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THE POPULATION SIZE, DEMOGRAPHY AND THE HARVEST STRATEGY FOR THE RED DEER (*CERVUS ELAPHUS* L.) IN THE POLISH EASTERN CARPATHIANS

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ABSTRACT.– Using a line intercept snow track index, the population density and numbers of red deer (Cervus elaphus L.) *in 8 Forest Districts (Baligród, Cisna, Dukla, Lutowiska, Komacza, Stuposiany, Rymanów and Wetlina) were estimated during February 2000. The total number of red deer inhabiting the study area (134.0 thousand hectares of forest) was 4,081 individuals. The average population density was 30.4 red deer/1000 ha and it ranged from 10.1 animals/1000 ha in Wetlina Forest District to 39.3 individuals/1000 ha in Dukla Forest District. In September 2000, observation records of 952 red deer indicated that male/female ratio was 1: 1.6, and the calf/female index was 31 calves per 100 females. Using a population dynamics model, an annual population recruitment rate was calculated. It ranged from 10.5% to 18.1% of the population size in March and it was negatively correlated with the population density of wolves. A computer simulation of various harvest strategies showed that the low percentage of old stags in the present red deer population was caused by over-harvest of 2-5-year-old stags. Therefore, it is suggested that the percentage of young males in the hunting bag should not be higher than 30% of the total harvested males.*

RÉSUMÉ.– En février 2000 nous avons estimé la densité de population et le nombre de cerfs (Cervus elaphus L.) *dans 8 Districts Forestiers (Baligrod, Cisn, Dukla, Lutowiska, Komancza, Stuposiany, Rymanow et Wetlina). Pour celá un index des empreintes sur la neige interceptant une ligne a été utilisé. Le nombre total de cerfs habitant dans la zone d'étude -134.000 ha de forêt- s'élevait à 4 081 animals. La densité moyenne de la population était de 30,4 cerfs par 1000 ha, chiffre oscillant entre 10,1 animals par 1000 ha dans le District Forestier de Wetlina et 39,3 individus par 1000 ha dans le District Forestier de Dukla. En Septembre 2000, les observations enregistrées pour 952 cerfs ont montré que le sex-ratio était de 1: 1,6, et la relation faon/femelle était de 31 faons pour 100 femelles. En appliquant un modèle de dynamique de population, nous avons calculé le taux de recrutement, lequel peut*

aller de 10,5% à 18,1 % du total de la population au mois de mars; il était négativement corrélé avec la densité de population de loups. La simulation sur ordinateur des différentes stratégies d'extraction a montré que le bas pourcentage de vieux mâles observé dans la population actuelle était dû à la surchasse des mâles âgés de 2-5 ans. Nous pouvons recommander que la pression de chasse sur les jeunes mâles ne dépasse pas 30% du nombre total de mâles chassés.

RESUMEN.– Durante febrero del 2000 se estimó la densidad de población y el número de ciervos (Cervus elaphus *L.) en 8 distritos forestales (Baligród, Cisna, Dukla, Lutowiska, Komacza, Stuposiany, Rymanów y Wetlina) por medio del índice de intercepción lineal de huellas en la nieve. Se obtuvo un total de 4081 individuos para el área de estudio (134.000 ha de bosque). La densidad media fue de 30,4 ciervos/1000 ha y su rango osciló de 10,1 ciervos/1000 ha (Distrito Forestal de Wetlina) a 39,3 individuos/1000 ha (Distrito Forestal de Dukla). En septiembre de 2000 la observación de 952 individuos arrojó una sex-ratio de 1: 1,6 (machos: hembra) y un índice de 31 crías por cada 100 hembras. La tasa de reclutamiento anual se calculó mediante un modelo de dinámica poblacional, oscilando ésta entre el 10,5% y el 18,1% del tamaño poblacional en marzo y estando correlacionada negativamente con la densidad de lobos. Un programa informático de simulación de distintas estrategias de aprovechamiento cinegético mostró que el bajo porcentaje de machos viejos era debido a un exceso de caza de los venados de 2 a 5 años de edad. Por lo tanto, se recomendó que la proporción de machos jóvenes en el cupo no debería superar el 30% del total de machos cazados.*

Key-words: Harvest strategy, Polish Eastern Carpathians, population density, red deer, recruitment rate, sex ratio.

