Hacquetia 17/1 • 2018, 25–34 DOI: 10.1515/hacq-2017-0009

DE GRUYTER OPEN

Grazing, abandonment and frequent mowing influence the persistence of the steppe marmot, *Marmota bobak*

Galina Savchenko[1] & Vladimir Ronkin[1]

Keywords: fattening, growing season, regrowth, rodent, water content.

Ključne besede: debeljenje, rastna sezona, ponovna rast, glodalci, vsebnost vlage.

Abstract

The goals of the study were to illustrate how parameters of steppe marmot settlements change after abandonment of livestock grazing, to evaluate differences in vegetation characteristics between grazed and abandoned habitats, to find the links between these characteristics and the persistence of marmot settlements and to establish whether it is possible to maintain the food base of marmots by applying frequently repeated mowing. Data were collected in 1991–2016 in the steppe marmot (*Marmota bobak*) settlement in the Regional Landscape Park "The Velykyi Burluk-Steppe" (Kharkiv Region, Northeastern Ukraine). We found that grazing prolongs the period of active plant growth and supports a regrowth during periods of intensive feeding of all age groups of marmots. In abandoned habitats the vegetation period ended before the end of active feeding of reproductive females and juveniles. This resulted in lower reproductive success, which determines a decrease in the population and may in the future result in a larger decline of settlements. Frequently repeated mowing by a lawnmower at a cutting height of 6–9 cm prolongs the vegetation period and maintains a water content in the plants similar to that of grazed habitats throughout the active season of steppe marmots.

Izvleček

Cilj raziskave je bil ponazoriti kako se dejavniki naselbine/kolonije stepskega svizca spremenijo po opustitvi paše, ovrednotiti razlike v lastnostih vegetacije med pašenimi in opuščenimi habitati, najti povezavo med temi lastnostmi in obstojnostjo naselbin/kolonij stepskega svizca in ugotoviti ali je moč ohranjati osnovno hrano za svizce z pogosto košnjo. Podatke smo zbrali med letoma 1991 in 2016 v naselbini/koloniji stepskega svizca (*Marmota bobak*) v Regionalnem parku "Stepa Velykyi Burluk" (regija Kharkiv, severovzhodna Ukrajina). Ugotovili smo, da paša podaljša aktivno rast rastlin in omogoča ponovno rast v obdobju hranjenja svizcev vseh starostnih skupin. Na opuščenih habitatih se vegetacijska doba zaključi pred obdobjem hranjenja plodnih samic in mladičev. To se odrazi v zmanjšanem reproduktivnem uspehu in zmanjšanju populacije ter v prihodnosti tudi v večjem zmanjšanju števila naselbin/kolonij. Pogosta košnja s kosilnico na višini 6–9 cm podaljša vegetacijsko dobo in ohranja vsebost vlage v rastlinah, podobno kot paša stepskih svizcev med aktivno sezono.

Received: 20. 2. 2017
Revision received: 30. 6. 2017
Accepted: 12. 10. 2017

Co-ordinating Editor:
Orsolya Valkó

1 Department of Zoology and Ecology, V.N.Karazin Kharkiv National University, Svobody sq. 4, Kharkiv, 61022, Ukraine; E-mail: savchgala5@gmail.com.

Introduction

Livestock grazing is considered to have an important anthropogenic impact on grassland ecosystems with a variety of effects (Dengler et al. 2014). In order to mitigate the negative effects of overgrazing, which remains a problem for many countries, sustainable pasture management strategies are proposed to be implemented (Baranova et al. 2016). Finding the best grazing practice is proposed as a solution for many problems of Palearctic grasslands, such as maintaining the optimal level of biodiversity, suppression of weed growth (Török et al. 2014, 2016) and support of steppe-like vegetation and arthropod assemblages (Polchaninova et al. 2016). Abandonment of grazing has been an object of studies as well. It was shown that pasture abandonment leads to an increase in vegetation height and in the richness of mesophytes, plants with leafy canopy and red-list species, whereas grazed plots are often characterised by higher total species richness and more xerophytes, rosette forming and spring-flowering species (Vassilev et al. 2011).

Conservation management strategies for grasslands should be based on the knowledge of local ecological specifics of these sensitive systems (Valkó et al. 2016). The results of various studies of maximum number of their components including herbivores and granivores mammals should be taken into account as well. Previous studies reported that intensive grazing negatively affects the abundance and diversity of small mammals (Yarnell et al. 2007). Effects of management actions on grassland mammals may be mediated by vegetation height (Mérő et al. 2015), quality of available food (Abaturov 2006) and proportion of food plants in the total aboveground phytomass (Ronkin & Savchenko 2000).

