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# Loss Calculation Model of Brown Hare (*Lepus europaeus* Pall) and its Application in the Hunting Grounds of Vojvodina Region (North Serbia)

**Zoran A. Ristić,[1] * Vladimir Marković,[1] Vladimir Barović[2] and Djordjije A. Vasiljević[1]**
[1] *Department of Geography, Tourism and Hotel Management, Faculty of Science, University of Novi Sad, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia*
[2] *Department of Media Study, Faculty of Philosophy, Zorana Đinđića 2, 21000 Novi Sad, Serbia*

**Abstract.-** The greatest losses in brown hare population appear during the reproduction period in winter season. Since it is not possible to give a precise assessment of adult hare loss, this paper proposes its expression in coefficients. Losses during reproduction period are calculated as correlation of autumn headcount, bagged game, actual growth coefficient and spring headcount. According to results of our investigations, average losses in reproduction period range between 11.93% and 47.01%, or on the average annually 32%. Winter losses are calculated by utilising the same parameters with the difference of spring headcount which has been included in this study in the following year. In order to determine more adequate and precise state of losses accurately, it is necessary to identify losses due to game wounding. Average losses between start of hunting season (October) and beginning of following reproduction period (March) range between 3.25% and 45.47%, or on the average annually 32% during 41-year period in the hunting grounds of Vojvodina. As losses are considerably bigger than in previous period (when they were approx. 20-25%), authors propose the acceptance of new losses value (32%) in creation of planning documents.

**Key words:** Brown hare, winter losses, reproduction period, Vojvodina

## INTRODUCTION

The brown hare (*Lepus europaeus*, Pallas 1778) has been the most common game species in the Vojvodina region (Northern Province of Serbia), their numbers vary between 400.000 and 500.000 (Vapa *et al.*, 2007) since the end of 1950s. Reduction factors affect the hare populations. Within populations characterised by high fertility, losses are the most significant in population regulation (Gossow, 1976).. Reduction in young individuals is very high *e.g.* 60% (Petrusewicz, 1970), 39-74% (Raczynsky, 1974), 77% (Pielowski, 1976), and 74-90% (Möller, 1971) of the total number of new-born hares. Investigations in Vojvodina have shown that average survival rate of young hares before hunting season during 10-year period (1967-1976) was 23.3% (Jovanović, 1971; Šelmić, 1977).

Survival rate of young individuals and actual increase in the whole population, may be calculated with age structure in fall (at the beginning of hunting season). Losses in adult segment must be taken into account due to their twofold influence on population - firstly, potential loss of adults in fall population and secondly, their total or partial absence from reproduction. Adult losses during reproduction period is generally ignored in calculating real increase by some authors (Petrov, 1967; Černe, 1971; Tomilova, 1972), while others used those as a coefficients in regard to spring number, ranging between 0.1 and 0.3 (Hell, 1972; Pielowski, 1976; Šelmić, 1977; Möller, 1978). These losses must not be ignored, but it is also incorrect to take them as a constant coefficient. As reported by Raczynsky (1974) actual increase in population may be satisfying even with low participation of youngsters in fall population, provided losses during reproduction period were low. However, even if the losses of fertile individuals in reproduction period are not the same every year, they must be positively correlated to losses in youngsters, since both segments of population live together, under the same ecological conditions.

Since it is impossible to calculate adult losses every year, the most acceptable method is to express those by coefficient. Value of such coefficient may

* Corresponding author: zoran.ristic@dgt.uns.ac.rs
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be verified each year by partial counting in fall, at permanent experimental plots.

According to principle that usage of a hare population or micro population must be within boundaries of annual real increase, it is necessary to calculate losses from the start of the hunting season till the next reproduction period ("winter losses") and to subtract this value from actual population increase before the hunting season.

## MATERIALS AND METHODS

*Study area*

The study area encompasses 21.506 $km^2$ (Statistical Office of Republic of Serbia), which includes 93 hunting grounds. All official hunting associations in the Vojvodina region annually submit their reports on the conditions of game including roe deer to the Hunting Association of Vojvodina. The present study is based on the above data.

*Losses in reproduction period*

Several factors, such as illnesses, predators, climate, intensive agriculture and hunting affect hare population. The number decrease due to hunting (killing and catching live hares) is called usage of population, while decreases due to other factors are considered as losses. In hare populations, losses during reproduction period have been decisive. Rate of losses during March 15$^{th}$ (beginning of reproduction period) and October 15$^{th}$ (start of hunting season) calculated for determination of real increase of population or micro population number (fall ecological density), may be corrected during a year. Nevertheless, amount of planned losses in period between start of a hunting season (October 15$^{th}$) and beginning of next reproduction period (March 15$^{th}$) must be calculated as precisely as possible, in order to determine rational rates of usage of hare populations and micro populations and avoiding danger of decreasing spring ecological density.

