

European hares in areas of pure pine forests and surroundings

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Bielova O. 1996. European hares in areas of pure pine forests and surroundings. *Baltic Forestry*, 2: 40-44.

For the maintenance of a sustainable population of the European hare the current goal of evaluation and optimization of the habitat conditions in the different areas of the Lithuania is of great importance. The habitat conditions of the separate categories of forests – namely of the pure pine ones – and surrounding areas were evaluated and favourable reciprocity of these conditions were singled out by optimization. The main index of the living conditions is the density of hares, which determines the intensity of interactions between animals and their habitats. The main environmental factors are certain climatic factors, woodedness, fertility of soils, hilliness, diversity of areas, size of fields. Because of low carrying capacity and specific reciprocity of mentioned factors the density of ecological populations of hares isn't more than the average density in the Lithuania. But it is stable though in the time of common decline of population. The hares are able to adapt because of their ecological flexibility. The measures of care would be applied under the extreme conditions.

Key words: European hare, pure pine forests, climatic factors, diversity, soil fertility, woodedness, relief, flexibility, ecological evaluation

Introduction

The essential changes in the Lithuanian landscape and the influence of other environmental factors caused a change of the borders of the hares' habitats, distribution, social interrelations, and population indices. The range of tolerance to limit factors changed too (Bielova 1989). The impact of natural factors become stronger during the period of population decline. This influence is caused by an anthropogenic factors. The evaluation and optimization of conditions of the hares habitats is of great importance in this case. This problem is relatively little recognized. The habitat conditions are evaluated and favourable composition of biotopes as well as optimal relation of ones are singled out by optimization. The main index of favourability of living conditions is the density of hares. The hares' density also determines the intensity of interactions between hares and their habitats. The living conditions differ in the various physical geographical districts of Lithuania. This study is part of a general study of carrying capacity of European hare habitats in areas of different categories of forests as pure pine, pine with spruce, mixed spruce-deciduous and deciduous with spruce ones. The main purpose of the study is the ecological evaluation of hare habitats in areas of pure pine forests and surrounding areas (because of mixed ecotype of European hare – Bielova 1988, 1990) by the way of optimization of habitat conditions depending on limiting factors and a biological characteristics of hares. The separation and evaluation of these factors should be allowed to reveal the hares' ecological reserves and possibilities to display ones in

the certain habitats of different territories of Lithuania. The evaluation and optimization of hare habitats is the basis of the regionalization of territory for hares depending on favourability of habitat conditions and on carrying capacity.

MATERIALS AND METHODS

The studies consisted of various parts. In the first the habitat conditions were evaluated. The second part is preparing the data for the regionalization of the territory of Lithuania for small game animals. The climatic conditions were evaluated the data from 1861 to 1965 (Dorfman, et al. 1959; et al), the last 20 years, and by the data of climatic factors in the study areas during field work. The main climatic factors for hares (Bielova 1989, 1990) were: depth of snow (cm), its structure, the number of thaws, the number of winters with variable snow cover (%), regime of temperatures during the cold and vegetation periods, the congelation of soil, the relative moisture of air during the different seasons. To determine the degree of the inclemention of weather Sa during the cold period, Bodman's formula was applied (Bielova 1989, 1990) $Sa=(1-0,004t)(1+0,272V)$ where t is air temperature C , V – wind speed, m/s, and to determine the precipitation the factor of rain Lf was used formula $Lf=\Sigma mm/t$ (Puppe 1966), where Σmm is total quantity of precipitation, and t – air temperature.

