

## Spatial distribution of brown hare *Lepus europaeus* populations in habitats of various types of agriculture

Krzysztof LEWANDOWSKI and Jacek J. NOWAKOWSKI

Lewandowski K. and Nowakowski J. J. 1993. Spatial distribution of brown hare *Lepus europaeus* populations in habitats of various types of agriculture. Acta theriol. 38: 435 – 442.

In 1987 – 1990 an investigation was made on the spatial structure of brown hare *Lepus europaeus* Pallas, 1778 populations using the transect routes method. The investigation was carried out in two different parts of Poland that differed in the character of agriculture: I – northeastern with large fields of state farms, and II – east-central with small fields of individual farmers. The results indicate that independently of the agrarian structure, the distribution of hares in crops corresponds to their percentage share in the region, with exception of rape fields, which show a tendency to be avoided. There was also a significant relationship between the spatial distribution of the hare and the habitat diversity – highly variegated fields are more consistently inhabited by hares. Besides, hares show a distinct tendency to prefer areas close to the field margins. Positively oblique distance distributions between the individuals and the margins of field crops are particularly strongly expressed in the region of a highly monotonous crop species. It may be expected that a change in type of farming by passing to the large-fields and continuous cropping is one of the factors that make it difficult for the hare to utilize the space within the habitat.

Teachers Training College, Department of Ecology and Environmental Protection, Żołnierska 14, 10-561 Olsztyn, Poland

*Key words:* *Lepus europaeus*, spatial distribution, habitat, agriculture

### Introduction

The spatial structure of the brown hare population in the relationship to the organization of agrocenoses is relatively little recognized. This problem was discussed by many authors, who investigated the relationship between the spatial structure of hare population and its density (Pielowski 1966, Pepin 1978, Meriggi and Alieri 1989), the effects of spatial distribution on the shyness of the hare (Jeziński 1973) and the character of the spatial distribution of hare populations (Jeziński 1968, 1972).

The relationships between the spatial distribution of hare populations, the diversity of habitats and the stability of that system are hardly touched by research (Bresiński 1976, Bresiński and Chlewicki 1976).

The objectives of this investigation were: to assess the effect of habitats diversity and type of managing agrocenoses on the spatial distribution of hares, and to determine different ways of utilization of various habitats by a hare population during autumn and winter seasons.

### Study areas

The investigation was conducted in two different parts of Poland that differed especially in the character of agriculture.

The area I – Wopławki is located in northeastern Poland (near Kętrzyn city) on the Sępopolska Lowland. This area is one of the coldest in the country as mean annual temperature is lower than 7°C and is largely influenced by winter temperatures. The mean temperature of January drops below -4°C and the winter season lasts 100 – 120 days. There are 170 – 190 days with precipitation per annum and the snow accounts for the third part of all precipitation days. Snow cover lasts 76 – 96 days a year. Mean annual precipitation varies from 500 to 550 mm. Vegetation period is 180 – 200 days long. State farms are predominant in this area and one-species crops frequently cover an area of 200 ha.

The area II – Siedlce is in the east-central part of the Mazowiecka Lowland. The climate of the area is under the continental influences. Mean annual temperature is ca 7°C, winters are 90 – 100 days long and snow cover is persistent. The mean temperature of January is -3.5°C. Mean annual precipitation varies from 550 to 600 mm. The vegetation period lasts 180 to 200 days. This region is little industrialized and covered by small fields belonging to individual farmers. During the study period, the number of farms increased and the area of arable land per farm decreased from 9.5 ha in 1987 to 7.5 ha in 1989. Thus the diversity of the habitat increased, which is associated mainly with the increase of edges of cultivated fields.

### Methods

The investigation was performed using the transect routes method. Each of the study area (I and II) was covered with 30 transect lines, each 2 km long. The particular transect lines were set along field roads, which made the lines easily accesible. To avoid the influences of tracks on spatial distribution of hares, which was indicated by Bresiński (1983), field roads with low traffic intensity were chosen.

During assessing, the spots of the occurrence of hares, kind of cultivation, distance from the investigator and the time of starting up hares were determined. To obtain a full image of agrocenoses, the time of trespassing from on cultivation to another was also recorded. Data were collected during autumn and winter, once a month in the seasons 1987/88, 1988/89 and 1989/90. Altogether, 611 comings across individual hares were recorded.

To assess the habitual value for the hare, the habitat preference index (HPI) was used

$$HPI = \frac{\sum \sqrt{N}}{n} \quad (1)$$

where:  $N$  – number of hares met on an assessment line during a control,  $n$  – number of controls.

Such an index was calculated for each assessment line and was information of the stability of inhabiting the lines by individuals.