Survival rate for young hares is very low, which is in the average only 23.3% until hunting season. Losses during reproduction period, though considerably low, are present in adult hares too. About 30% hares from spring do not live until hunting season. Certainly, decrease in population continues during hunting season and in winter, as a consequence of harsh living conditions, but it also depends on some inter-population relationships. Losses in hare populations during the period between end of reproduction period and the beginning of reproduction period in following year are 32% of the fall number, but differ from year to year. It was found that participation of youngsters in fall population has considerable effect on these losses, *i.e.* losses are higher if youngster participation is higher. This confirms once more the ecological rule that populations with high fertility bear heavy losses.

*Winter losses*

Winter losses are defined as total losses in the population, micro population or any of their parts, from start of hunting season until the beginning of next reproduction period. Losses are calculated as a difference between two game countings *viz.*, at the end of hunting season until December 31$^{st}$, and at the beginning of the next reproduction period (March 15$^{th}$).

Reducing factors continue to effect naturally after start of hunting season, but some additional factors such as losses due to hares injured during hunting, as well as unfavourable weather conditions during winter are added. The direct losses due to winter though are not large and comprise about 6% of fall number (Pielowski, 1976), most authors in population-dynamic calculations report much larger losses *e.g.*, 10% (Szederjei and Studinka, 1962), 15% (Hell, 1972), 20% (Jakšić 1957; Černe, 1971; Heltay and Széki, 1975) and even 25%-30% in fall (Petrusewicz, 1970; Ladziansky, 1977).

For example, investigations in five experimental hunting grounds in Croatia, with different usage intensity (Romić, 1965) have shown that losses vary every year (11.1%-67.5%) and that they are higher in hunting grounds with highest density or in hunting grounds with no hunting at all during the past 5 years (on the average, 58% per year for five-year period). In other hunting grounds, average losses were much smaller *viz.*, mostly 18.7%. Nevertheless, we must mention that this refers to losses from end of hunting season (December 15$^{th}$) until the beginning of reproduction

period (March 15th).

Similar investigations in Vojvodina (Šelmić and Bojović, 1979) have shown that average losses in three populations during six consecutive years (1973-1978) were from 8.9% to 29.5% in fall, but in the period between November 1st (start of hunting season in that period) and March 1st in following year. Annual variations were so high that it totally excludes use of these data in planning management of hare populations. In addition, a positive correlation was found between participation of youngsters in fall population and the winter losses, and it was strongest in population with poorest ecological conditions, somewhat smaller in population with moderate ecological conditions, and smallest in population with best ecological conditions. Therefore, age structure of a hare population or micro population in fall is not only a consequence of certain changes within population due to biotic and abiotic factors, but it is a cause of important changes itself.

*Calculation of losses during reproduction period*

Losses and percent of losses during period between beginning of reproduction period (March 15th) and start of the hunting season (October 15th) were calculated: using following formula (Ristić, 1997):

$$Lr = Fn – k – N$$

where Lr, losses during reproduction period; Fn, fall number of population (Fn = N x c); k, kill; N, spring number of population; c, real increase coefficient.

% Lr – losses percent during reproduction period was calculated as follows:

$$\%Lr = (Lr \times 100) / Fn$$

By analyzing results obtained for 42-year period, losses were found during reproduction period per year.

*Calculation of winter losses*

Amount of planned losses in period between start of hunting season (October 15th) and the beginning of next reproduction period (March 15th) must be calculated as precisely as possible, in order to determine ratio of rational usage for hare populations and micro populations, and to avoid depletion of spring ecological densities. These losses are important in devising planning documents, such as hunting basics and annual management plan.

Losses and percent of losses were calculated using following formula:

$$Lw = Fn – k – Nn+1$$

Lw, winter losses; Fn, fall number of population (Fn= N x c); k, kill; Nn+1; spring number in following year; c, real increase coefficient.

Percent of winter losses was determined by using the formula:

$$\% Lw = (Lwx100)/ Fn$$

Therefore, in calculating hare populations dynamics in planning documents (hunting basics and annual management plan) losses of about 32% during winter period must be taken into account.

