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Dynamics of the European hare populations (*Lepus europaeus* Pallas, 1778) in the steppe zone of Ukraine

Key words: agrocoenoses, habitats, dynamics, *Lepus europaeus,* European hare, hunting, number, population, steppe zone, Ukraine

Introduction

South Ukraine is inhabited by the European hare of subspecies *Lepus europaeus transilvanicus* (fig. 1). In spite of limited use of its resources and a positive trend in the end of the 20th century, now its number has reduced everywhere. Therefore we set the aim to study characteristics of functioning of the European hare steppe population and reveal causes of its decrease.

Fig. 1 A European hare in the meadow of Azovo-Sivash National Park (23.08.2012); Photo by A.Volokh

Field material was collected from 1976 to 2012 in different areas of the steppe zone. To reveal the relationship between the population dynamics and population structure there were identified sex and age of hares (n = 816) bagged in Zaporozhye Region. To study the impact of hunting, in addition to researches on a permanent plot, a method of questionnaires was used in 1977–2003. It allowed to receive information about features of taking from the wild, population density and habitat distribution of 9763 hares in all sites of the steppe zone. To reveal characteristics of the European hare dynamics in 1950–1990 it was analyzed the hare's pelts harvesting in Ukraine.

Habitats

In former times, in the south of Ukraine the habitats of the European hare were steppes and meadows, shrub thickets, and gullies. Especially many European hares inhabited a virgin steppe near the private residence "Askania Nova" (Falz-Fein 1997) and in Aleshkovskie Sands at the Lower Dnieper (Brauner 1923). However, already in the late 19th century, the

considerable anthropogenic transformations started and led to a complete transformation of the steppe biota. As a result, everywhere arable lands became dominant (table 1), and appeared a great number of planted forests and artificial bodies of water, which contributed to the reduction of species diversity of steppe plants and animals (Formozov 1962).

However, the European hare adapted to changed ecological situation. Now in the steppe zone of Ukraine its main habitats are agrocoenoses (fig. 2), where over 73 % of these animals are recorded. Of this percentage, the highest number of hares (29.9 %) was counted on fields with winter crops (wheat and barley), 16.0 % – on arable lands, and 9.6 % – in plantations of perennial grasses.

In addition to agrocoenoses the very important habitats of the European hare in the steppe zone of the country are small deciduous forests with the area of 10–100 ha, meadows, gardens and vineyards as well as forest belts. At the same time, the number of animals has a positive correlation with the length of the forest outskirts and forest belts as it was noticed also in other countries (Hespeler 1988). Other lands, due to

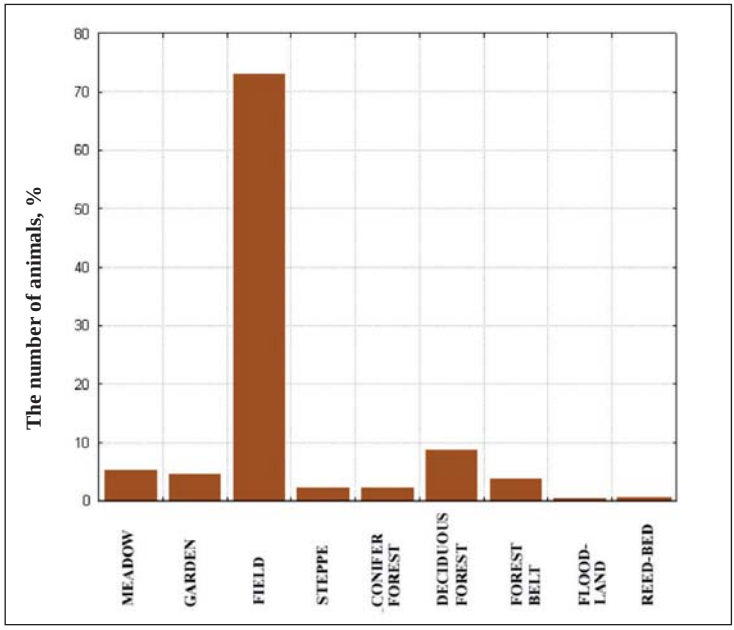

Fig. 2 Habitat distribution of the European hare (n = 9763)