To determine the degree of diversification of the habitat, the heterogeneity index ( $H'$ ) for each assessment line was calculated according to the formula of Shannon & Weavers (Odum 1959).

$$H' = - \sum P_i \log_2 P_i \quad (2)$$

where  $P_1$  is a proportion of the share of the size of a given field of the same cropping to the whole of cultivations on the assessment line.

For each hare, the distance from the spot of its recording on the transect to the nearest edge of a field was calculated. For the computed distances, statistics of distribution of this distances were calculated and for the analysis of relationship between spatial structure of hare population and fields edges an values of skewnees measure of distribution ( $\alpha_3$ ) was used

$$\alpha_3 = \frac{1}{N} \sum \left( \frac{x_i - \bar{x}}{s} \right)^3 \quad (3)$$

where  $N$  – number,  $x_i$  – value of measurement,  $\bar{x}$  – mean,  $s$  – standard deviation.

Values of  $\alpha_3$  for distribution of distances between hare and the nearest field edge and a values  $\alpha_3$  of distributions of the distances from randomly chosen points on the assessment transects to the nearest field edges were compared with Student  $t$ -test (Hogg and Craig 1978, Platt 1978).

ANOVA was used for analysis the distribution of hare populations in diffrent kinds of cultivation (Platt 1978, Sokal and Rohlf 1981).

## Results

### The dynamics of the hare population numbers

The employed transect routes method does not allow to refer the results obtained to a definite unit area and, thus, to calculate the population density. To investigate the dynamics of hare populations the average values of meetings across the individuals on the transect were estimated. The comparison of these values assures to determine the character of the trend of population numbers without determining its density.

The results obtained in both areas point at a decreasing tendency of hare numbers (Fig. 1). Since assessing is connected with frightening of individuals, it seems likely that results obtained may depend on the differences in shyness of hares. Therefore, mean distances between starting up hare and the investigator in particular seasons were calculated and the significance of the differences between them were tested. The means are not significantly different ( $t_s = 0.77$ ,  $p > 0.05$ ,

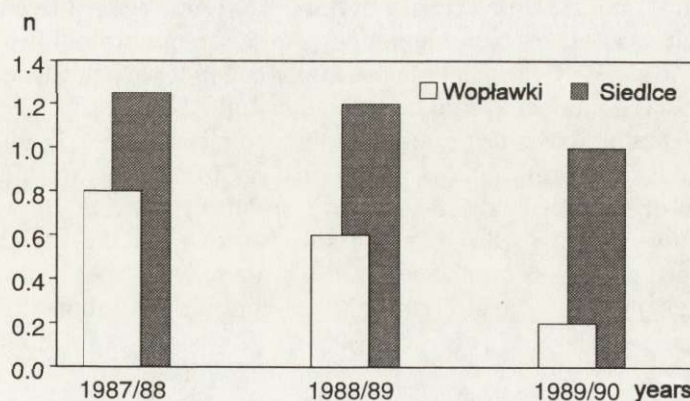


Fig. 1. Mean number ( $n$ ) of observed hares on a transect per day in the two studied areas.

Student *t*-test), therefore, it may be assumed that the shyness did not modify the obtained results of comings across hares and the differences between the subsequent seasons result from the difference in population density.

#### The distribution of hares in different kinds of cultivations

Based on the timing of cultivations, a percentage share of cultivation in particular transects and mean percentage share in each season on both study areas were obtained. The proportions of ploughed fields and winter cereals in both types of farming are alike and they account for ca. two-thirds of the cultivations of winter season. Appreciable differences can be seen in the share of rape crops and stubble fields which, in case of state farms, make ca 20% of the total and in the individual farms they account for a small percentage only (0.5%).

Table 1. Analysis of variance of habitat preferences of brown hares in the two studied areas.

Source of variability	Number of rank	Sum of square	Mean square	<i>F</i>	<i>F</i> <sub>0.05</sub>
Siedlce					
Years	2	1.99376	0.997	3.123	6.94
Cultivation	4	1.92052	0.480	1.505	3.84
Error	8	2.55400	0.319		
Total	14	6.46828			
Wopławki					
Years	2	1.89301	0.947	2.832	6.94
Cultivation	4	3.19443	0.473	1.416	3.84
Error	8	2.67343	0.334		
Total	14	7.76087			

To assess the habitual preference of hares to the discerned five cultivations, the values of ratios of logarithm of mean percentage frequency of hare populations in particular types of cultivations to logarithm of mean length of these cultivations on an transect were analyzed. The two-dimensional ANOVA employed with fully randomized blocks and with one element in sub-class (Table 1) allowed to determine the habitual preference of hares with regard to the variability resulting from the different shares of cultivations on particular transects, the variability in the share of cultivation in subsequent study seasons, and the variability due to the reduction of population numbers.