All of Lithuania belongs to the broadleaved coniferous forests' Baltic province of the Central Europe medium continental climate zone. There are different climatic subregions

(Dorfman et al. 1959) as Ia,b, Ia,b,c, IIIa,b which are different in main climatic factors and in different parts of Lithuania in dependence of prevailing climatic situation. The suitability for hares was ascertained by the climatic conditions of certain areas. The climatic subregions were chosen and grouped according to the category of forest and surroundings, in specific pure pine ones. Pure pine stands predominate in the territory of the continental climate (viz. IIIb climatic subregion) prevailing in the southeastern part, and of the maritime climate (II a climatic subregion) -in the littoral zone. It is important to note that the European hare prefers as open landscape as forest and the occurrence in the forest is more in the areas of greater woodedness (Bielova 1982,1983,1989; Bresinski 1983; etc.) Taking into account the mixed ecotype of hares (Bielova 1988,1989,1990) forest units as well as field habitats were investigated (namely, the adjacent areas that are remote from the forest fringes at average 400 m and more in dependence on the season and other environmental local conditions – Bielova 1990). Various territorial units were grouped according to the prevalent soils, topography, the woodedness of territory, characteristics of the category of stands and surrounding areas. The study areas were estimated by the last data of organization of the forest, agriculture, and game exploitation (namely species composition, fertility of prevalent soils, habitat conditions, age, other characters of forest and their surroundings) and also during the field works. The soils of farmlands were estimated by the Lithuanian soil regionalization

efficient of aggregation as a unit of ratio of a single and group tracks (Bielova 1990). The individual tracking method was also used (n=23). The feeding conditions were established by the sample plot method. The number of sample plots (5x10 m, 10x10 m) were 2 per route unit. Control plots were 1 per route unit. The total number of sample plots of all categories of territory was 477 in the open landscape and 632 in the forest habitats. The total length of route was 1393 km, the total study area was 86.4 thousand ha including 10.5 ha of pure pine forests and their surroundings.

Results

The optimization of hare living conditions is based on their favourability for hares. The differences of the density in the various types of areas (in this case pure pine forests and surrounding areas as an indivisible natural complex which belongs to the different climatic subregions) resemble on the background of general diminishing of the abundance of hares. Differences depend upon the favourability of the foraging, shelter conditions of habitats, intensity of changes of habitats and anthropogenic factors. All these factors influence hare density as the index of habitats' favourability. The average density of hares in the woodlands and surroundings of the continental and littoral parts of pure pine forests is presented in the Table 1.

Table 1. The average density of the European hare ecological populations in the continental and littoral parts of pure pine stands category

Territorial part	Climatic sub-region	Woodedness,%		Average depth of snow, cm	Average fertility of arable land soils, sc. number	Winters with unstable snow cover, %	Density of hares ind. per 1000 ha
		total	area of forestry				
Continental	IIIb	51.7	56.0	23	28	12	11
Littoral	IIb	46.3	71.6	18	39	50	26

(Vaitiekūnas et al. 1965; Mališauskas et al. 1970). The fertility was assessed by the 100 estimation number system. The density of hares was estimated by the data of annual census for the last 25 years – these densities are quite comparable among themselves. Regression analysis was used for the estimation of dependence of the hare density upon the main factors of habitat, and by the way of optimization. It was essential to know the carrying capacity of a range, and how various levels of hare density and environmental factors affect it. The sum of total data of the organization of forest, agriculture as well as data of my field studies were used. The forage and shelter characteristics of the habitats were estimated by the belt transect routes method (4x100). The frequency of occurrence in territories by hares was calculated: $Ii = \sum Ns / \sum nL / G$, where Ns is the frequency of discovery of hare tracks, nL is the number of route units m, and G is coef-

The differences among territorial units are obvious. Accordingly, the main environmental factors of various areas have different influence on the hare elementary population densities there. The dependences of the hare density upon main environmental factors are presented in the Table 2.