Table 1 Characteristics of European hare areas in the steppe zone of Ukraine (thousands of ha)

Administrative region	Total area	Agricultural lands	Arable lands		Area of forests
			total	% of total area	
Odessa	3331.0	2562.7	2081.0	62.5	72.6
Nikolaev	2460	2010.0	1716.0	85.4	38.0
Kherson	2846.1	1965.5	1770.8	62.2	45.0
Zaporozhye	2718.0	2299.3	1636.7	60.2	42.8
Dnepropetrovsk	3190.0	2258.9	1517.5	45.6	78.9
Donetsk	2650.0	2037.0	1686.0	63.6	94.2
Lugansk	2670.0	1888.0	1458.0	54.6	155.8
Overall:	***19865.1***	***15021.4***	***11866.0***	***59.7***	***527.3***

their small size (steppe areas) or unfavourable conditions (overflow lands, reedbeds), have no essential significance as habitats for these animals. For instance, on a marshy Obitochnaya Spit (the Sea of Azov), where the reed is dominated and artificial deciduous plantations grow, we only 3 times for 27 years of studies recorded single hares at the distance of 18–20 km from the continent.

In Western Europe the highest number of European hares was counted on arable lands and on fields with winter wheat – it was recorded in France (PÉPIN 1987), Romania (Almasan & Cazacu 1976), Bulgaria (Petrow 1976) and other countries. In Germany, in spite of insignificant correlation between the European hare population density and the area occupied with winter crops (r = 0.5) there was no any essential relationship between using of this kind of fields and those with other agricultural plants (Schröpfer & Nyenhuis 1982).

In the late 20th century in the south of Ukraine considerable areas were occupied with sunflower fields, which growing in a zone of risk agriculture brings high and stable profits. Even after harvesting, former sunflower plantations, where 9.9 % of animals were recorded, provide good shelter for the hares. Much fewer animals were found in vegetable gardens (4.2 %), fields with spring crops (2.1 %), maize (1.1 %), beetroot (0.7 %), melons and gourds (2.1 %), and in stubble-fields (2.0 %). On marine spits and islands the favourite habitats of the European hare are sandy meadows where the animals feed, rest and reproduce.

Everywhere in Ukraine, due to the collapse of stock-raising, the area of perennial grasses sharply reduced which in previous years had been very important as forage and shelter for the hare. In many countries plantations of the clover and lucerne are the most preferable habitats of this species as places of the most efficient breeding and feeding (Frylestam 1980). In England, in addition to them, important habitats are fields with spring and winter crops. The size of these fields occupied with different agricultural plants usually does not exceed 10 ha (Hecker 1983). At the same time, in South Ukraine an average size of 1 field is approximately 100 ha with the dominance of monocultures. Certainly, the above-mentioned changes in agriculture and stock-raising influenced on habitat preferences of the European hare and contributed to its redistribution in hunting lands of the steppe zone.

Nowadays the habitat distribution of hares is entirely depends on the structure of agrocoenoses which occupy the most territory of South Ukraine. Though, this distribution also varies under seasonal dynamics of forage and protection conditions. However, the fields remain to be the most preferable habitats for the species throughout a year, and their value only slightly decreases in spring and summer (table 2).

Table 2 Seasonal distribution of the European hare per habitats (n = 9763)

Habitat	Spring		Summer		Autumn		Winter		Overall:	
	Abs.	%	Abs.	%	Abs.	%	Abs.	%	Abs.	%
Meadows	34	2.1	154	11.4	136	5.5	184	4.3	508	5.2
Gardens	91	5.5	63	4.6	109	4.4	186	4.4	449	4.6
Fields	1092	66.5	894	65.9	1788	72.0	3363	78.5	7137	73.1
Steppes	56	3.4	68	5.0	51	2.1	30	0.7	205	2.1
Conifer forests	101	6.2	47	3.5	13	0.5	54	1.3	215	2.2
Deciduous forest	219	13.3	67	4.9	202	8.1	361	8.4	849	8.7
Forest belts	44	2.7	63	4.7	173	7.0	81	1.9	361	3.7
Flood lands	4	0.2	-	-	-	-	6	0.1	10	0.1
Reed beds	1	0.1	-	-	9	0.4	19	0.4	29	0.3
Overall:	***1642***	***100.0***	***1356***	***100.0***	***2481***	***100.0***	***4284***	***100.0***	***9763***	***100.0***