Independently on the type of farming, hare populations inhabit the places according to the percentage share of cultivations in the regions ( $F = 1.505$ ,  $F = 1.416$ ,  $p > 0.05$ , ANOVA).

Although no significant preference of hares to any of the cultivations was found, there was, however, a tendency for the population to avoid rape plantations and

in the last season to choose stubble fields which in the winter season made a small percentage of the total cultivations.

#### The spatial structure of the hare population in diversified habitats

Habitat preference index (HPI) and heterogeneity index  $H'$ , were correlated. The linear correlation coefficient for Siedlce ( $r = 0.67$   $p < 0.05$ ,  $n = 90$ ) points at a significant relationship between the distribution of hares and the degree of diversification of the habitat. On the lines with a high size reduction of the fields one can see a stabilized arrangement of the population and it is at higher levels of the numbers than on the lines with the share of large size fields (Fig. 2). In the area of a small habitat diversification (Wopławki) such a correlation is not

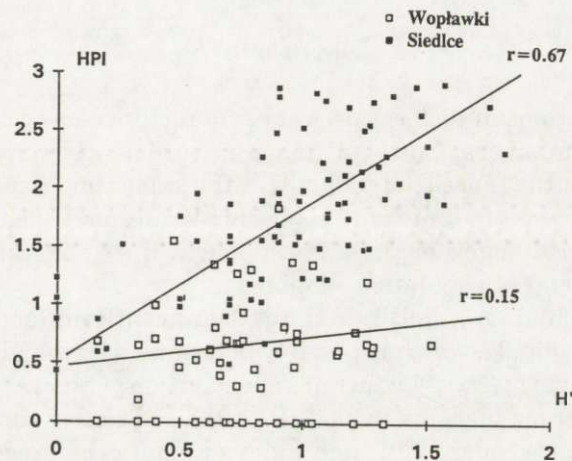


Fig. 2. Relationship between habitat preference index (HPI) and habitat heterogeneity index ( $H'$ ) in two studied areas.

observed and the variation in inhabiting particular transects seems to depend on the factors of the classically understood biotope.

#### The relationship between the spatial population structure and field edges

The distribution of hare populations along the edges of cultivations was investigated. Considering the numbers of the material and a lack of differences in this type of distribution at various population densities (Andrzejczyk, in litt.), the whole of the material was handled together.

The obtained positively oblique image of distance distributions between individuals and field edges (Fig. 3) points at a significant arrangement of the hares in the proximity of field crop edges. Such an image is stronger in the case of the habitat of a high rate monotony of farming (i.e. in Wopławki,  $t = 6.622$ ,  $p < 0.001$ , Student  $t$ -test), than in Siedlce ( $t = 0.942$ , ns, Student  $t$ -test).

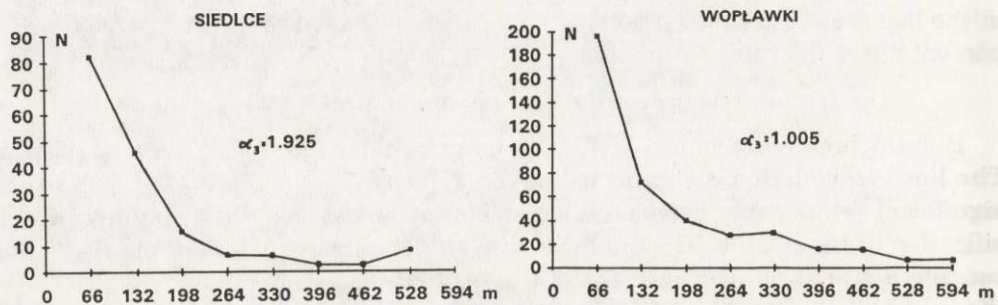


Fig. 3. Distribution of distance between hares spotted on transect and field margins (m).  $\alpha_3$  - skewness of distribution.

### Discussion

The hare populations in the both areas are characterized by constant a reducing tendency of hare numbers. Such an image is sufficiently convergent with the general situation of that species in Poland, at the same time a process of reducing trend on the study area is unusually clear-cut (W. Jezierski, pers. comm.). Such a situation appears though not the all assessment lines suggest complex factors influencing that trend of population numbers.

The drop of population numbers did not significantly influence the means of distribution of individuals, which is possibly determined by the high size reduction of fields and fields geometry. The fact of dependent dispersion of hare individuals in neighbourhood crops margins (balks) (Fig. 3) and positive correlation between the habitat preference index (HPI) and index of habitat heterogeneity ( $H'$ ) gives the evidence of that. Merrigi and Alieri (1989) paid attention to dependence of dispersion of hare population and fields size. W. Jezierski (pers. comm.) discovered that increase in field size have reduced the hare density. Hares strongly preferred a regions connected with field edges. It can approach, that area inside homogeneous crops (200 ha), frequent in case of state farms, determines spaces not inhabited by hares, thus reducing its life and reproduction potentiality. Kovacs and Buza (1988) noted that hare home range were usually between 20 - 50 ha irrespective of field size. In monoculture areas hares inhabit only those parts which offer a variety of vegetation types (Fig. 2) and parts near field edges.

