionally favourable for the roe deer, herds of 80 up to 300 individuals were observed during winter. At present, the remains of this population form small herds of several up to more than ten individuals.

The importance of the roe deer in the biotope can be analysed from two points of view. The first approach is to understand their role in the functioning of the biotope. The second approach is to identify the influence of the biotope on the roe deer population. In natural conditions free of human pressure roe deers played a role in the ecological succession. They carry seeds and spores between the ecosystems, and integrate them in this way. The role of the roe deer in this process is important. Population size of the roe deer, their reproduction rate, longevity of individuals, their density, and the production of the biomass the population, which can be utilised by the manager of the hunting ground, depend to a great extent on the structure of landscape and processes that take place there. The ability of roe deers to compensatively use the ecosystems of different feeding capacities acts in favour of this species. Compensation of food supply occurs when one ecosystems supports the needs of these animals that cannot be met in the neighbouring ecosystem. Such situations occurs during harsh winters, which occur in our climate zone every few years. The land use is different in each ecosystem, and the mosaic and location of these ecosystems form the man-made landscape, thus it is important to allow space for game animals and for hunting practice in such areas. Landscape transformations cause limitation to migration routes of animals. Spatial and qualitative structure of crops change, as so does the possibilities of the habitat use by animals. The habitat structure affects the availability and the quality of food, which is decisive for individual growth and body mass of roe deers.

The aim of the study was to identify variation in the body mass of bucks and does of the roe deer hunted in 2005–2011 in a hunting district at the border of Poland and Czech Republic. We formulated the hypothesis that extensive transformations of the landscape formed by a mixture of fields and woodlands, which is the habitat of roe deers, might have a negative impact on the condition of this species. The first symptom would be changes in the mean body mass in the population. The study verifies this hypothesis by statistical analyses.

MATERIAL AND METHODS

The material for this study were roe deers shot in the hunting district 109 located in the foothills of the East Sudety Mountains, in the region of Opole (Fig. 1). The district has an area of 5 375 hectares and is located in the area of the lowest forest coverage (7.7%) in the whole Opole region. Our study area, the hunting district 109 includes vast monocultures of rape and maize, where agrichemical treatment prevail. This caused transformation of the food base and habitat conditions for roe deers, including reduction of thickets and woodlands among fields and disappearance of boundary strips, ditches and ponds, which used to increase habitat diversity.

We analysed by statistical methods a sample of 334 roe deers, including 173 bucks and 161 does. Cooled bodies were weighted with 0.5 kg accuracy. The bodies of bucks were collected between of 11 May and 30 September, and of does between 1 October and 15 January, in 2005–2011.

RESULTS

The type of land use is decisive for the living conditions of animals that inhabit some ecosystems. Population numbers, structure and dynamics of game herbivores depend to a large extent on exploitation by hunters. Among the known methods used to assess the population size, the best measure is the size of the hunting bag during a time period. The longer is this time period the more accurate information on the population dynamics we obtain (Tab. 1, 2). The increase of hunting of roe deers from main herds, from 13% up to 35%, occurred during the last 20 years of the XXth century (the increasing trend in Tab.1). This leads to the question: what factors caused such an intensive exploitation of this species? Could these be any environmental factors, or was human control of the population size of the roe deer? In 2001–2011 the numbers of roe deers hunted in Poland became more stable and collection of individuals of the main herds decreased from 26% to 19.5%. At the same time a gradual increase of the population size occurred, from 400 thousands in 1976 up to 826 thousands in 2011 (Tab. 1, 2). The coefficient of variation of the population size in Poland during 2000–2011 was v = 11%. But the numbers of animals hunted in this period was stable and did not exceed 7%. The most variable measure was the number of individuals obtained from the main herd, which oscillated between 18.5% and 26% during 2001–2011 (Tab. 2). But this coefficient became stable after 2000 in comparison with 1971–1995, when the exploitation of the main herd oscillated between 13% and 35%, and the variation coefficient of the numbers of hunted individuals reached v = 36% (Tab. 1).