1. Introduction

Hunting clubs in Poland do not pay for damage done by red deer in forests providing they maintain the population density and carry out harvest according to standards imposed each year by the local Forest Service. The number of red deer in hunting districts should be estimated by hunting clubs after finishing the hunting season and according to harvest success and the number of animals seen in fields. Such assessment is very subjective and very often prone to serious errors (BOBEK *et al.*, 1997; BOBEK *et al.*, 2001; PUCEK *et al.*, 1975). Recently, the State Forest Service has seriously questioned this data on red deer numbers.

Since 1988, due to the high level of damage by red deer in young forest plantation (GDEK, 1995; SZUKIEL, 1982), the Forest Service obliged hunting clubs to increase the harvest quotas of red deer in all hunting districts located in the Polish Eastern Carpathians. This programme was continued to the end of 1999 resulting in a decline in the numbers of red deer, especially males of the older age classes. It became very urgent to know what the real population size of red deer was and why the number of old stags rapidly decreased.

These two questions were major research tasks of the work presented here: (1) To estimate, by means of an objective population number assessment method, the number of red dear inhabiting the Polish Eastern Carpathian Mountains, and compare the result with the number of red dear local hunters obtained by round year observation (guessetimation) and (2) show that the current strategy of intensely harvesting stags that belong to the youngest age class (2-5 years old animals) causes a low percentage of old stags (ones older than 10 years old) in the hunting bag. The Polish Eastern Carpathians are the best red deer habitat in the country: the high quality antlers of red deer living there are very attractive for domestic and foreign hunters providing local people with an important source of income (BOBEK *et al.*, 1990).

2. The study area and methods

The Polish Eastern Carpathians are situated in the southeastern part of the country (Figure 1). The eastern part of this mountain range, where the forest districts of Cisna, Lutowiska, Stuposiany and Wetlina are located, is

Figure 1. Forest districts: Baligrod (BAL), Cisna (CIS), Dukla (DUK), Komancza (KOM), Lutowiska (LUT), Rymanow (RYM), Stuposiany (STU), Wetlina (WET), Bieszczady National Park (BNP), Magurski National Park (MNP).

higher than its western part administered by Baligród, Dukla, Komacza and Rymanów forest districts. The highest mountain of the eastern part, Tarnica, reaches 1348 m a. s. l., the highest one of the western part, Woosa, 1071 m a. s. l. (KONDRACKI, 1989). The climate is very variable in this region. The average annual temperature is +6°C. In winter months it falls as low as -35°C. Snow cover stays for 90-140 days (HESS *et al.*, 1977; MICHNA & PACZOS, 1972) and the average snow cover depth fluctuates between 40 and 80 cm and is considerably thicker in the eastern part of the study area (MICHNA & PACZOS, 1975, 1988). The total study area encompassed 134,000 hectares of forest.

The dominant forest cover type is beech – fir association (*Fagetum-carpaticum)* supplemented in higher elevation with small parts of mixed mountain forest *Abieti Picetum mountanum*. Red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), bison (*Bison bonasus*) and roe deer (*Caproleus caproleus*) are the largest ungulates in the region (JAMROZY, 1994). There are also large carnivores roaming in the Bieszczady: brown bears (*Ursus arctos*), wolves (*Canis lupus*) and lynx (*Lynx lynx*) (GULA & FRCKOWIAK, 1996; BOBEK *et al.*, 1997; NOWICKI, 2001; PODZIE *et al.*, 1996).