In the second half of summer habitat distribution of the European hare in the steppe zone sharply changes that was also recorded by other researchers (Kolosov & Bakeev 1947). It is not connected with harvesting of crops which in southern regions of Ukraine are carried out in short terms – usually from 15 June to 20 July. Some later, 5 to 20 August the green maize is mowed for silo, and since 15 August the early sunflower is harvested. Therefore, the lowest number of hares in the fields is registered in late summer and early autumn when vast areas are turned into partly ploughed up and plantless plains.

It leads to increase of the hare density in forest belts and planted forests. For example, in September – October 1982 the hare density in these habitats in the territory of Ukrainian Azov area reached 25–30 individuals/100 ha compared to 1–5/100 ha in agrocoenoses. In steppe regions of Russia, in areas with forest belts the number of the European hare almost 12 times increased that in equal lands but without forest belts (Lvov 1974).

For the European hare of the steppe zone the forest plantations are especially important in winter. In Melitopol District (Zaporozhye Region) the day after the first snow (23.12.1984) 12 hunters in the arable land, maize stubble and weeds (~ 300 ha) frightened only 4 hares, while in a 30 ha forest – 43 hares. Other researchers also note that the European hares prefer forest lands during snowy winters.

When the vegetation period of most plants finished, the great impact on spatial distribution of animals is provided by weather conditions. In autumn, in rainy weather the hares prefer forest belts, sands, rather often visit coniferous young forests, forest gullies, virgin lands and in recent years are also recorded in the fields cultivated with a subsurface cultivator. In winter, in case of snow cover, higher areas where the snow cover is lower are usually better inhabited with these animals than lowlands. In Ukrainian Azov area after snowfalls the hare density on elevated fields with winter crops can increase up to 30–80 individuals/100 ha. After improving of climatic situation the hares disperse over a vaster territory.

Number dynamics of the European hare

Formerly, there was no census of the European hare numbers in Ukraine but we can judge about the dynamics by harvested pelts. Hunters were obliged to deliver pelts to procurement stations and were additionally encouraged with possibility to buy the goods which were deficit at that time (powder, shot, etc.) Therefore, the data on harvested pelts quite reliably show the number dynamics of the European hare before 1985 (fig. 3).

In first years after World War II the hunting became a significant factor influencing on the European hare number in Ukraine. In 1946/47 in the country 2 mln 163 thou animals were bagged which was maximum for all the years of Soviet regime. Since the years mentioned, the number of hunted European hares decreased from 1 mln 680 thou (1947/48) to 450 thou (1952/53) or 73.2 % for 5 years. Further, impact of hunting on the European hare increased under intensification of agricultural production. In spite of fluctuation of the number typical for this species, for the period of 30 years there was not at least one year when harvesting of pelts could even approach to former values. In fact, from 1962 to 1965 it reduced by 54.4 % compared to 1961. It was a consequence of high mortality of the species caused by different factors, and hunting was among the leading ones (fig. 4).

In the 1970s Ukraine implemented a special system of "hunting days" to reduce a negative impact of hunting on the European hare population. The hunting was limited to only 1 day a week – Sunday, and only 1 animal could be bagged. The total number of hunting days was decided according to the number of animals which had been counted immediately before a hunting season. In 1981, within our study plot (1459.5 ± 101.75 ha) for 171 man-days hunters (n = 28.5 ± 1.52) shot 254 European hares or 1.48 animal/1 hunter/1 hunting day (table 3) which was violation of the hunting law. In 1980/81 in lands with low density (1.02–1.87 animals/1 sq.km) every day it was bagged 20.4–40.6 % of the hares frightened by hunters. With density over 2 hares/1 sq.km, the abovementioned value often exceeded 60 %. In general, in years with relatively high numbers,