Grazing in the grasslands of Northeastern Ukraine may be completely abandoned in the nearest future due to significant changes in livestock farming. One of the endangered open landscape rodents, the steppe marmot (*Marmota bobak*), is a secondary user of these grazed grasslands (Ronkin et al. 2009). Similar to the Alpine marmot (Arnold 1990, Perrin et al. 1993, Lenti Boero 1996, 2001), all individuals of a family of steppe marmots hibernate together in the same winter burrow. During vegetation season marmots must obtain the required amount of food for reproduction, growth and fat storage for hibernation (Frase & Armitage 1989, Bibikov 1989, Melcher et al. 1989, Mashkin 1997). These rodents consume a large number of plant species (Chovankova & Soltesova 1988, Bassano et al. 1996, Herrero et al. 2002), but they do not feed in proportion to the species abundance in the environment; instead, a few food species may fulfil a large part of their nutritional needs (Massemin et al. 1996, Ronkin & Savchenko 2004).

The goals of the study were: a) to illustrate how parameters of the marmot settlements change after abandonment of cattle grazing, b) to evaluate differences in vegetation characteristics of grazed and abandoned habitats that are important for the marmots' food base, c) to find the links between the habitat characteristics and the persistence of marmot settlements and d) to establish whether it is possible to maintain characteristics of the vegetation similar to grazed habitats by applying frequently repeated mowing.

Materials and methods

The study was conducted in 1991–2016 in the steppe marmot settlement in the Regional Landscape Park "The Velykyi Burluk-Steppe" (Kharkiv Region, Northeastern Ukraine). In this part of the Kharkiv Region, the mean annual rainfall is about 540 mm with a peak in June (63 mm), and the mean annual temperature is 7.0 °C, with July and August temperatures often exceeding 36 °C. In January the mean temperature ranges from –6.8 °C to –8.5 °C, with a minimum temperature of –35 °C.

The permanent observation plot was located near the village of Nesterivka (49° 55' 19" N; 37° 18' 46" E). The studied area of the marmot habitats is about 85 ha in size. The land use history, relief, common management practices, flora and vegetation of this permanent study area were described in detail in a previous publication (Ronkin & Savchenko 2016).

Sampling methods

The number of marmot families and the density of the marmot population were estimated by counting the winter burrows of a given territory. For the mapping of inhabited and uninhabited winter burrows, a handheld Global Positioning System device (Garmin Oregon 600 Series) and the program QGIS v.2.18.8 were used.

Observations were made in activity hours of marmots (in spring and autumn during the day, in summer in the morning and/or evening); the fieldwork lasted no less than 100 hours per year. The following parameters were recorded: habitability of a winter burrow, number of family members, phase of active season of marmots (emerging from hibernation, beginning and end of active feeding, juveniles' first appearance above the ground).

The number of marmots in the family was counted with binoculars and spotting scopes when the animals were feeding freely. Individuals were counted and grouped into the following three categories: adult males + non-reproductive females, reproductive females (females having offspring in the current year) and juveniles. Whether an

observed animal belonged to a particular family was determined by its position. This approach was chosen since steppe marmot family members use a certain territory that does not overlap with home ranges of other families. The size of their home range varies in different habitats from about 0.6 to near 2.5 ha (Mashkin 1997). At least one winter burrow, foraging areas and refuges are the obligatory elements of their home range. This spatial structure of the settlement has been determined in previous studies on tagged marmots (Nikol'skii & Savchenko 1999). Because the positions of the obligatory elements of a home range do not change for years and borders of families are stable (Mashkin 1997), the family membership of an observed animal may be distinguished on the basis of its position.

Observations of marmot behavior and appearance helped to determine the beginning and the end of certain phases of the marmots' active season. In this research we were interested in the periods of active feeding (fattening period). The predominance of feeding activity marks the start of the fattening period, and completion of shedding and accomplishment of fatness marks its end (Bibikov 1989, Mashkin 1997).

Vegetation characteristics and management regimes

The grasslands of Northeastern Ukraine were formed by livestock grazing (mainly cattle and sheep). In the 1990s maximal grazing pressure was 4–5 cows/ha. Because "The Velykyi Burluk-Steppe" is a gully net (Figure 1), the vegetation of the marmot habitats is characterised by communities of both the forb-fescue-feather grass steppe (mainly

Figure 1: Gully relief of the Regional Landscape Park "The Velykyi Burluk-Steppe" (A), heavily grazed habitat of *Marmota bobak* (1996) (B) and habitat after abandonment (C). Photos: Vladimir Ronkin.
Slika 1: Razgiban jarkast relief v regionalnem krajinskem parku "Stepa Velykyi Burluk" (A), močno popašen habitat vrste *Marmota bobak* (1996) (B) in habitat po opustitvi gospodarjenja (C). Fotografije: Vladimir Ronkin.