The number and density of red deer population was estimated using so called "Carpathian method" (BOBEK *et al.*, 1997) which is based on relationship between absolute population density (N/1000 ha of forest) as a dependent variable and a snow track density index (T per km/day) as an independent variable. In the whole study area, 81 line transects of a total length of 483 km were established by systematic placement. They were non-public, forest roads accessible by car in winter. During 5 consecutive days, fresh snow tracks left by red deer were counted and always cleared after counting. Then, the average index of T/km . day^{-1} for the line transects, separately for each inventory block (3-4 thousand hectares of forest), was calculated. The following formulas were used to calculate the red deer density in the inventory units (BOBEK *et al.*, unpubl. data):

$$Y_1 = -1.552 + 27.269\ X \quad (1)$$

$$Y_2 = 11.531 + 12.002\ X \quad (2)$$

Where Y_1 and Y_2 stand for the density of red deer population inhabiting high (Cisna, Lutowiska, Stuposiany and Wetlina Forest Districts) and low (Baligród, Dukla, Komacza and Rymanów Forest Districts) elevated parts of the study area, respectively, and X is the snow track density index. Using the above relationship and the entire forest area of each inventory block, the number of red deer per inventory block was estimated. By compiling data from the inventory units, the number of red deer in each forest district was obtained.

Computer simulations of various hunting strategies affecting red deer population were performed by using the "Wieniec 2000" harvest model (BOBEK & GAWOR, unpubl. data). Input data necessary to utilize this model are: (1) March population numbers broken down into males and females, (2) the calf/female ratio in September, (3) winter calf mortality and (4) the mortality of adults in summer and winter. Additionally, it is necessary to declare a harvest strategy that is the planned percentage of stags, hinds and calves in the hunting bag, as well as the planned percentage of young stags (2-5 year olds), mid age stags (6-10 year olds) and old stags (older than 10 years old) harvest of the male population segment. Output data of the model are the number of stags broken into three age classes, and the number of hinds and calves which should be harvested.

The simulation of harvest strategy "A" relied on the input data currently used for harvest planning in the area of the Polish Eastern Carpathians. In strategy "B' input data on the harvest of calves, the share of which in the total hunting bag had been decreased from 17.5% to 5%, the stags/hind ratio was the same as in strategy "A" in the case of harvest strategy "C", it was assumed that the percentage of young, mid-age and old stags in the total hunting bag of stags should amount to 50%, 30% and 20% respectively. As for the simulation of harvest by means of strategy "D", the percentages of individual categories were 30%, 50% and 20% respectively.

3. Results and discussion

In the whole study area, the average population density of red deer was 30.4 animals/1000 ha of forest (Table 1). Observation records of 952 red deer (September 2000) indicated that the male/female ratio was 1:1.6 and the calf/female index was 31 calves per 100 females. The distribution and population density of red deer in the study area was not uniform. The lowest distribution (10.1-16.6 animals/1000 ha) was recorded in the forest districts located in high mountain ranges (Cisna and Wetlina Forest Districts), and the highest distribution (39.3 animals/1000 ha) was observed in Dukla Forest District, which is situated in the low elevated forest ranges. This pattern of red deer distribution resulted from varying snow depth. In the higher elevated ranges deep snow was forcing the animals to migrate in the direction of forest situated in the lower elevated parts of the study area. Such a migration pattern is common for ungulates inhabiting mountain areas in temperature zone of climate (GEORGII, 1980; BOBEK *et al.*, 1992).

Table 1. Density and population size of the red deer in the Polish Eastern Carpathians. Calculations were based upon snow tracks data (T per km/day) collected along the line transects in February 2000 and the straight line regression between the population density obtained from sampling plot (Y= N/1000 ha), and snow tracks density index (T per km/day) in south-eastern Poland (BOBEK *et al.*, unpubl. data). Accuracy of mean at 95% confidence level is 4.84% i. e., 3,883-4,278.