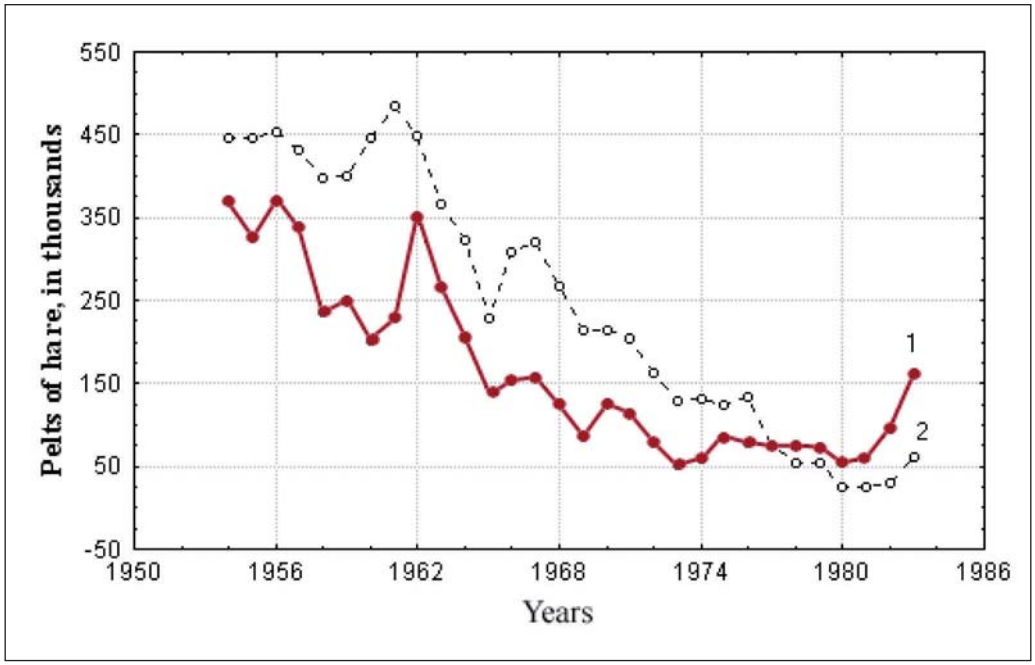

Fig. 3 Dynamics of harvested pelts of the European hare in the steppe zone (1) and other regions of Ukraine (2)

Fig. 4 Rural hunters after successful hunt on the European hare; Photo by A. Volokh

during 6 hunting days the volume of bags constituted about 70–80 % of autumn population. According to the data of our research carried out in 1999-2002, out of 1996 hares frightened by hunters 1597 animals were shot which made up 80.01 %. This volume of bags was exces

sive and considerably exceeded the reproduction rate which resulted in reduction of the hare number in next years (fig. 5).

Fig. 5 Number dynamics of the European hare in the late 20th – early 21st centuries

Table 3 Influence of hunting on the European hare population in a period of high number (1981)

Days of hunting	Area of lands, ha	Number of animals				Volume of bags, %	Number of hunters
		absolute		Per 100 ha			
		1*	2**	1*	2**		
1.	1923	116	69	6.03	3.59	59.48	35
2.	1542	64	45	4.15	2.92	70.31	29
3.	1273	67	39	5.26	3.06	58.21	26
4.	1263	62	41	4.91	3.25	66.13	28
5.	1412	56	35	3.97	2.48	62.50	29
6.	1344	33	25	2.46	1.86	64.10	24
Total:		321	254	5.21	3.27	79.13	-