Festuca valesiaca agg. and forbs) and steppe meadows (mainly *Poa angustifolia* and forbs) (see also Ronkin & Savchenko 2016). Further in the text, these communities are referred to as steppe and steppe meadow, respectively.

The following characteristics of the habitats were recorded between 2009 and 2016: presence or absence of cattle grazing, its intensity, height of the basic grass layer and phase of vegetation (active growth, maturing of grasses, vegetative rest, senescence).

To evaluate fluctuations in the water content of the vegetation in foraging areas of different habitats (grazed and abandoned steppes and steppe meadows), vegetation samples were collected twelve times during the seasons of marmot activity in 2012/2013 (between mid-April and mid-October). The vegetation was clipped at a height of about 6 cm and immediately weighed, then dried to a constant weight and weighed again. We used a lawnmower for a mass collection of the vegetation samples and recommend it as a very useful tool for collecting such samples.

Experiments on frequently repeated mowing of the vegetation of the habitats after abandonment were carried out in 2014/2015. Two areas of 0.01 ha each (a steppe and a steppe meadow) were mown by a lawn mower at a height of 6 cm during the growing season. A grass area of 2 m^2 was mown to determine the productivity. The frequency of mowing – 20 times in 2014 and 15 times in 2015 – was conditioned by the regrowth of the basic level of the grass up to 8–9 cm. With this very frequent mowing, we wanted to model the effects of heavy grazing. The water content was determined in each sample.

Statistical analysis

The average number of individuals of three groups (adult males + non-reproductive females, reproductive females and juveniles) in a marmot family was estimated on annual basis between 2005 and 2013 and used in a factorial ANOVA. As factors, two parameters of the settlement were included: factor "habitat" with two levels (steppe or steppe meadow), factor "management" with two levels (grazing or abandonment) and their combination (habitat × management). Since the average number of reproductive females and juveniles on the sites after abandonment differed significantly from normal distribution ($P < 0.05$, Shapiro-Wilk and Kolmogorov-Smirnov normality tests), the U-test (Mann-Whitney) was additionally applied. In order to estimate differences in reproduction success on the sites, only juveniles that subsequently survived the first hibernation were considered in the tests. This approach, i.e. focusing on the number of marmots that survived at least one hibernation, is also used by other marmot specialists, for example when analysing group size (Blumstein & Foggin 1997).

The combination of habitat and management allowed us to distinguish four sites ("grazed steppe", "grazed steppe meadow", "steppe after abandonment" and "steppe meadow after abandonment"); these names are used further in the text. The Mann-Whitney test was used in the water content analysis (where "habitat", "management" and "year" were included as factors). For each site, the durations of the growing season in 2009–2016 were analysed using Kruskal-Wallis ANOVA by ranks, and the end dates of the fattening period of different marmot groups together with the dates of the onset of vegetation rest were analysed using one-way ANOVA (the variables were tested for normality).

Statistical significance was set at $P < 0.05$. The Least Significant Difference (LSD) criterion was used for means comparison relating to phases (periods) in plants and marmots. All calculations were performed in the program StatSoft Statistica v6.0.

Results

Characteristics of the marmot settlement

In 1991, 51 marmot families were registered in the settlement under study. At that time all marmot habitats were heavily grazed by cattle. The grazed area began to decrease in 1992, and by 2014, only 10 marmot families stayed in the ungrazed part of the settlement, which was 36% of the families compared to 1992. The population density decreased from 1.2 to 0.4 families/ha on the site "steppe meadow after abandonment" and from 0.8 to 0.2 families/ha on the "steppe after abandonment". In contrast, the number of families within the zone of intensive grazing remained on the same level as it was in 1992 (23 families) (Figure 2).

We found that only one factor – "management" – had a statistically significant influence on the number of individuals in a marmot family (factorial ANOVA, $F = 16.9$, $df = 3, 30$, $P < 0.001$) (Figure 3). The average number of individuals was lower in both habitats "after abandonment" for all the groups of marmots, especially for reproductive females ($U = 36.0$, $n_1 = n_2 = 18$, $P < 0.0001$) and juveniles ($U = 21.0$, $n_1 = n_2 = 18$, $P < 0.0001$). On the site "steppe after abandonment", an appearance of juveniles was registered only once during 2005–2013, but no young animals emerged after the first hibernation. On the site "steppe meadow after abandonment", an appearance of offspring was observed three times. The total number of juveniles was ten, and only four of them emerged after the first hibernation.