It is obvious that the hare density especially depends on the state and depth of snow cover, except in the littoral area, and upon the woodedness of the area being studied. Influence of the separate factors aren't isolated and the reciprocity of the factors is important in this case. Unique conditions are in the littoral territory. The climate is mild, the snow cover is variable there (50% of the winters have unstable snow cover, average depth of snow $h=16$ cm). Total woodedness is 38.3% and of the territory of forestries- 58.6% (till 79% in the continental part and 71.6% – in littoral zone). However, cold, snowy winters predominate in the continent-

Table 2. The dependence of the hare population density (y) upon the main environmental factors (x) in the areas of pure pine forests and surroundings

Factors	Pure pine forests and surrounded areas		
	regression equation	Correlation coefficient, r	R
Woodedness,%	$y= 35.05-0.36x$	-0.63	0,91
Fertility of predominated soils of farmlands, scale numbers	$y= 3.76+5.56x$	0.31	0,81
Fertility of woodland soils, scale numbers	*	0.13	
Size of fields, (10-15 ha)	$y= 31.29 - 0.98x$	-0.68	0.93
Hilliness of relief	$y= 16.12+2.19lnx$	0.53	0.85
Winters with unstable cover of snow, %	$y=10.57+1.30x-0.02x^2$	0.51	0.91
Depth of snow, cm	$y= 35.05-0.36x$	-0,81	0.91
Factor of rain, Lf	$y= 31.79-0.26x$	-0.39	0.86
Average density of hare population, ind/1000 ha	20.9±4.32		

al part that of the IIIb climatic subregion (average depth of snow h= 20-30cm, number of winters with unstable snow cover is only 12-14% there). The deep snow is especially dangerous at the end of January and in the February when the metabolism of the hares become more intensive and their need for a forage of higher quality increases (Bielova 1989, 1990). The snow cover is an important regulator of forage accessibility, and also is the catalisator of the optimum of age and sex structure and reproductive potences of the hare population (Bielova 1990). Because of this factor, hares are forced to crowd into a limited area. Then the foraging features of habitats, locality of feeding places especially depends on the diversity of areas ($r=0.853\pm 0.03$). Open areas and forests are diverse and more favourable in southwestern part of pure pine forests. Gramineous plants, winter crops and similar ones are important for normal gametogenesis (Bielova 1989, 1990) but ones are inaccessible, and these all influence the fecundity of hares. However, a deep cover of snow facilitates the foraging in the forests. The clumped distribution predominates there: the index of clumping is $\delta^2 / Ii > 1$ where $\delta^2=16.12$ is dispersion and $Ii=2.38\pm 0.23$ – intensity of use of the territory and $G=0.38$ – one is highest 6.77 in comparison with other territories and the more even distribution is in littoral area. The interspecific competition is “exploitative” one (when some hares deprive others of the benefits of local resources) till direct competition, hazard of

predators, other disadvantages increases, and the foraging conditions become worse because of overdensity in these places. There are more days with blizzards than in the littoral zone (N=18.3 and 0.4 days per year and per April compared with N=13 and 0.1 in the littoral zone), and fewer thaws (N=43 days, compared to N=46 in the littoral zone). Temperature fluctuations are less stable than in the littoral part, even in early vegetation, since it is the most dangerous region for late and early frosts. But the reciprocity of a temperature and windiness determines strong inclemention of weather in the littoral territory ($Sa=2.8$ in comparison with one in continental part $Sa= 1.97$). The higher density of hares is conditioned by the more favourable weather and shelter conditions as well as by a abundance of natural grass communities and the status of Reserve of littoral area. Some of these conditions are fulfilling in the southwestern part of continental part of the pure pine forests and surroundings. The quantities of precipitation are similar in the whole territory though the climate of littoral area is maritime. The warm winters prompt the early heat of hare but the dampness and inclemention of weather determines the suspension of ovulation of females (Bielova 1989) and micromigrations become more intensive. If during the culmination of reproduction the quantity of precipitation is more than 280mm, the decay of embryos become more frequent (Puppe 1966) as well it take place because of increasing of Lf (Bielova 1989). This could diminish the potency of the population. But the factor of rain is not crucial. The hares turned for the staying in the open places – more than in the forests ($r=-0.94$). Foraging areas and shelter are distributing evenly and reduce the negative influence of the precipitation. The inclemention of weather is especially unfavourable to vitality of the first and last offspring. However, the hares are able to adapt because of their ecological flexibility (Bielova 1989) (that is a species-specific ecological, including behavioural ability or plasticity of the European hare to adapt themselves to changes of their habitat). On the other hand, because of frequent thaws and winters with unsettled snow cover, 50-90% of territories are covered with an ice layer which would be 20-40mm in the open landscape. The hare density in the study area slightly depends on the fertility of soils ($r=0.13$). The soils of pure pine forests and surroundings is rather poor. The soils of sand, sand loam, sod and soddy predominate in the forests (till 97%), turfy soddy, sand soils predominate in the fields (82%). The dependence of hare density upon the field soils fertility is greater than in the forests ($r= 0.31$). The diversity of relief is very important and causes the diversity of ecological conditions and more ecological sustainability ($r=0.53$). The waviness of relief is favourable. Because of comparatively poor soils, highest woodedness, the character of relief as well climatic factors, field size is becoming more important as regulating factor. Fields of 10-15 ha and ones that are