1* - number of revealed animals; 2**- number of bags

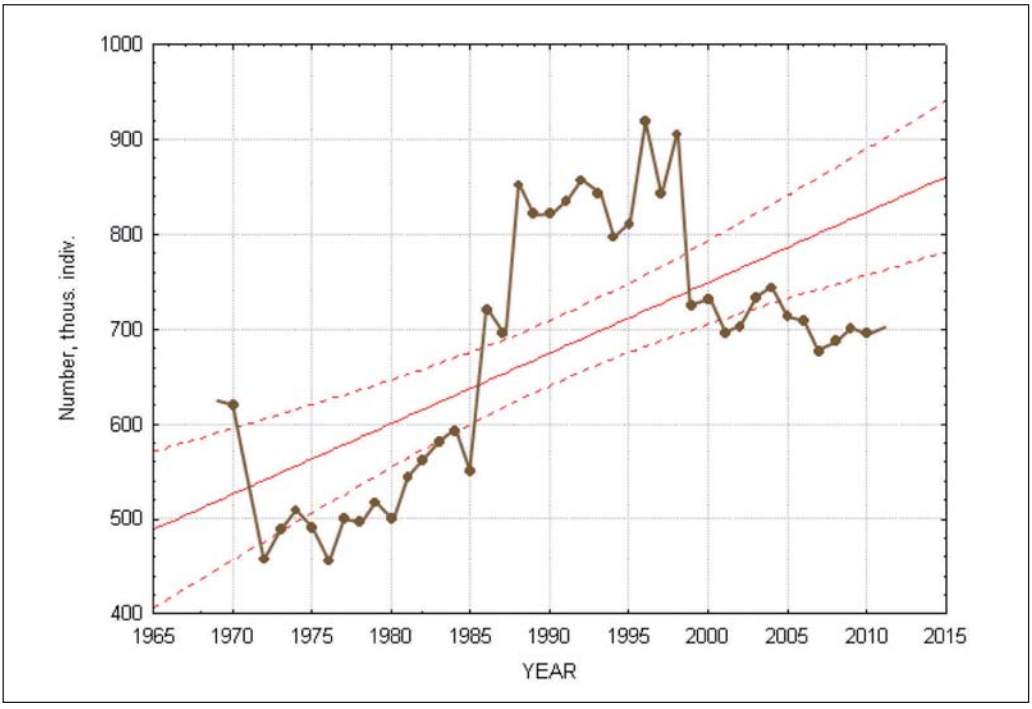

Fig. 5 Number dynamics of the European hare in the late 20th – early 21st centuries

After a catastrophic depression of 1971–1978 the European hare number in the steppe zone of Ukraine had been steadily increasing but sharply reduced after reaching its peak in 1996. At first, the reason of it was draught, and then – destruction processes developed in the country after the collapse of the Soviet Union.

The European hare population dynamics is closely connected with their age-sex structure. Usually, when the population is increasing, the number of females exceeds that of males and percentage of juveniles can reach 80–100 %. However, long-term researches in the permanent plot (1967–2002) did not reveal any definite regularities of changes in sex ratio of adult hares during different status of their numbers (fig. 6). Dominance of females or males was recorded both during increase and decrease of the population, though in 1966/67 in territories of the hunting farms, involved in breeding and distribution of hares, sex ratio of these animals was 1:1.38:1.77 in favour of females (Galaka 1969).

In different years percentage of young animals in the Azov marginal population can fluctuate 51.4 % to 66.9 % but, on average, this value is 60.8 % (Volokh et al. 1988). And the level of the number fluctuations greatly depends on the number of young hares which survived until November ($r = 0.59$; $p = 0.05$). In other areas of the steppe zone in the late 1970s percentage of young animals was 48.6–78.5 % and their number for 1 adult female – from 1.9 to 6.0 (Galaka 1969). During the number depression of 1969/72, according to L.S. Shevchenko, the number of young hares considerably reduced and even in lands of state hunting farms did not exceed 14 % (Nikolaev Region), and 20–31 % in best (Zaporozhye Region). A considerable variability of sex-age structure of the European hare along with its high reproductive ability was also registered in other European countries. For instance, in Germany percentage of young hares fluctuates both in years (45–72 %), and per different kinds of lands (30–70 %) (Rieck 1963).

Mortality

The European hare is very vulnerable to impact of natural and human factors. The number dynamics of its populations often depends on mortality rate of juveniles which in the south