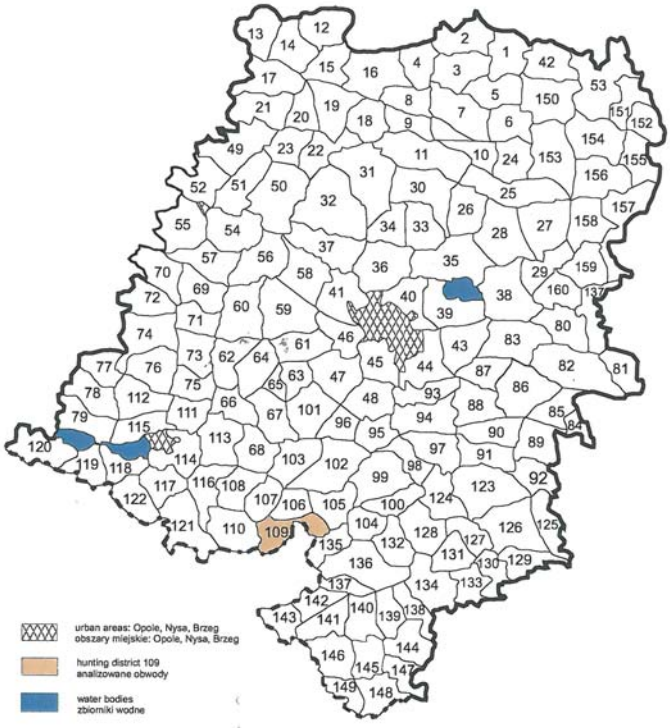

Fig. 1. Analysed hunting district in the Opole province
Ryc. 1. Analizowane obwody łowieckie w województwie opolskim

Table 1. Hunting bag of the roe deer in Poland. Five-years mean values in 1971–1995 [Dzięciołowski and Fruziński 1998] and 2001–2010 [GUS 2008, 2011] provided
Tabela 1. Pozyskanie saren w Polsce. Średnie wartości z 5-lecia 1971–1995 [Dzięciołowski i Fruziński 1998] i 2001–2010 [GUS 2008, 2011]

Year Rok	Population size (thousands of individuals) Stan (tys. szt.)	Hunting bag (individuals) Pozyskanie (szt.)	Proportion (%) of population hunted during 5 years Procent pozyskania z liczebności populacji w 5-leciu
1971–1975	–	29 900	–
1976–1980	402.2	52 429	13.04
1981–1985	476.5	90 290	18.95
1986–1990	560.8	119 040	21.23
1991–1995	514.9	179 814	34.92
2001–2005	650.0	150 600	23.17
2006–2010	764.4	151 000	19.75

– a lack of data
– brak danych

Table 2. Hunting bag of the roe deer in Poland in 2000–2011 [GUS 2008, 2011]
Tabela 2. Pozyskanie saren w Polsce w latach 2000–2011 [GUS 2008, 2011]

Year Rok	Population size (thousands of individuals) Stan (tys. szt.)	Hunting bag (thousands of individuals) Pozyskanie (tys. szt.)	Proportion (%) of population hunted during a year Procent pozyskania z liczebności populacji w roku
2000	597.1	–	–
2001	614.4	158	25.72
2002	623.2	149	23.91
2003	652.6	146	22.37
2004	668.2	149	22.30
2005	691.6	151	21.83
2006	706.5	147	20.81
2007	705.8	134	18.97
2008	760.2	141	18.55
2009	827.5	157	18.97
2010	822.0	176	21.41
2011	825.8	161	19.50
$\overline{x}$	707.9	151.73	21.31
δ	80.13	10.63	2.15
V%	11.32	7.00	10.08

– a lack of data
– brak danych

During the 1995/1996 hunting season, 7 439 roe deers were shot. During the 2007/2008 hunting season the population of roe deer in the Opole region was 30 100 individuals, hunting grounds covered 766 100 ha, and 6 145 roe deers were shot, according to the Main Statistics Office [GUS 2008]. These figures were 17.4% lower then in the results of hunting in the season 1995/1996. In the Opole region the density of roe deers in the hunting season 2007/2008 was 3.93 individuals per 100 ha of hunting grounds. Dzięciołowski and Fruziński [1998] stated that the population density of roe deers should not exceed 10–12 individuals per 100 ha of the forest area, even in woodlands that offer them the best feeding conditions. The forest area in the hunting grounds in the Opole region is 214 400 ha. If the whole populations of roe deers, from both fields and forests,

would move to forests it would give the density of 14 individuals per 100 ha. Analysing these values, we should consider not only too high density of this population, but also its uneven use of the potential habitats within the hunting grounds. Roe deers use both forest and field habitats, but they avoid red deers, and in particular the noisy and aggressive fallow deer, which inhabit forests. Such behaviour of roe deers has been observed in the hunting district at the border of Poland and Czech Republic in the forest complexes in the foothills of the East Sudety Mountains, where the fallow deer moved from the Czech to the Polish side. In this area roe deers gradually abandon habitats that they traditionally used, retreating from fallow dears.

