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# ELEMENTS OF THE POPULATION DYNAMICS OF THE GREY PARTRIDGE (*Perdix perdix* L.) IN SUBURBAN HABITATS

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*Summary:* The main objective of this study was aimed at calculating the degree of loss and survival in grey partridge (*Perdix perdix* L.) populations as the basic elements of population dynamics based on the established density in two, for the game management, the most important periods, that is, the parent stock immediately before the start of reproduction and the hunting fund, that is, the population size before the beginning of hunting season. The studies were conducted in the period 2007-2011 in suburban environment at an area of 450 ha, or in the part of the hunting ground for small game "Trubarevo" managed by the Faculty of Forestry in Skopje, located in the south-eastern part of the periphery of the city and bordered by the suburbs and the city most densely populated municipality. Data collection was performed using complete counting in the periods 15.02. - 15.03. and from 10.09. to 10.10. in each year. The spring - summer losses, or survival rate in grey partridge micropopulation have been calculated on the basis of comparison of the autumn ecological density obtained by counting and the theoretical autumn density calculated from the spring ecological density and the ideal growth (production of young) by a really formed pair in the spring.
The results of investigated elements in the 100 ha area (number of pairs 10.00; autumn density of 48.00; spring - summer losses of 112.00; micropopulation survival rate 29.93%) indicate that the favorable area structure provides the survival of a relatively stable population even in suburban environment with frequent harassment and the absence of predation control.
*Keywords:* Grey partridge, density, loss, survival rate

## Introduction

The various human activities, in terms of intensive environmental changes, have led to strong, in many cases irreversible processes, which are directly reflected in the change or complete destruction of certain ecosystems, and thus, irreversible vanishing of a large number of organic species, or in the reduction of their population to critical. The most typical example are the modern agro-ecosystems where it has been registered a decline of 85% of bird species [8], and out of 256 species of the order of chicken, 27% is under threat of global vanishing, compared with 11% of all bird species [31].
Vulnerability and the reduction of the number of partridges (*Perdix Perdix* L.) is a global process which in the last few decades gets alarming proportions [1]. In the UK the number of this species in the period from the fifties to the mid-eighties was reduced by 80% [27], in the Czech Republic from 1965 until the late eighties – even up to 95% [39], and the situation is similar in Poland [21], in Vojvodina [4, 32] and in R. Serbia [25].
The reasons for this trend are numerous, directly caused, and most often difficult or impossible to eliminate. The problem lies in two, often conflicting and mutually exclusive attitudes: the utilization and changing of its habitat in order to increase the yield of agricultural crops grown on them, and on the other hand – their protection.
Studying the bioecology of every kind of game requires the registration of the basic elements of population dynamics, i.e.:

- population density, i.e. number per unit area;
- population growth and its factors, i.e. birthrate, mortality and migration trends, and
- population structure (age and sex).

The migration, especially for the species whose characteristic is the "loyalty" to their habitat, which is the case with the partridge (except in cases of drastic and sudden changes in its biotopes), has almost no influence on changes in the density of its population. The literature identifies data on larger and regular migration of subspecies *Perdix perdix robusta* [38], as well as on the occasional migrations of *Perdix perdix lucida* [27]. In subspecies inhabiting this region, the *Perdix perdix perdix* [17], there may be eventually vertical micromigrations of isolated and scarce micropopulations, inhabiting atypical places at higher altitudes [35, 14].
The age structure, as an indicator of the survival rate of individuals in different age classes, despite the difference in capacity of laying eggs between young females and the ones older than one year, also has no large influence on their numbers, which is typical for species with rapid replacement of generations, which for the

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partridge is 3 - 4 years [20]. Moreover, its influence is annulled by the fact that the reproduction involves the individuals even in their first year of life.
The sex ratio in natural populations in the grey partridge is almost uniform, with a slight predominance of male individuals [9, 11, 12, 19, 13, 20, 5, 37].
For these reasons, the main emphasis in this paper is on the calculation of loss and survival rate as the basic elements of population dynamics, on the basis of the determined grey partridge population density in two, for the game management, most important periods, i.e. the parent stock immediately before the start of the reproduction and hunting fund, or population size before the start of the hunting season. Namely, the density, as well as its factors, is the most important attribute of the population of each species, especially those inhabiting biotopes heavily influenced by anthropogenic factors, and where, during a single reproductive season, drastic changes occur in the environmental conditions that influence their survival. In birds that breed on land, nesting and rearing young is the most critical period of the life cycle, when losses in the population often have the greatest impact on population dynamics in the function of time and space. Due to the fact that the reproductive potential of the grey partridge is known, i.e. determined by the genotype species, it appears that the level of mortality determines whether the population numbers is rising or falling from generation to generation.