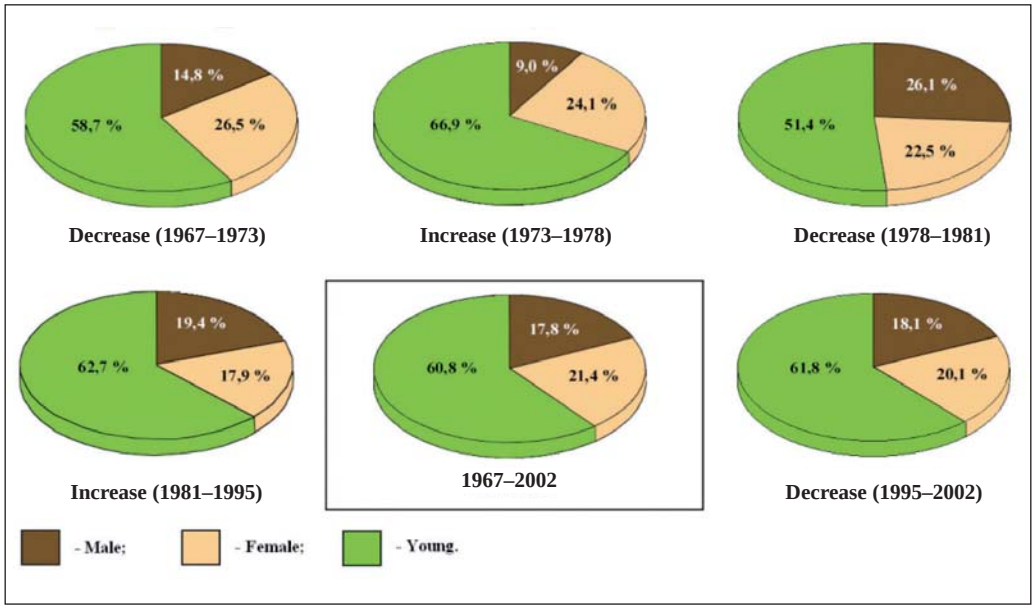

Fig. 6 Structure of the European hare population in different periods of its development in Zaporozhye Region (n = 816)

of Ukraine amounts to 1–1.5 hare cubs per female. Indirectly, it is shown by percentage of young hares ranging from 51.4 % to 66.9 %. More negative impact on the European hare populations is provided by agricultural activities which are the cause of death for over 40 % of all found hares (fig. 7).

Agricultural production obtained especially considerable impact on the European hare populations after implementation of chemical pest control remedies for agricultural crops. Experiments showed that when fed with small doses of DDT (0.8 g/1 kg of forage) 6 % of animals died during 10 days, and the survived hares demonstrated a lowing level of haemoglobin, changes in activity of enzymes, increase of blood sugar level, etc. (Aleeva et al. 1972). In experiments with Trichlorfon (0.3–0.8 g/1 kg of forage) there were registered morphological changes in liver of the hare. Besides, blocking of choline esterase led to accumulation of acetylcholine that had a negative impact on conduction of nerve impulses through synapses (Shevchenko 1969). Death of hares from pesticides reached the largest scale in the 1970s–90s and caused a long-lasting depression of the population not only in the steppe zone but also everywhere in Ukraine.

With high population density of the animals, a possibility of the number reduction due to increasing mortality from epizootic is also high. In particular, in the European hare there were revealed agents of 10 bacterial infections, among them the most usual are coccidiosis (infectiousness can reach 60–100 %) and toxoplasmosis (9–41 %). While coccidiosis causes deaths of hare cubs, toxoplasmosis leads to infertility of adult females, aborts and birth of weak juveniles.

This disease causes high mortality of young hares in Switzerland in years with warm winter or warm and rainy summer (Eiberle u. a. 1982), and also in Germany where in populations of the European hare coccidian infectious-

