

The place of the steppe marmot in steppe ecosystems of Ukraine: an historical approach

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All natural settlements of the steppe marmot in Ukraine are described. The vegetation of steppe marmot habitats is described and the food preferences are determined. The dynamics of the steppe marmot numbers in the Kharkov and Lugansk regions during XIX-XX centuries was traced. The process of the progressive increase of livestock pressure on potential habitats of the steppe marmot is presented. This process caused the restoration of grazing ecosystems with the steppe marmot as one of the basic components. The key role of the anthropogenic factor in the dynamics of the fluctuation of *Marmota bobak* populations is described.

KEY WORDS: foraging, grazing, *Marmota bobak*, population dynamics, gully, vegetation.

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INTRODUCTION

The steppe marmot is considered the original inhabitant of virgin steppes. From the late XVIII century, steppes have been converted to arable land. In the beginning of the XX century the European subspecies of the steppe marmot (*Marmota bobak bobak* Müller 1776) was under threat of extinction. Then, in the early sixties, its rapid “renewal” occurred. There are two historical refuges (i.e. “renewal” centers) in Ukraine: “Veliki Burluk” (Kharkov region) and “Strel’zolskaya steppe” (Lugansk region). These territories are the integral geomorphologic unit but for the marmots there are isolation barriers (for example, big rivers). Thus Ukraine has two populations of the steppe marmot — Lugansk and Kharkov. They have no contact in the territory of Ukraine.

Currently the steppe marmot inhabits agricultural landscapes, but does not occupy conserved steppes, which traditionally was considered as the vast sea of a feather grass. This raises the question — was the steppe marmot the inhabitant of virgin steppes? Its historical area has always ranged to steppe and forest-steppe zones. Or has the steppe marmot undergone strong ecological and ethological changes and is acquiring new features which were not typical of it before?

The aim of this paper is to determine the place of the steppe marmot in the steppe ecosystems of the Ukraine and to describe the ecological factors supporting the presence of *Marmota bobak* in modern steppe ecosystems in Ukraine.

MATERIALS AND METHODS

The mapping (cartography) of marmot settlements was carried out 4 times: in 1980-1981, 1986-1987, 1995-1996 and 2005-2006. We used the standard techniques of settlements mapping (MASHKIN 1997) and standard spatial criterion of home range boundaries (SEREDNEVA 1986). We counted the number of marmot families but other authors have counted number of marmot individuals. To compare all the data we used a correction coefficient. After long-term researches in various marmot colonies, we found that a marmot family includes an average of five individuals (TOKARSKY 1997). Thus, we have used the coefficient “five” to convert family numbers to numbers of individuals.

We conducted feeding trials with cage-kept marmots (1990-2005). The marmots were fed various mixtures of fresh plants of the same vegetative phase (RONKIN & TOKARSKY 1993) to determine the plant species preferred or rejected by the animals. Fifteen adult cage-kept animals from the Biological Station of Kharkov Karazin University and Regional Landscape Park “The Veliki Burluk-steppe” were used. Vegetation of the marmot habitats was investigated by standard geobotanical methods (0.25 square-meter method).

RESULTS

All natural settlements of the steppe marmot in the Ukraine are located within the steppe and forest-steppe zones of industrially undeveloped territories on the left bank of the river Severski Donets. Settlements of marmots on flat

steppes are not present in the Ukraine. The basic habitats of marmots are gully systems on valleys of influents of the river Severski Donets: Volchya, Khotomlya, Viliky Burluk, Oskol, Aydar, Evsug, Kovsug, Derkul and their reservoirs.

Vegetation of marmots' habitats

The basic modern economic use of gully systems is cattle grazing like that of primitive nomadic pastoralism. The vegetation of gullies is characterized by communities of meadows, northern meadow-steppe, "forbs + fescue + feather grass" steppe, and thyme calcareous-steppe. The following basic types of vegetation cover the marmot home ranges:

1. Wet-meadow vegetation. It is available on moist places; e.g., on gully bottoms. The basic community is "bluegrass + leguminous + dandelion + yarrow" (*Poa pratensis* L., *Taraxacum erythrospermum* Andr., *T. officinale* Webb. ex Wigg., *Trifolium fragiferum* L., *T. medium* L., *T. pratense* L., *T. repens* L., *Achillea submillefolium* Klok. & Krytzka).