The density of the roe deer population changes constantly. The density, which might be for example 10 individuals per 100 ha, is the effect of opposite processes: reproduction and mortality, and immigration and emigration. Naturally, the number of individuals that are born equal those that die, and of those that leave the area does not equal those arrived there. The population size vary even in stable populations within one generation (oscillations) and from one generation to the next (fluctuations). Within some range of a population density, optimum for the population development, no negative effects on survival, reproduction and mortality of individuals occur. The optimum density is the number of individuals per unit of surface, when the highest survival and fertility occurs in a population. Thus the correlation between the features of individuals and the increase of population density should be positive up to some level of the density, but negative beyond this threshold.

The relation between the population size and the habitat capacity of a hunting ground is another factor that affect animals' body mass. If we compare two populations of different densities, but with similar habitat capacities of the hunting grounds, the mean body mass of individuals should be higher with the lower density. But high population density should not have a negative effect on individuals' condition in a hunting ground abundant in food. To explain the effect of density on the body mass of roe deers we analysed the body mass of 161 does and 173 bucks collected in the hunting district 109 in 2005–2011. The density of this population was 4.7 individuals/100 ha.

Table 3. Variation of the body mass (kg) of the roe deer hunted in the hunting district 109 in the Opole region during 2005–2011
Tabela 3. Zmienność masy (kg) tusz saren pozyskanych na Opolszczyźnie w latach 2005–2011 w obwodzie 109

Measures of central tendency and distribution Miary położenia i rozproszenia	Body mass of – Masa	
	bucks – kozłów	does – kóz
$\sum$	2738.5	2648.5
$\bar{x}$	15.83	16.45
δ_n	2.53	2.09
δ_{n-1}	2.54	2.10
Me	16	16
Mo	15	15
Min	9	11
Max	22	21
v%	16.0	12.7
n	173	161

Table 4. Body mass and numbers of roe deers hunted in the district 109 in 2005–2011
Tabela 4. Całkowita masa i liczebność pozyskanych saren w obwodzie 109 w latach 2005–2011

Sex Płeć	Years – Lata						
	2005	2006	2007	2008	2009	2010	2011
	Body mass (kg) – Masa (kg)						
Buck – Kozioł	382.03	278.97	444.08	333.00	426.00	435.50	439.00
Doe – Koza	352.00	282.08	293.08	388.93	424.00	417.50	491.00
∑	734.03	561.05	737.16	721.93	850.00	853.00	930.00
Numbers – Liczebność							
Buck – Kozioł	23	17	26	20	28	29	30
Doe – Koza	20	16	17	23	28	26	31
∑	43	33	43	43	56	55	61

Table 5. Body mass of the roe deer bucks hunted in the district 109 in 2005–2011
Tabela 5. Masa pozyskanych tusz kozłów z obwodu łowieckiego 109 w latach 2005–2011

Measures of central tendency and distribution Miary położenia i rozproszenia	Body mass of bucks (kg) Masa tusz kozłów (kg)						
	2005	2006	2007	2008	2009	2010	2011
$\sum$	382	279	444	333	426	435.5	439
$\bar{x}$	16.61	16.41	17.08	16.65	15.21	15.02	14.63
δ_n	2.059	2.809	2.074	1.981	3.004	2.163	2.254
δ_{n-1}	2.105	2.895	2.115	2.033	3.059	2.202	2.293
Me	16	17	18	17	15	15	14.75
Mo	15	16	18	15	15	18	15
Min	13	12	10	12	10	11	9
Max	20	22	20	20	21	19	19.5
V%	12.4	17.11	12.15	11.90	19.75	14.41	15.41
n	23	17	26	20	28	29	30

The body mass in the studied population of does had right-skewed and non-symmetrical distribution, and the following relation occurred: $\bar{x}$ = 16.45 > *Me* = 16.0 > *Mo* = 15.0 (Table 3). This showed that individuals of the best condition in the population were hunted. The body mass in the studied population of bucks had left-skewed distribution, because the relation *Mo* = 15.0 < $\bar{x}$ = 15.83 < *Me* = 16.0 occurred (Tab. 3). This showed that bucks of low body mass were hunted.