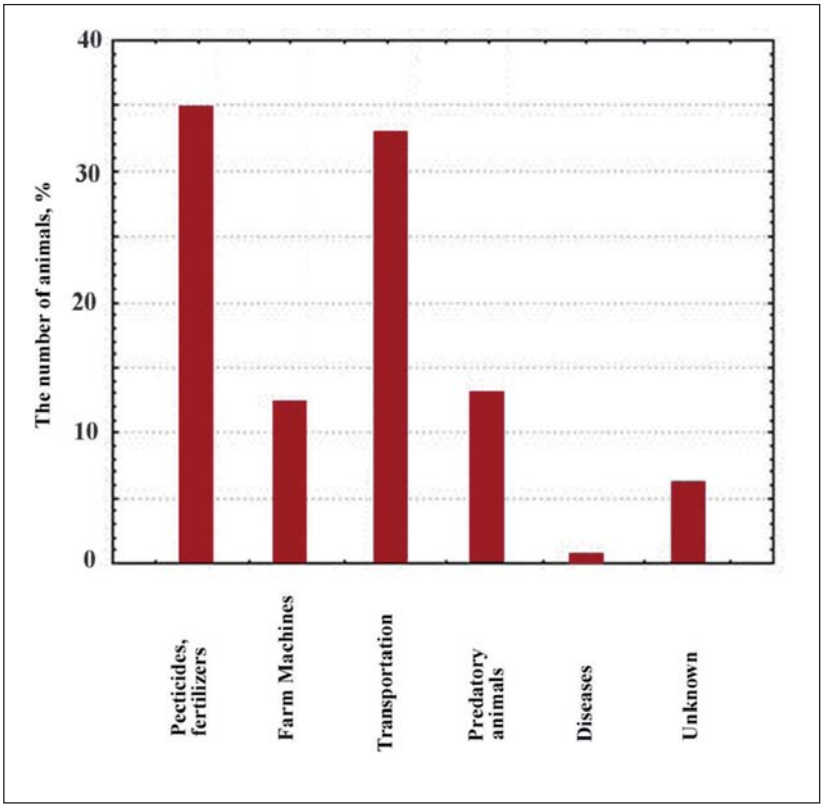

Fig. 7 Reasons of destruction of the European hare population in 1983/84

ness reaches 97.7 %, and mortality – up to 20 % (Spitler 1987; Hoesch 1979). However, the most dangerous infection for the European hare is pseudotuberculosis, which has acute form in hare cubs and contributes to their death. In adults it becomes chronic and leads to malnutrition and flabbiness which also increase the mortality level (Dunaeva 1980).

In the steppe zone a very common disease of hares is tularaemia caused by bacteria *Pasteurella tularensis*. In 1923 it caused mass mortality of animals in Askania Nova Reserve. In the winter of 1928/29 this disease covered almost all regions of Ukraine. Now niduses of tularaemia are revealed in many areas of the south. In May 1961 on Biryuchy Peninsula there were recorded mass deaths of the European Hare and mouse-like rodents caused by tularaemia. Epizootic reduced the hare population by 90 % (Kolosov 1975). Such catastrophic consequences were induced by high numbers which in 1957 on the peninsula (5300 ha) constituted 550, and in 1960 – over 2000 individuals (Bessalov & Korol 1972). According to our calculations, in the first case the population density of animals was about 11, and in the second case – over 40 ind./100 ha. A next investigation of Biryuchy in the summer of 1974 showed the low number of the hare and dominance of adults in the population (more than 80 %). Pathologicoanatomic analysis of 7 animals revealed tularaemia in 4 of them (57.1 %). Besides, 9 hares of 13 had serious pathological changes in lungs and spleen, and 2 had affection of testicles (Shevchenko 1978).

Rather a high number of hares are killed under car wheels and by predators, mostly by the wolf. In 1996–2003 remains of the hare we found in 14 (58.3 %) stomachs of this predator (n = 24).

Restoration of resources

In Ukraine the special reproduction areas are used to restore resources of game animals. They constitute at least 20 % of lands in each hunting farm. In addition, this function is fulfilled by different areas of the Nature Reserve Fund where any kind of hunting has banned since 2010. Our research (Volokh 2007) in the State Landscape Reserve "Staroberdyansky" (Zaporozhye Region) has shown that the protection regime provides a positive influence on