## Materials and Methods

The studies were conducted in the period 2007 - 2011 in suburban conditions at an area of 450 ha, that is, in a part of a small game hunting ground "Trubarevo" managed by the Faculty of Forestry in Skopje. It is the smallest hunting ground in R. Macedonia (1,475 ha) and the only non-commercial hunting area intended for teaching - scientific objectives. It is located in the south-eastern part of the periphery of the city and bordered by the suburbs and the city most densely populated municipality. It is a typical plain hunting ground with an altitude of 235.0 to 239.6 m and represents the bottom of the former extended river bed of the Vardar river, now covered with young alluvial deposits. Natural conditions of the habitat and the mosaic representation of planted crops are optimal for the survival of partridge. Cereals (wheat, barley and corn), garden culture (tomatoes, peppers, potatoes, carrots, etc.) and melons occupy approximately 15% of the total area, clover and riverside vegetation (groves and bushes) about 5% each, orchards 20 % and the remaining 30% are uncultivated and weedy fields. The land belongs to small owners and is bordered by hedges, for the most part (80%) with an area of 0.1 to 0.3 ha, while only 10% is larger than 1 ha.

Data collection was performed using a complete counting, more accurately, by monitoring of the partridge numbers at least three times a week. The spring density, that is, the number of separated couples, was being determined in the period 15.02. - 15.03., and the fall density – after collecting most of the crops and the completion of morphological development of the raised offspring, or from 10.09. to 10.10. each year. In addition to the total density, in the fall count was performed also a registration of the number of clusters and the number of partridges in a flock, which served as the basis for all calculations of population dynamics. When collecting these data, we started from the assumption that the cluster represents two or more individuals [33]. Flocks of more than 18 specimens are counted as one nest, ignoring the possibility of integration of two or more flocks and joining young adults with no young. Counting was performed with 3 - 4 participants and 2 hunting dogs – bird dogs of excellent quality. The five-year period of research is carried out without the reduction of the natural predators of the grey partridge.
The spring - summer losses, i.e. the survival rate of micropopulation of grey partridge have been calculated on the basis of comparison of the autumn ecological density obtained by counting and the theoretical autumn density calculated from the spring ecological density and the ideal growth (production of young) per really formed pair in the spring, or by formulas:

$$\mathbf{Ip = Peg/2 \times 14} \quad \text{and} \quad \mathbf{Tjg = Peg/2 \times 14 + Peg}, \quad \text{that is:} \quad \mathbf{Tjg = Ip + Peg}$$

The brood size, i.e. the average number of chicks in the nest, was not determined directly in the field, from the reason that this element has been thoroughly researched and varies in small limits, and according to many authors varies in the range of 14-15 individuals [12, 34, 33, 2, 3, 7, 23, 24, 30, 26, 27]. Regarding the conditions in R. Macedonia, it has been found that the average number of hatched partridge per pair is 14 individuals [10, 18], so we manipulated with these numbers in order to calculate the ideal weight growth, that is, the theoretical autumn density.

The spring - summer losses, or the survival rate of the grey partridge micropopulation were obtained using the formula:

$$\mathbf{Plg = (Peg + Peg/2 \times 14) - Jeg}$$

From the formula Peg/2 x 14 + Peg = Tjg follows **Plg = Tjg – Jeg**, that is

$$\mathbf{Spm\% = \frac{Jeg}{Peg/2x14 + Peg} x100}, \quad \text{that is} \quad \mathbf{Spm\% = \frac{Jeg}{Tjg} x100}$$

Abbreviations used in the formulas indicate:
Peg - spring ecological density
Peg/2 - number of pairs in the spring count
Ip - ideal growth
Tjg - theoretical autumn density
Jeg - autumn ecological density
Plg - spring - summer losses
Spm - micropopulation survival rate

For the statistical processing of the data, we used the program SPSS version 17.0. The relationship between certain parameters was assessed by Pearson correlation coefficient, i.e., by linear regression.

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## Results and discussion

Table 1. Spring and autumn density, loss and the survival rate of the micropopulation

| Parameter | min/year | max/year | $\bar{x}$ | SD | SD % |
|---|---|---|---|---|---|
| Peg/2 $km^{-2}$ | 7.56/2010 | 11.78/2008 | 10.00 | 1.75 | 17.50 |
| Jeg $km^{-2}$ | 33.78/2010 | 57.11/2009 | 48.00 | 9.28 | 19.33 |
| Plg $km^{-2}$ | 87.11/2010 | 136.89/2008 | 112.00 | 2.15 | 1.92 |
| Spm % | 27.36/2008 | 32.05/2007 | 29.96 | 2.15 | 7.18 |