2. Steppe vegetation. It is the vegetation of dry slopes with the high insolation. The basic community is "forbs + fescue + feather grass" (*Salvia nutans* L., *Crinitaria villosa* (L.) Grossh., *Veronica spicata* L., *Festuca valesiaca* Gaud., *Stipa capillata* L.).

3. Upland-meadow vegetation (*Artemisia austriaca* Jack., *A. absintium* L., *Euphorbia virgata* W. & K., *E. stepposa* Zoz., *Adonis vernalis* L.).

4. Vegetation of pastures and roadsides (*Polygonum aviculare* L., *Poa bulbosa* L., *Capsella bursa-pastoris* (L.) Medik.).

5. Agricultural vegetation of vegetable gardens and fields.

As a rule, each marmot family uses at least two types of vegetation; combinations of wet-meadow + upland-meadow, wet-meadow + steppe, upland-meadow + roadside, i.e. the meadow vegetation is an obligatory attribute of the marmot home range. Its shortage can be replaced in part by agricultural or roadside vegetation. Plots with wet-meadow vegetation provide the most stable foraging zones. Winter burrows are built on higher places.

In laboratory feeding trials, the basic food species of marmots, i.e. the plants eaten by the majority of experimental animals during all periods of activity were determined. The list of the most preferred plants includes 30 species (Table 1). Animals selected them from among more than 200 species covering the marmot natural habitats. Generally, the feeding tests of marmots indicated a preference of agro-biological group "forbs + Leguminosae" over group "Gramineae + Juncaceae + Cyperaceae" but certain grasses were tolerably eaten (for example, *Agropyron repens* L.).

One hundred per cent of the preferred species are those of seral communities (or sere), 80% of them are species of early succession, 60% of them are species of a late stage of pasture degradation, 53% — r-strategists and 87% have a long-lasting vegetative period (nearly 200 days). We observed that in modern steppe ecosystems, the seral communities appear in abundance only under grazing pressure. The preferred plants are dominant in the seral communities and the proportion of the total aboveground phytomass is more than

Table 1.

Successional status and ecological strategy of the plant species preferred by the steppe marmot.

Species	1*	2	3	4
<i>Achillea millefolium</i> , <i>Artemisia vulgaris</i> , <i>Cichorium intybus</i> , <i>Taraxacum officinale</i> , <i>Trifolium repens</i> , <i>Polygonum aviculare</i> , <i>Plantago major</i> , <i>Convolvulus arvensis</i> , <i>Capsella bursa-pastoris</i>	+	+	+	+
<i>Lotus corniculatus</i> , <i>Chenopodium album</i> , <i>Stellaria media</i>	+	-	+	+
<i>Medicago lupulina</i> , <i>Trifolium fragiferum</i> , <i>T. pratense</i> , <i>Plantago lanceolata</i> , <i>Ranunculus polyanthemos</i>	+	+	-	+
<i>Centaurea jacea</i> , <i>Medicago sativa</i> , <i>Trifolium sativum</i>	+	-	-	+
<i>Lactuca chaixii</i> , <i>L. serriola</i> , <i>Heracleum sibiricum</i> , <i>Daucus carota</i>	+	-	+	-
<i>Taraxacum erythrospermum</i> , <i>T. serotinum</i> , <i>Medicago romanica</i> , <i>Plantago media</i>	-	+	-	+
<i>Trifolium medium</i> , <i>Plantago salsa</i>	-	-	-	+

* 1, species of the early stage of succession; 2, species of the late stage of pasture degradation; 3, species with r-strategy; 4, species with a long-lasting vegetative period.

70%. The absolute value of consumed phytomass is not less than 85 g/m² (dry weight) and it is present for not less than about 150 days of the active period of the marmot.