more narrow and long are most favourable to hares. The plants of fields aren't diverse. The factor of bigger fields is in the inverse dependence on the hare density. In the south-western part, the field soils are richer, and there are more smaller stands (till 100 ha, 101-500ha, n=20 and 11 accordingly) that supremacy caused a display of forest edge effect. The influence of the woodedness is negative and the influence of the number of winters with unstable snow cover is positive there. The dependence of hare density (y) upon the woodedness of territory (x_1), the depth of snow cover (x_2) in the areas of pure pine forests and surroundings is expressed by equation:

$$y = 51.11 - 0.27\ln x_1 - 1.33x_2 \quad R=0.95$$

The dependence of the hare density (y) upon the reciprocity of woodedness (x_1), the number of winters with unstable snow cover (x_2), and the depth of snow cover (x_3) is expressed by equation:

$$y = 109.21 - 0.18x_1 - 0.74x_2 - 3.03x_3 \quad R=0.86$$

The influence of reciprocity of the soil fertility (x_1), the hilliness of the relief (x_2), and of the size of fields (x_3) to the density of hares (y) is noticeable there, and is expressed by equation:

$$y = 45.85 - 0.47x_1 - 0.44x_2 + 252\ln x_3 \quad R=0.90,$$

and also the reciprocity of the woodedness (x_1) and the size of surrounding fields (x_2) is important to the hare density (y):

$$y = 45.93 - 0.41x_1 - 0.35x_2 \quad R=0.94$$

The dependence of the hare density (y) upon the main individual environmental factors (x) in the territories of pure pine forests and surroundings is shown in Table 2.

Discussion and conclusions

The main purpose of this work isn't to examine an effect of individual environmental factors on the hare population in Lithuania. This problem as different questions of hare spatial distribution, impact of predators, agricultural system and other reasons of reducing hare population was discussed by many authors from many countries. However, the state of hare population in dependence on the certain habitat conditions as forest composition, habitat and other habitat factors stipulated the category of forest wasn't recognized till now. This problem is especially important for the regionalization of Lithuania for the game animals, for the preparation of the optimal norms of animal density and using, also for the maintenance of biological diversity in the forest ecosystems and adjacent field ecosystems as European hare habitats. The regionalization of territory was prepared in some European countries (Czechia and Slovakia, for example) and the optimal norms of density were revealed in dependence on certain living conditions (Schneider 1979; Kulich

1980; Gerceg 1983; Slamečka 1991; Hansen 1992; et al) but we had not any works of regionalization of territory for game animals in Lithuania till now in accordance to the up-to-day environmental conditions. It is necessary to emphasize the mixed ecotype of the European hare, especially in the wooded territories and specific state of the local population and to maintain the possible abundance of hare in certain habitats as is category of pure pine forests.