**Table I.- Number of years of average losses during reproduction period and winter divided into six categories of hare population in Vojvodina during 1967-2008.**

| Categories of average losses | Number of years | |
|---|---|---|
| | Reproduction period losses | Winter losses |
| Under 20% | 3 | 3 |
| 20 – 25 % | 4 | 4 |
| 25 – 30% | 9 | 5 |
| 30 – 35 % | 5 | 11 |
| 35 – 4 0% | 17 | 12 |
| Over 40% | 4 | 6 |

Source: Hunting Association of Vojvodina

## RESULTS AND DISCUSSION

For period observed (Table I), in most of years losses were between 35% and 40% (in 17 years), and in 3 years they were under 20%, so for the whole period average losses during reproduction period were 32.14%. Therefore, in calculating hare populations dynamics in planning documents (hunting basics and annual management plan) losses of about 32% during reproduction period must be taken into account (Fig. 1).

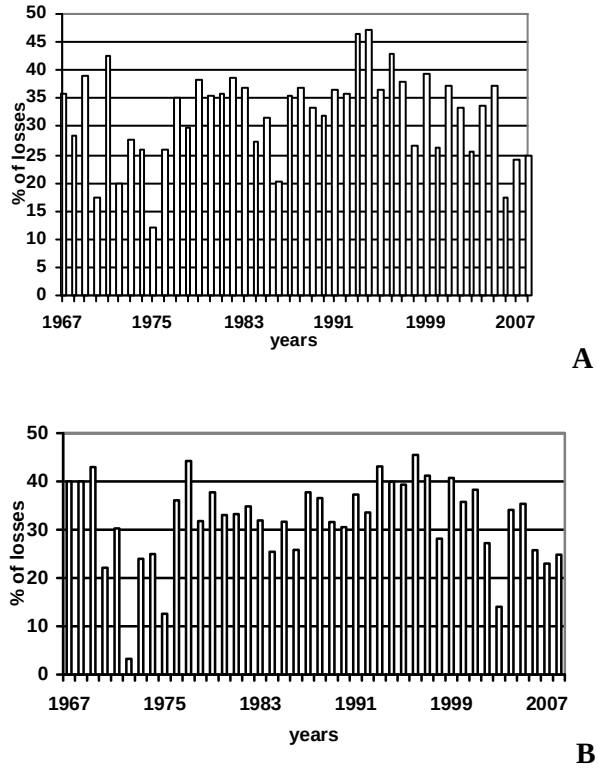


Fig. 1. A: Hare loses in reproduction period. B: Winter hare losses

For 41-year period observed (Table II), in most years losses were between 35% and 40% (12 years) and only in 3 years losses were fewer than 20%, so for a whole period average winter losses were 32.31%.

The losses in reproduction period and winter losses are very different in Vojvodina (North Serbia) as in other surrounding countries. Winter losses were defined by some authors as only direct losses due to winter and snow, and as a consequence of food shortage because of snow cover. Others calculate total losses for population, defining the period, or if a period is defined, they do not count losses during hunting season. Attention to these losses was drawn only by Landziasky (1977).

Šelmić (1984) in his investigations showed two kinds of losses. First, losses that would occur even if there were no hunting, due to normal mortality rate for hare population, as a result of all reduction factors in certain conditions. Second, losses due to usage of population and hunting, which were not registered as kill. These losses are due to injured hares, and are calculated as 30% of kill. Šelmić (1984) notes that these losses are not of interest in hunting grounds where only one hunt is organized per area, using circular hunt, but in his opinion these are very important in our conditions nevertheless.

According to results of our investigations, average losses in reproduction period range between 11.93% and 47.01%, or 32% on the average annually. Also, average losses between start of hunting season (October) and beginning of following reproduction period (March) range between 3.25% and 45.47%, or 32% on the average annually for 41-year period in the hunting grounds of Vojvodina.

Data regarding two kinds of losses are necessary for preparation of real planning documents like hunting basics and annual management plan. Losses occurring in two investigated periods are considerably higher than in previous period, ranging between 20 and 25% regarding both spring and fall number.

As it is shown in Table I, there is a wide range in both losses, but having in mind that a long period was processed, suggested average losses for production of planning documents are valid adequately to be included in future planning documents.

Winter losses and reproduction period losses are 32% each, so we suggest inclusion of those numbers in planning documents in order to plan management of hare populations realistic, and therefore for ensuring high-quality balance of population, which would mean long-term protection of hare population. In this way, a hare pool would be preserved for a number of years, which was the aim of our investigations.

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