The number of pairs per 100 ha in the spring count in the studied micropopulation of the grey partridge ranged between 7.56 and 11.78, with an average value of 10.00 (Table 1). After the peak registered in 2008, followed a two-year downward trend, i.e. in 2010 was established a minimum value of this parameter (Figure 1). The difference between these two values was over 55% compared to the minimum. Large variations of spring ecological density, to some extent confirmed in our research, are characteristic for this species, both in years and in the same year in neighboring micropopulations with relatively similar environmental conditions. Thus, for example, in western Slovakia, the average spring density of 100 ha in 12 monitored hunting grounds after the disastrous winter fell from 21 to 14 individuals [12], in Macedonia, in one micropopulation in two successive years the difference was 101.3% [36], while in Poland, during the eight years of study there were registered a much larger fluctuations, that is, the spring density per unit area ranged from 2.0 to 34.5 individuals [7]. The greatest influence on the variability of this parameter have the degree of use of the population and the winter losses. As in our case only a symbolic shooting was carried out, and the impact of winter losses was absorbed by the favorable structure of cultivated crops and the high percentage of untreated surface and available shelters in winter, the spring numbers in the study period were relatively stable.

The mean value of the autumn ecological density of the grey partridge micropopulation was 48 individuals. After a relatively uniform values in the first three years and the maximum reached in 2009, followed an observable decline of 41% starting as soon as the next year, when the minimum density was registered. Although the numbers in autumn does not follow the movement of parent fund in the entire study period, due to small differences in the amounts in the years with the opposite trend (2008 and 2009, Figure 1), a strong correlation between these two elements of population dynamics (r = 0921; p = 0026, n = 5, y = - + 4874 x 0742) has been established.

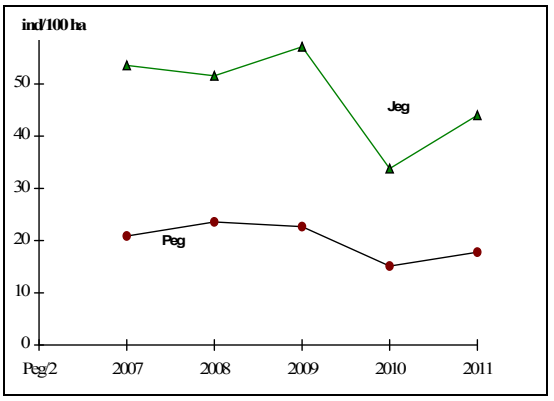


Fig. 1 Spring and autumn ecological density at 100 ha

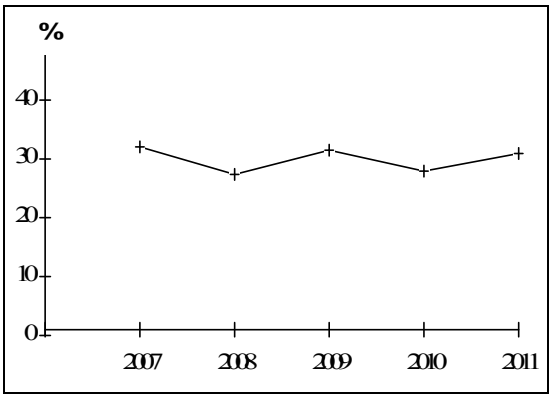


Fig. 2 Survival rate of the micropopulation

Similar studies on the numbers in autumn, carried out in Macedonia in Europe, also revealed a large variability of this indicator. In a three-year study on the elements in the grey partridge population dynamics in five typical places in Macedonia, autumn densities ranged from 13.3 to 70.4 specimens [18], while still in process is the determining of the reproduction coefficient in three locations during the 4 years determined fluctuations between 33.18 and 130.09 individuals [15]. In the former Czechoslovakia, in 6 hunting grounds of 2065 ha total area, autumn density varied in the range between 20.0 and 104.0 [20], while in Poland the minimum and maximum value was 9.1, i.e. 63.8 birds per 100 ha [7].

All these data indicate that the autumn ecological density of the grey partridge is directly related to the real periodic growth, which in turn is directly dependent on the size of the value of losses during nesting and rearing of young, that is, the degree of survival of the specific population or micropopulation. This is related to the results of our studies, which show that the average losses in this period, calculated on the basis of ideal growth, i.e. the theoretical grey partridge population, is as much as 2.3 times higher (112: 48, Table 1) than the actual situation on the terrain, while the maximum mortality rate of 136.89 individuals at 100 ha was registered in 2008.