The analysis of some main factors and their influence on the hares shows that the favourability of the living conditions and hare susceptibility to the seasonal changes are determined by the reciprocity of natural factors. Influence of some is reinforced by anthropogenic factors. The hares are rather flexible to the anthropogenic changes and they are inflexible to the changes of natural factors (Bielova 1989). This response had formed evolutionally. One significant factor is soil fertility as in farmland and in forests, also shelter factors and carrying capacity of habitats. However, the density of hares fluctuates greatly in the territorial groups of similar soil fertility because of combined influence of several limiting factors and climatic factors. The main climatic factors are regime of temperature and its changeability, factor of rain, precipitation during the vegetation season, the depth and stability of snow cover. The great importance of a climatic factors were usually emphasized (Puppe 1966; Bresinski, Chlewski 19776; Bresinski 1983; Onderscheka 1984; et al) especially in connection with the European hare population dynamics and an increment of population and responses of different groups of a population as a fecundity of females, daily and spatial activity of adults or young hares (Puppe 1966; Hecker 1983; Bielova 1989; Onderscheka, 1984). The young hares of the first generation and females are more sensitive and about of 10% of total loss of hare died through the direct influence of climatic factors (Puppe 1966; Hecker 1983; Onderscheka 1984). The character of relief determines the realization of reproductive potency and most favourable of which is mixed plain-wavy relief. The best indices of population are in areas where fields of 10-15 ha are predominate. The importance of the field size was emphasized before (Onderscheka 1984; Bielova 1990; et al.). The structure of farmlands has a lesser importance. The least densities are in the continental southeastern part of pure pine forests and surroundings (12 ind. per 1000ha) except the littoral and southwestern continental parts of these territories. The most woodedness, poorest soils, deep snow cover and spring-autumn frosts negatively influence hares. But general situation is not crucial. The more stable later weather is favourable for the later offspring and for the first one surviving heretofore. The stability of weather is particularly important in the first 1.5 month of postnatal time. This condition is fulfilling in the some southern areas of continental part of pure pine forests, and in the littoral area. In the smaller fields (as till 10 ha, $r = 0.72 \pm 0.23$), diversity of relief and forest edge effect are favourable. But above-

mentioned poor soils influence lower diversity of plants, poor habitats (cl, v) and lower carrying capacity are predominated there. The characteristic features of hares are their eurytopic peculiarity, the ability to adapt themselves to deep-snow winters or more often thaws owing to the variability of their micromigrations, behaviour and rhythm of activity, character of feeding and other features, also of an increasing synantropism. Because of increasing of the clumped distribution and hare gathering in the more favourable places, it is necessary to pay attention to the possibilities of the interspecific competition there (viz. amensalism in relations with ungulates), the rather that the intraspecific competition increase too. Because of natural selection the more resistant individuals have survived. The density of the hare ecological populations is less than average density in the Lithuania but stable one though in the time of common decline of the population. The measures of care would be applied under the extreme conditions.

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ЗАЯЦ-РУСАК В ЧИСТЫХ СОСНОВЫХ ЛЕСАХ И ОКРЕСНОСТЯХ

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Резюме

Для поддержания устойчивой популяции зайца-русака большое значение имеет нынешняя цель оценки и оптимизации условий местообитаний в разных территориях Литвы. Были оценены и выделены благоприятные взаимодействия этих условий отдельных категорий лесов – в данном случае чистых сосновых – и их окрестностей. Основной индекс жизненных условий – плотность населения зайцев, определяющая интенсивность взаимоотношений между зайцами и их местообитаниями. Основные факторы окружающей среды – определенные климатические условия, лесистость, плодородие почв, холмистость, разнообразие территорий, площадь полей. Из-за низкой емкости обитания и специфики взаимодействия указанных факторов плотность населения экологических популяций зайцев не превышает среднюю в Литве, однако она остается стабильной на фоне общего упадка численности зайцев в Литве. Зайцы в состоянии адаптироваться на основании их экологической пластичности. При экстремальных условиях необходимы мероприятия по охране и заботе.

Ключевые слова: заяц-русак, чистые сосновые леса, климатические факторы, разнообразие, плодородие почв, лесистость, рельеф, пластичность, экологическая оценка