Population dynamics

The number of the steppe marmot in the Kharkov and Lugansk regions during 1955-2005 fluctuated (Fig. 1).

The marmot population of the Kharkov region was increasing from the late 1950s to the early 1980s until all potential habitats were occupied. Then it became stable and in the late 1980s, there appeared some tendency for population decline in the oldest (central) part of the area (i.e. Burluk district) (Fig. 2).

The peripheral area had low population density, but had the potential resource for increasing numbers due to condensation of settlements. Thus, population decline in the entire area happened later; namely, in the early 1990s (Fig. 1).

At present the potential habitats are not filled; therefore, the populated area is expanding. The same processes — population growth from the middle of the 1950s to the early 1980s followed by a decrease since the early 1990s occurred in the Lugansk population (its renewal center is the “Strel'zolskaya steppe”).

The increase of marmot populations followed the increase of cattle grazing pressure on the potential habitats of the marmot; the decrease of marmot population followed the decrease of grazing pressure (Fig. 3).

We observed the typical settlement of the steppe marmot for about 30 years. The population density of marmots decreased 4 times for 5 years in that part of this settlement where cattle grazing was stopped. Where grazing pressure did not change, population density of marmots did not change.

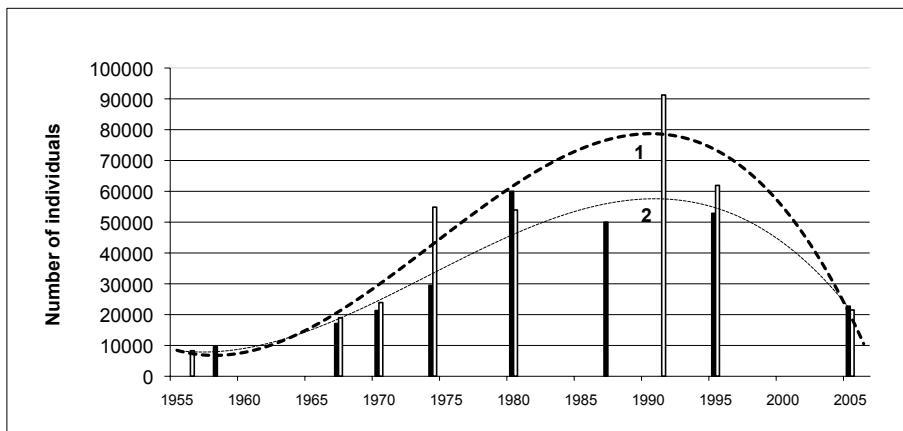


Fig. 1. — Numbers of individuals of *Marmota bobak* in the Ukraine in 1955-2005. 1, Lugansk population; 2, Kharkov population; 1955-1975 (ABELENTSEV 1975); 1991 (MASHKIN 1991); 1980, 1995-2005 (our data).

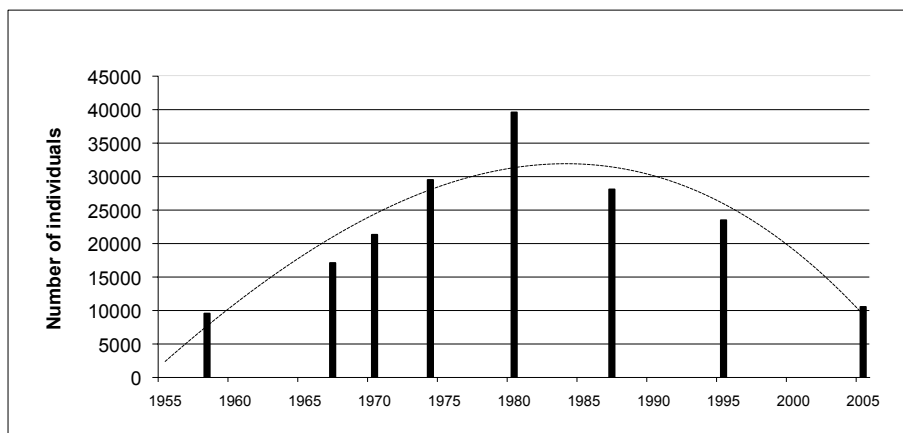


Fig. 2. — Numbers of individuals of *Marmota bobak* in the oldest (central) part of the Kharkov population (Burluk district) from 1955 to 2005; 1955-1975 (ABELENTSEV 1975); 1980-2005 (our data).