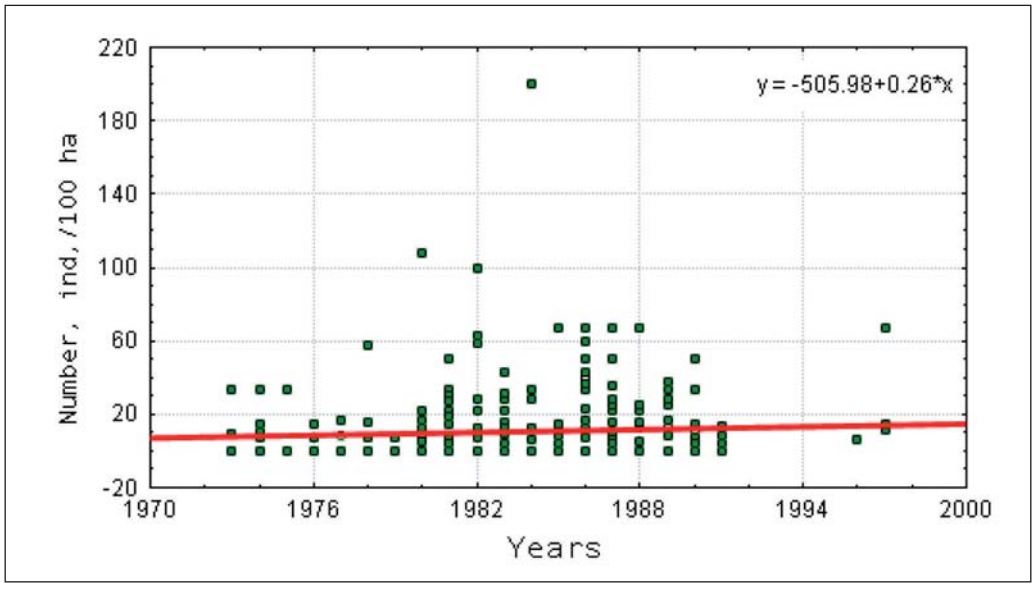

Fig. 8 Number dynamics of the European hare in the State Landscape Reserve "Staroberdyansky" (Melitopol District, Zaporozhye Region)

the number of the European hare for a long period of time (fig. 8).

The number of animals in the reserve sharply increased in periods when hunting for the species was provided in adjacent hunting lands. Thus, in November before hunting season the European hare population density in the reserve was near 9 ind./100 ha, and in December, when hunting is the most active, it increased 1.8 times (table 4).

Thus, in years with high numbers of the European hare (1981–1983) these values were higher and amounted to 100–200 ind./100 ha.

Conclusions

1. In the last quarter of the 20th century it was a substantial reduction of the European hare numbers over the entire territory of Ukraine conditioned by global impact of anthropogenic factors, and the steppe populations suffered the most.
2. In spite of intensive use of chlororganic substances for rodent control and use of mineral fertilizers which negatively affect reproductive function of the European hare, in 1980–1982 due to short and almost snowless winters it was a noticeable increase of the species numbers almost in all regions of the country, from the Carpathians to the steppe zone inclusively.
3. Southern peripheral populations of the European hare are characterized by a very low level of the number growth and its significant amplitude which is a consequence of intensive agricultural production, overhunting and abnormal weather phenomena.

Summary

Dynamics of the European hare populations (*Lepus europaeus* Pallas, 1778) in the steppe zone of Ukraine

Now in the steppe zone of Ukraine main habitats of the European hare are agrocoenoses, where over 73 % of these animals are recorded. Of this percentage, the highest number of animals (29.9 %) was counted on fields with winter crops (wheat and barley), 16.0 % – on arable lands, and 9.6 % – in plantations of perennial grasses.

In the late 20th century in the south of Ukraine considerable areas were occupied with sunflower fields, which growing in the zone of risk agriculture brings high and stable profits. Even after harvesting, former sunflower plantations, where 9.9 % of animals were recorded, provide good shelter for the hares. Much fewer animals were found in vegetable gardens (4.2 %), fields with spring crops (2.1 %), maize (1.1 %), beetroot (0.7 %), melons and gourds (2.1 %), and in stubble-fields (2.0 %).

In first years after World War II the hunting became a significant factor influencing on the European hare number in Ukraine. In 1946/47 in the country 2 mln 163 thou animals were bagged which was maximum for all the years of Soviet regime. Since the years mentioned, the number of hunted European hares decreased from 1 mln 680 thou (1947/48) to 450 thou (1952/53).

After a catastrophic depression of 1971–1978 the European hare number in the steppe zone of Ukraine had been steadily increasing. However, after reaching its peak in 1996, it sharply reduced. At first, the reason of it was draught, and then – destruction processes developed in the country after the collapse of the Soviet Union.

Table 4 Population dynamics of the European hare in the State Landscape Reserve "Staroberdyansky" (forest – 996 ha)

Situation outside the reserve	Survey area, ha	Density, ind./100 ha	
		Mean ± SE	Range
Hunting is closed	857	9.1±1.40	0.2– 66.7
Hunting is open	523	16.3±5.40	3.2–200.2

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