Table 6. Body mass of the roe deer does (kg) hunted in the district 109 in 2005–2011
Tabela 6. Masa pozyskanych tusz kóz (kg) z obwodu łowieckiego 109 w latach 2005–2011

Measures of central tendency and distribution Miary położenia i rozproszenia	Body mass of does (kg) Masa kóz (kg)						
	2005	2006	2007	2008	2009	2010	2011
$\sum$	352	282	293	389	424	417,5	491
$\bar{x}$	17.6	17.63	17.24	16.91	15.14	16.06	15.84
δ_n	2.010	2.176	1.476	2.244	1.552	1.908	1.829
δ_{n-1}	2.062	2.247	1.522	2.295	1.580	1.946	1.872
Me	18	18	18	17	15	16	16
Mo	20	18	18	18	14	17	15
Min	14	13	15	12	11	11	11
Max	20	20	19	21	19	20	19
v%	11.42	12.35	8.57	13.27	10.25	11.88	11.55
n	20	16	17	23	28	26	31

Table 7. Body mass (kg) of 173 of the roe deer bucks hunted in 2005–2011
Tabela 7. Masa w kg 173 kozłów w latach 2005–2011

No. Lp.	Body mass (kg) Masa (kg)	Count Liczebności bezwzględne	Relative frequencies (%) Częstości względne (%)	Cumulative count Skumulowane liczebności	Cumulative relative frequencies (%) Skumulowane częstości względne (%)
1	2	3	4	5	6
1	9.0–10.3	4	2.3	4	2.3
2	10.4–11.6	5	2.9	9	5.2
3	11.7–12.9	11	6.4	20	11.6
4	13.0–14.2	27	15.6	47	27.2
5	14.3–15.5	33	19.1	80	46.3
6	15.6–16.8	22	12.7	102	59.0
7	16.9–18.1	45	26.0	147	85.0
8	18.2–19.4	13	7.5	160	92.5
9	19.5–20.7	11	6.4	171	98.9
10	20.8–22.0	2	1.1	173	100.0
Total Razem		173	100.0	---	---

In 2011, 85% more roe deers were hunted than in 2006, but the total mass of collected bodies (in kg) increased only by 66% (Tab. 4). The detailed analysis showed that since 2007 hunted individuals had gradually lower mean body mass (the population mean). This is reflected by the measures of variation. The decrease of the body mass was

as follows: mean $\bar{x}$ = 2.45 kg, median *Me* = 3.25 kg, mode *Mo* = 3.00 kg (Tab. 5). This has been verified by the analysis of regression and by correlation of the data on 173 bucks, where the body mass (x) of the collected bodies was a function of time (y) during 2005–2011. The body mass of the hunted bucks decreased during seven years, as reflected by the multiple correlation coefficient r = (- 0.96) and the coefficient of determination r^2 = (-0.92). The mean body mass in a population decreased by nearly 2.5 kg between 2007 and 2011.

Table 8. Body mass (kg) of 161 of the roe deer does in 2005–2011
Tabela 8. Masa w kg 161 kóz w latach 2005–2011

No. Lp.	Body mass (kg) Masa (kg)	Count Liczebności bezwzględne	Relative frequencies (%) Częstości względne (%)	Cumulative count Skumulowane liczebności	Cumulative relative frequencies (%) Skumulowane częstości względne (%)
1	2	3	4	5	6
1	11.0–12.0	4	2.5	4	2.5
2	12.1–13.0	6	3.7	10	6.2
3	13.1–14.0	18	11.2	28	17.4
4	14.1–15.0	29	18.0	57	35.4
5	15.1–16.0	25	15.5	82	50.9
6	16.1–17.0	23	14.3	105	65.2
7	17.1–18.0	28	17.4	133	82.6
8	18.1–19.0	14	8.7	147	91.3
9	19.1–20.0	13	8.1	160	99.4
10	20.1–21.0	1	0.6	161	100.0
Total Razem		161	100.0	---	---

Variation in the body mass of hunted does was reflected by the measures of central tendency and distribution presented in Table 6. The decrease of the body mass of does was shown by the mode, which decreased by 25% during seven years. This means the decrease of the body mass of the most frequently hunted individuals by 5 kg. The proportion of the weakest individuals increased in this population.

The cumulative relative frequencies (Tab. 7, 8) showed that the proportion of hunted bucks that weighed below 13 kg was two times higher than of the does. The proportion of hunted individuals heavier than 18 kg was 2.4% lower among the bucks than among the does. The results show cyclic variation of the body mass, shown by a sinusoid, and the decreasing trend. After the years when heavy does were hunted, the body mass of collected does became gradually lower.

DISCUSSION

The body mass, which is a proxy for the individual's condition, reflects the animals' habitat conditions. The body mass of individuals also depends on the population density in a habitat [Andersen *et al.* 2000].