DISCUSSION

The most characteristic habitats for the steppe marmot in all the parts of the range in the past were steppes used by nomads as pasture (KIRIKOV 1966). Since ancient times till the XIX century, natural pastoralism remained the most advanced branch of the steppe zone agricultural economy. In historical times, the most progressive settlements of the steppe marmot were located

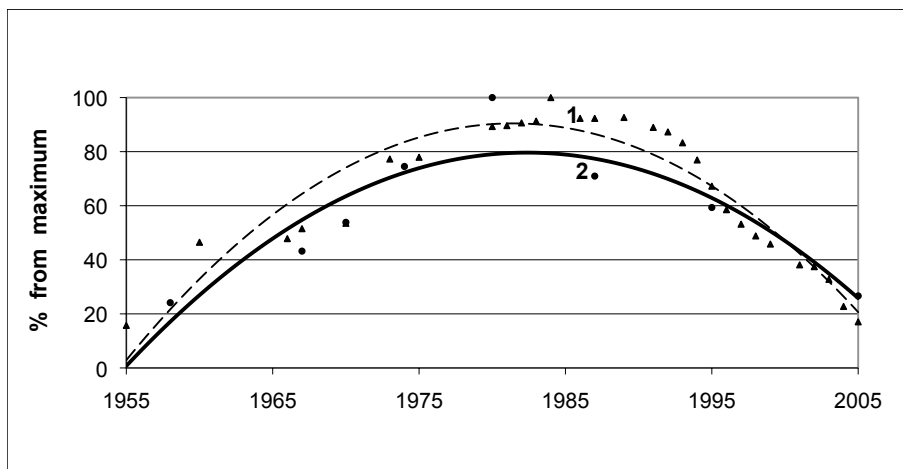


Fig. 3. — The dynamics of cattle grazing pressure (1) in % from maximum and the dynamics of marmot' population (2) in % from maximum in the oldest (central) part of area of Khar'kov population (Burluk district) from 1955 to 2005.

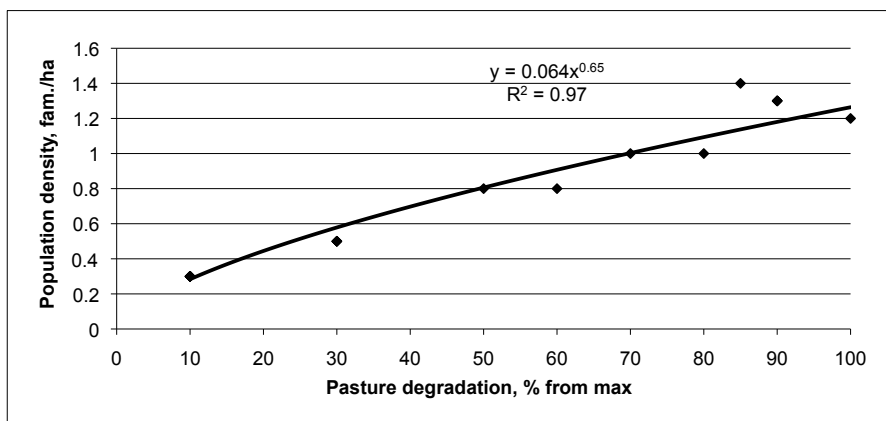


Fig. 4. — Relationship between density of the marmot population (fam./ha) and the degree of pasture degradation (in per cent from maximal degradation corresponding to the latest V stage described by RAMENSKY 1971). Data based on direct observations in the Regional Landscape Park, "The Veliki Burluk-steppe" from 1992 to 2008.

in the zones of extensive livestock husbandry (KIRIKOV 1966) which was similar to natural pastoralism.