Increasing the size of simple field, to facilitate and accelerate of runing the farms, and with share of cost of farming production, brings about a liquidation of all refuge areas on the fields (for example balks, shrubby, tree stand, ground depression). It can significantly influence the settling this area and the production of hare population, because places with dense and high grasses also bushes and tree stand offer protection against bad weather and predators (Taper and Barnes 1986). Meriggi and Verri (1990) recorded the highest densities of sheltering hares in areas where shrubby and herbaceous layer have reached a heights of more than 40 cm.

Persistent relationships between hares and some transects (high value of HPI) occur in the Wopławki area and are more frequent than in Siedlce area. Probably high heterogeneity of habitat occurring in the Siedlce area favour the possibility of inhabiting each point of populations area, which is not limited of share of space near crop edges.

Dispersion of hares in different kinds of cultivations showed the absence of habitat preference of hares and their random appearance of in field area. It is only noted a tendency of the population to avoid rape plantations. Frylestam (1986) found, that hares might possibly avoid rape food in the late autumn due to its content of glucosinulates. In the case of monocultures (state farms) the share of rape plantations in general area of cultivations may modify a space distribution of hare populations.

Aknowledgements: We are grateful to Prof W. Jezierski and Dr J. Markowski for the comments on an earlier draft of this paper. This study was realized within the project No. RR-II-17.II-5.

### References

- Bresiński W. 1976. Agrarian structure vs. the European hare population density. [In: Ecology and management of European hare populations. Z. Pielowski and Z. Pucek, eds]. State Publ. for Agric. and Forestry, Warszawa: 195 – 197.
- Bresiński W. 1983. The effect of some habitat factors on the spatial distribution of a hare population during the winter. *Acta theriol.* 28: 435 – 441.
- Bresiński W. and Chlewski A. 1976. Tree stands in fields and spatial distribution of hare populations. [In: Ecology and management of European hare populations. Z. Pielowski and Z. Pucek, eds]. State Publ. for Agric. and Forestry, Warszawa: 185 – 193.
- Frylestam B. 1986. Agricultural land use effects on the winter diet of Brown hares (*Lepus europaeus* Pallas) in southern Sweden. *Mammal Rev.* 16: 157 – 161.
- Hogg R. V. and Craig A. T. 1978. Introduction to mathematical statistics. Macmillan Publishing Co., Inc., New York: 1 – 438.
- Jezierski W. 1968. Some ecological aspects of introduction of European hare. *Acta theriol.* 13: 1 – 30.
- Jezierski W. 1972. Elements of space structure of European hare (*Lepus europaeus* Pallas, 1778) population. *Ekol. pol.* 20: 593 – 607.
- Jezierski W. 1973. Environmental conditioning of the space structure and shyness in hares (*Lepus europaeus* Pallas, 1778). *Ekol. pol.* 21: 1 – 12.
- Kovacs G. and Buza Cs. 1988. Characteristics of the home range of the brown hare (*Lepus europaeus* PALLAS) in a forested and in a large-scale cultivated agricultural habitat. 1. Size of the home range. *Vadbiologia* 2: 67 – 84.
- Meriggi A. and Alieri R. 1989. Factors affecting Brown hare density in northern Italy. *Ethol. Ecol. & Evol.* 1: 255 – 264.
- Meriggi A. and Verri A. 1990. Population dynamics and habitat selection of the European hare on poplar monocultures in northern Italy. *Acta theriol.* 35: 69 – 76.
- Odum E. P. 1959. Fundamentals of ecology. W. B. Saunders Co., Philadelphia: 1 – 546.
- Pepin D. 1978. Structure de populations de lievres en automne dans differents agrosystemes. *Ann. Zool. Ecol. Anim.* 10: 97 – 112.
- Pielowski Z. 1966. Forschungen über den Feldhasen XII. Die Raumstruktur der Population. *Acta theriol.* 11: 449 – 484.

- Platt C. 1978. [Problems of probability calculus and mathematical statistics]. Polish Sci. Publ., Warszawa: 235 – 266. [In Polish]
- Sokal R. R. and Rohlf F. J. 1981. Biometry. 2nd ed. W. H. Freeman, New York: 1 – 859.
- Tapper S. C. and Barnes R. F. W. 1986. Influence of farming practice on the the ecology of the brown hare (*Lepus europaeus*). J. Appl. Ecol. 23: 39 – 52.

*Received 17 February 1992, revised 22 September 1993, accepted 6 November 1993.*