Forest districts		*Numbers and length of line transects*		*Mean snow tracks density index*	*Population of red deer*	
Name	*Area (ha* 10^3)*	*N*	*km*	*(T/km * day^{-1})*	*Density (N/1000 ha)*	*N*
BALIGROD	21.9	19	111	1.71	36.9	808
CISNA	11.6	6	49	0.72	16.6	193
DUKLA	18.1	23	55	1.94	39.3	711
KOMANCZA	19.2	14	88	1.93	35.6	683
LUTOWISKA	23.9	4	71	0.95	25.6	612
RYMANOW	21.7	11	53	1.72	32.3	701
STUPOSIANY	9.7	2	38	1.18	30.2	293
WETLINA	7.9	2	18	0.43	10.1	80
TOTAL/MEAN	*134.0*	*81*	*483*	*1.32*	*30.4*	*4081*

The total number of red deer inhabiting the Polish Eastern Carpathians was estimated at 4,081 ±142.4 (x±2SE) animals (Table 1), and it was much higher then the number indicated by the population census carried out by hunting clubs, i.e. 2,895 individuals. It is clear that the hunters' data on red deer numbers are not realistic and contain serious errors. It could be easily proved by analysing data on red deer numbers given by hunters and the harvest rate of this species for the last 10 years (Table 2). Due to a high wolf density (1.07 animals per 1000 ha of forest, BOBEK *et al.* unpubl. data) and very severe climate, the average annual recruitment rate of red deer population calculated by the population dynamics-harvest model (BOBEK & GAWOR. unpubl. data), is equal to 15% of the population size after the hunting season. If the hunters' data on red deer numbers were real, the harvest rate of red deer in the Polish Eastern Carpathians applied during the last 10 years, i.e. 48% of the population size after the hunting season, would have exterminated the population of red deer in the study area by 1992 (Figure 2). Using the population dynamics-harvest model, it was possible to estimate the total number of red deer inhabiting the Polish Eastern Carpathians in 1988, i.e. the first year of the deer control programme, not at 3,290 animals (see Table 2), but at 8,245 individuals, i.e. 61.5 red deer per 1000 ha of forest. Certainly, such high density of red deer had a negative impact upon young forest plantation. So, the decision on the red deer control programme taken by the Forest Service was very logical and well motivated.

Table 2. Numbers of red deer estimated by hunters in Polish Eastern Carpathians and harvest rate of this species during 10 years period.

Hunting season	*Harvest (H)*	*Population size in February (N)*	*Percent of deer harvested (H/N *100)*
1987/88	1 054	3 290	45.1
1988/89	1 484	3 357	33.7
1989/90	1 132	3 313	46.6
1990/91	1 545	3 712	64.1
1991/92	2 379	3 378	56.2
1992/93	1 900	3 555	35.5
1993/94	1 263	2 889	46.3
1994/95	1 337	2 696	52.3
1995/96	1 408	2 787	52.3
1996/97	1 459	2 898	—
Average	*1 496*	*3 187*	*48.0*

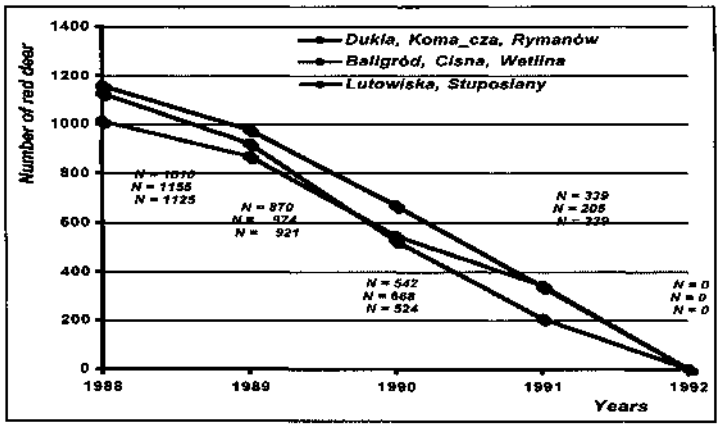

Figure 2. Simulation of the population dynamic of red deer inhabiting the Polish Eastern Carpathian. The input data were number of red deer estimated by hunters in February 1988, harvest rate of the animals (see Table 3), the annual recruitment rate of population and sex ratio of adult animals. The population dynamics-harvest model was employed to calculate projection red deer numbers in consecutive years of the deer control program.