Since the late XVIII century, the vast chernozem steppe has been exposed to anthropogenic transformation and converted to agricultural activity. To the mid of the XIX century the marmot settlements in Ukraine remained only in several places on the left bank of the Dnieper River (TCHER-

NAY 1853). Many authors consider two primary factors that depressed steppe marmot populations: ploughing of vast virgin steppes and unlimited hunting (FORMOZOV 1962, BIBIKOV 1989).

In the beginning of the XX century the insular settlements remained only on the left bank of the Severski Donets River. The steppes on the left bank of the Donets were hilly and richly intersected by rivers and gullies. The gullies could not be ploughed and they became the only potential habitats for the marmot.

At the beginning of the XX century the steppe marmot inhabited only the territories around the horse farms. This fact was known but ignored for a long time. We suppose that the dramatic increase of the occupied area and population numbers of the steppe marmot in the late 1950s was caused by the change in economic use of the area; specifically, by the increase of grazing pressure on marmot habitats. In the 1950s the government of the USSR carried out a policy of agricultural growth. The areas of ploughed lands and the number of livestock were increased significantly while the areas of hay-fields and pastures were reduced at the same time. Thus, the grazing pressure on the pasture areas (i.e. gullies) was greatly increased and the foraging base for the marmot radically improved, because the grazing provides during the entire active season a high accessibility to young parts of forage plants for the steppe marmot. Grazing makes practically the whole cover of the gullies suitable for foraging but especially the meadow vegetation on the wet places with chernozem soil. The relative abundance of favorable plants is here the best; vegetation period is the longest especially the leguminous plants with high protein content. Such plant communities are similar to alpine meadows and are suitable for all the species of *Marmota*. All species of marmots choose their food plants on the basis of relative abundance, phenology, nutritional quality, and rejection of plant with defensive compounds; e.g., yellow-bellied marmots, *M. flaviventris* (FRASE & ARMITAGE 1989). The general properties of the preferred plants are the following: they are species of seral communities, have a prolonged vegetative season, lack the chemical and mechanical protection from phytophagy, and have high ability to re-grow under any clipping. These species are some analogs of cultural green vegetables like salads, and it is the basis of the feeding strategy of the steppe marmot.

Today we are sure, that some herbivores (marmots, saiga antelopes, sousliks) are the secondary inhabitants of pastures and the satellites of large ungulates. Large ungulates are the historical creators of the whole ecosystem type named by ABATUROV (2006) the grazing ecosystem. Grazing pressure is that factor which determines the dynamics of the marmot population (Figs 1-2). The number of cattle is managed and grazing pressure may change at the will of people. The changing of marmot population follows the changing of grazing pressure (Fig. 3). Apparently, it is not an accidental coincidence.

At the same time that the number of cattle began to decrease and grazing pressure was becoming more variable (Fig. 3), in the same settlement all stages of pasture degradation occurred (Fig. 4).

The success of the marmot population is determined by the vegetation accompanying the late stage of pasture degradation. Requirements of herbivores, such as marmots, are met only with a high rate of green food intake (RONKIN & SAVCHENKO 2004). In spite of the fact that total aboveground phyto-

mass on pastures is less than in habitats without cattle grazing, a larger part of the phytomass is eaten. The greater the part of phytomass that is eaten, the greater is the rate of green food intake by marmots (RONKIN & SAVCHENKO 2000). An abundant regrowth of the plants grazed by cattle, long-lasting vegetation and specific flora on pastures provide a constantly high rate. Also on pastures there is no litter (the dead plant mass of the past years) which is responsible for the spring undernourishment of marmots (SEREDNEVA 1978).

Thus, the steppe marmot is a consumer of seral vegetation. It is a secondary user of the steppe pastures, thus the modern anthropogenic modification of natural pastoralism is the ecological factor that provides for the presence of *Marmota bobak* in modern steppe ecosystems.

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