The survival rate of the investigated micropopulation ranged in relatively small limits (SD% = 7.18) or ranged from 27.36 - 32.05, with a mean value of 29.96% (Table 1, Figure 2). The highest mortality rate, or the minimum value was established in the year with a maximum spring density (2008), while the highest survival rates were recorded at the beginning of our investigation in 2007. No statistical dependence was determined between the spring density and the survival rate (r = 0144, p = 0817, n = 5), while the correlation between the autumn number and the same parameters is medium strong (r = 0515, p = 0374, n = 5), which indicates to the fact that the micropopulation mortality level is much more affected by other environmental factors that influence its survival, primarily the climatic conditions, food availability and predator pressure. In contribution to the importance of meteorological conditions is the fact that in three out of four tested parameters (Peg, Jeg and Plg) the limit values (minimum spring and autumn populations and maximum spring - summer losses) recorded in the same year (2010), when, after a relatively snowy winter, in the time of pairs formation, there was a spill from the Vardar river bed, and in the nesting period (May and June) the intensity of the rainfall was extremely high. This confirms the results of earlier researches on the effect of some meteorological elements on the real periodic growth in grey partridges in Macedonia [16], when a high negative correlation was identified between the total rainfall, i.e. its duration in days during the period of breeding and rearing young (May, June and July) and the height of the real periodic growth in two out of the three investigated micropopulation, and a moderate dependence in one.

Many studies testify the significance of the survival rate, that is, the amount of loss in the period of breeding, as well as the different methodological approaches for its determination. Since it is considered that the fluctuations of grey partridge populations can largely be attributed to the annual variations of the chick survival rate [29], most authors dealt with the research of this element.

A very high percentage of 74.3%, determined in Poland in the period 1974 to 1984, was interpreted by the author [22] with the small sample taken for testing. At the same areas in the second period (1968 - 1977) [7], the survival rate of chicks ranged from 33% to 54%, with a mean value of 41%, with specific results for 1976 and 1977, when the autumn density was even lower than the spring (!) in the same year, that is, the achieved population growth could not compensate the losses from spring to autumn.

The most detailed analysis of this parameter was made in the UK, where the records of its size have been monitored since the early twentieth century, namely from 1903. The authors [29] divided the survival rate of chicks into two periods: from 1903 to 1952, or the period before the reduction of the grey partridge population (pre-herbicide era) and from 1962 to 1993, that is, the period of drastic fall in the number of this species (post-herbicide era). The average value of the survival rate of chickens after 1962 was 32.3 ± 1.4%, in comparison with 48.6 ± 2.8% before 1952. The minimum and the maximum values were 19.4 ± 1.4% recorded in 1954, and 67% in 1938.

The British authors [6, 26,27, 28, 29] in their research determined this parameter (CSR - "chick survival rate") by the number of offspring over the age of 6 weeks determined in the August count. Potts [26] believes that this parameter can be estimated from the curve of the equation:

$$\mathbf{CSR = 3.665\ X^{1,293}}, \text{ that is } \mathbf{CSR = \frac{X}{13.84} x100} \quad \text{when } \mathbf{X > 10}\text{ , where}$$

CSR – chick survival rate
X – geometric mean number of young per successful nest in August

The use of geometric rather than arithmetic means was suggested by the author, because the size of the brood tends to the logarithmic normal frequency of distribution. However, the size of nests in August does not reflect the true situation of survival in chicks due to possible losses of all offspring in the nest [26], which was concluded by the author himself.
Without questioning the fact that the survival rate in chicks has the greatest impact on the survival of the total population or micropopulation, we still believe that the simplicity of the method applied in our studies, i.e. determining the survival rate of the total micropopulation, not just its juvenile segment, has far greater practical importance in real determining of the rate of use during the hunting season. At the same time, one should bear in mind that the structure of agricultural land in Macedonia prevents realistic determination of the numbers and the age structure in this species in the summer months, due to low visibility, i.e. dense vegetation cover.

## Conclusion

The poorly expressed variations of investigated parameters in grey partridge population dynamics suggest, first of all, the stability of ecosystems in terms of small variability of factors that may negatively affect its density. The favorable structure and size of agricultural areas and the percentage of untreated and weeded fields, have enabled the survival of, in today's conditions, a solid density of the partridge, despite the suburban habitat, that is, the hunting grounds being surrounded by urban and suburban densely populated neighborhoods and frequent disturbance by agricultural work during the period of breeding and rearing of young. Considering that in the period of investigation it was not carried out any reduction of its natural predators (fox, weasel, marten, hedgehog, stray dogs and cats, hawks, species of the fam. *Corvidae*, etc.), their number and spatial distribution were in some kind of natural balance with the observed micropopulations and other members of the ecosystem, which has led to poorly expressed changes in the studied elements of population dynamics in grey partridge micropopulation. The unfavorable impact of climatic conditions, which often have a decisive influence on the major changes in the grey partridge population density, was significantly moderated by the above mentioned conditions in the habitat, i.e. the relative abundance of overgrown areas as shelters and sources of food all over the year.

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