Unfortunately, during the red deer control programme the hunting pressure on young stags (2-5 years old) was increasing year by year (Figure 3). The low survival rate of this age group reduced the number of older animal. It is well documented by the results of computer simulations using the red deer population dynamics-harvest model (Table 3 and 4). The low percentage of old stags in the actual red deer population seems to be the only negative effect of the red deer control programme. This situation can be slowly improved if the harvest rate of young stags is reduced. However, professional wildlife biologists must supervise the recovery programme of red deer because the abilities of the Polish Hunting Association and Forest Service are very limited in this field.

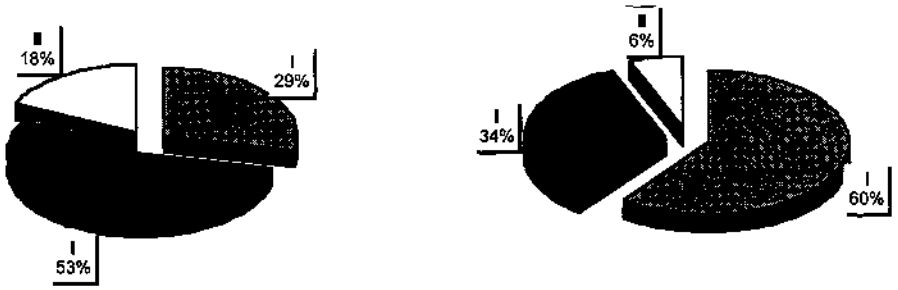

Figure 3. Age structure of red deer stags harvesting by hunters during beginning and end of the deer control program. I –animals 2-5years old, II –animals 6-10 years old, III –animals 11-15 years old.

Table 3. Input data that were used to calculate 4 harvest strategies of red deer in the Polish Eastern Carpathians. Data represent percent of stags, hinds and calves in the total hunting bag of red deer. The percentage share of harvested stags in 3 age categories in relation to the entire number of harvested stags is also given "A" represent actual harvest strategy of red deer in the study area.

Sex and age of red deer	*Harvest strategies*			
	A	*B*	*C*	*D*
Stags	34.7	40.0	40.0	40.0
Hinds	47.8	55.0	55.0	55.0
Calves	17.5	5.0	5.0	5.0
Total red deer	100.0	100.0	100.0	100.0
Stags 2-5 years old	60.2	60.2	50.0	30.0
Stags 6-10 years old	33.7	33.7	30.0	50.0
Stags 11-15 years old	6.1	6.1	20.0	20.0
Total stags	*100.0*	*100.0*	*100.0*	*100.0*

Table 4. The results of a computer simulation representing 4 different sustained harvest strategies of the red deer population in the Polish Eastern Carpathians. Data below are the numbers of animals that have to be harvested under various hunting regimes.

Age and sex	*Harvest strategies*			
	A	*B*	*C*	*D*
Stags	210	237	206	187
Hinds	294	338	309	294
Calves	108	31	28	27
Red deer total	612	605	543	507
Stags 2 – 5 years old (1st age class)	126	147	112	64
Stags 6 – 10 years old (2nd age class)	71	86	67	107
Stags 11 – 15 years old (3rd age class)	13	4	27	16
Stags total	210	237	206	187
Sex ratio (hinds per one stag) after hunting season	1.4	1.29	1.04	0.94

4. Management implications

1. The red deer control programme should be discontinued in the Polish Eastern Carpathians, and the population of this species has to be maintained at the level of 30 individuals per 1000 ha of forest. Because of the low recruitment rate of the population, maintaining lower densities may have a negative impact upon local hunting economy and will decrease the attractiveness of the region for ecotourists.
2. The red deer management strategy should be based upon the objective method of a population census and the population demography variables such as number of calves per female in autumn and the adult sex ratio during a hunting season (PYCH *et al.*, 1999). It is crucial to increase the number of older stags (5-15 years old) in the red deer population. It might be carried out by using the "Wieniec 2000" population dynamics-harvest model.
3. In order to mitigate the conflict between red deer and forestry, the wintering yards of red deer must be excluded from routine forest management. In these areas, a habitat improvement programme must be quickly applied to provide the animals with satisfactory winter food and thermal cover.

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