The survey of roe deers in the analysed hunting district showed that 250 individuals (of unidentified sex) inhabited this area. This gave the density of 4.65 individual per 100 ha in this district. The capacity of this hunting ground has been estimated at 645 individuals. Thus the level of use of this hunting area is relatively low, only at 39% of the habitat capacity. Thus this is not overpopulation of this area but other factors that influenced the mean body mass of this population. Hunting of the main herd varied during the studied area between 13.2% in 2006 and 24.4 % in 2011 (values calculated from data in Tab. 4). Thus the highest proportion of the hunted roe deers did not depart from the upper mean values during the last 10 years in Poland (Table 2). These results showed that in the analysed habitats the density of roe deers was lower than the actual capacity of the hunting ground.

This area is affected by extensive transformation of the landscape formed by fields and woodlands, which are habitats of the roe deer. Intensification of agricultural practices, with all its negative effects, occurs in this area (including reduction of thickets and woodlands among fields and disappearance of boundary strips, ditches and ponds, which used to increase habitat diversity). Studies on the plants that roe deers eat showed that they need diverse food to stay fit. The diet of the roe deer may include178 plant species [Bobek 1984, Brzuski *et al*. 1998, Matra *et al.*1989].

The results of habitat transformations has been reflected by the whole population of the roe deers in the studied hunting district. This was shown the most clearly by the mean body mass of the bucks, which was 14.63 kg in 2011 (Tab. 5). Almost 60% of the hunted bucks had body mass below 16.8 kg and only 1% above 20 kg (Tab. 7). Drozd *et al*. [2000] in their estimated of the phenotype trends also showed the decrease of the mean body mass of bucks. They recorded the largest negative regression among bucks from the Solska Forest and Roztocze mesoregions (–0.145 and –0.086 kg/year, respectively). In the Lublin region bucks of all age showed a decrease in their body mass [Dziedzic *et al.* 2007].

We observed enforced unidirectional exploitation of roe deers in the analysed habitats. The reason are attempts from the hunting area management to organise the for compensations to the farmers. In 2011 hunting of roe deer does increased by 94%, and of the bucks by 76%, in comparison with 2006. The increase of the meat sale increased only for 66% during this period. This came at the cost of the population condition in the whole population, because the mean body mass of an individual decreased for 12%. This shows a deterioration of the local population of the roe deer. This forms a deadly spiral, because the increase of demands for compensation from farmers enforces increase in the numbers of hunted game, considering their gradually worse condition. A lack of reaction and preventive measures from the nature conservation authorities in the past are the reasons that the capercaille and the black grouse are currently threatened species, and a steep decline of the grey partridge and the European hare occurred in the whole Poland. Studies on the population status of the roe deer in the whole country are needed urgently to save this species from the fate of the grey partridge or the European hare.

CONCLUSIONS

1. Statistical analyses showed a decrease in the body mass of roe deer bucks and does in 2005–2011. For bucks the multiple correlation coefficient was r = -0.96 and the coefficient of determination was r^2 = -0.92, while for does it was r = -0.97, r^2 = -0.94, respectively.

2. The deteriorating condition of the studied roe deer population was not caused by overpopulation, but by habitat changes.

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Streszczenie. Celem badań była ocena zmienności masy tuszy samców i samic saren pozyskanych w latach 2005–2011 w obwodzie łowieckim znajdującym się na pograniczu polsko-czeskim. Materiał badawczy w postaci 334 tusz, z czego 173 stanowiły kozły i 161 kozy, zważono z dokładnością do 0,5 kg i poddano analizie statystycznej. Ze szczegółowej analizy wynika, że od 2007 r. pozyskiwano osobniki o coraz mniejszej masie przeciętnej. Analiza tusz kozłów wykazała, że w ciągu siedmiu lat (2005–2011) nastąpiła wyraźna regresja ich masy. W liczbach bezwzględnych średnia populacyjna masa kozłów zmniejszyła się w ciągu pięciu lat o blisko 2,5 kg (2007–2011). Spadek masy tusz kóz obrazuje modalna, która w okresie siedmiu lat obniżyła się aż o 25%. W wartościach bezwzględnych oznacza to spadek masy najczęściej pozyskiwanych osobników o 5 kg. W tej populacji zwiększył się odsetek osobników najsłabszych. Po latach, w których pozyskano kozy o dużej masie, rejestrowano kozy o masach mniejszych. W 2011 r. pozyskanie kóz wzrosło o 94% w stosunku do roku 2006, a kozłów o 76%. Średnia masa pojedynczych osobników zmniejszyła się o 12%. Powyższe relacje świadczą o regresie całej lokalnej populacji saren.

Słowa kluczowe: sarna, masa tusz, biotop