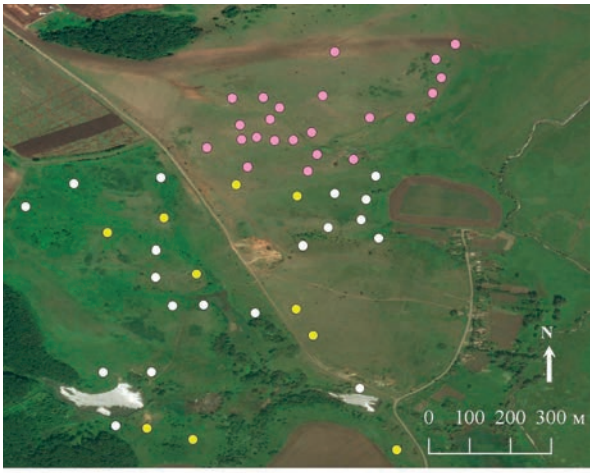

Figure 2: Location of marmot families in grazed and abandoned parts of the settlement in the Regional Landscape Park "The Velykyi Burluk-Steppe" near the village of Nesterivka (2014).

Slika 2: Lokacije kolonij svizcev v pašenem in opuščenem delu naselbine v regionalnem krajinskem parku "Stepa Velykyi Burluk" pri vasi Nesterivka (2014).

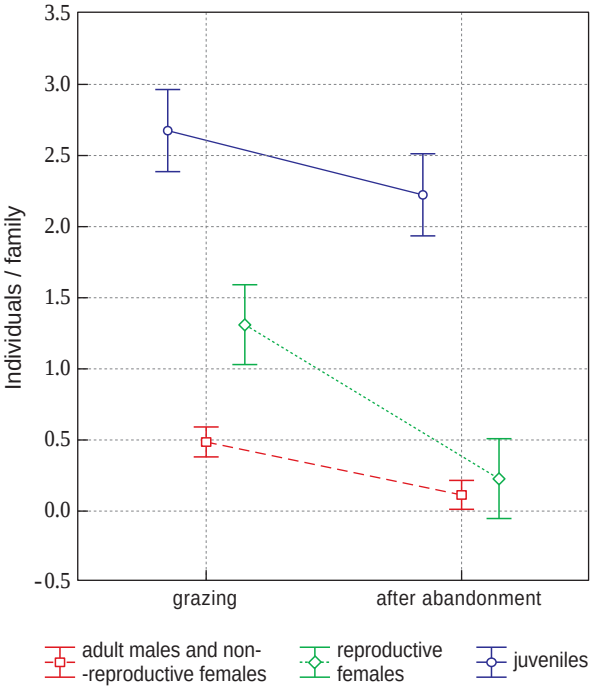

Figure 3: Mean number of individuals in a marmot family on grazed and abandoned sites (factorial ANOVA, F = 16.91, df = 3, 30, P <0.001).

Slika 3: Povprečno število osebkov v družinski skupnosti svizcev na pašenih in opuščenih habitatih (faktorska analiza variance ANOVA, F = 16,91, df = 3, 30, P <0,001).

Vegetation characteristics and management actions

The highest grass was registered in the "steppe meadow after abandonment". The basic level was at its highest from mid-June to late July (mean±SD: 64.6±7.4 cm) (Figure 4). In the "steppe after abandonment", the same characteristic gained its maximum from the middle of May to the end of June (mean 23.7±4.5 cm). On the grazed areas, the height was 4–7 cm during the whole grazing season (from early May to late September/early October).

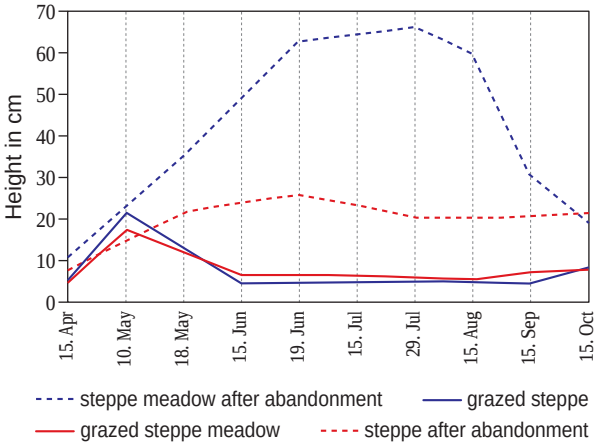

Figure 4: Height of the basic grass layer on different sites (mean of averages for the years 2012–2015).

Slika 4: Višina osnovne travniške plasti na različnih rastiščih (povprečja za leta 2012–2015).

Fluctuations of water content in the vegetation in the communities showed similar trends in 2012 and 2013 (Figure 5). The vegetation of the "grazed steppe meadow" was not only the wettest (with a mean water content of 72.3±4.4% in 2012 and 73.4±2.9% in 2013), but also that with the smallest fluctuations throughout the growing season. The vegetation of the "steppe after abandonment" showed the opposite characteristics (with a mean water content of 45.3±19.2% and 39.7±18.6%, respectively). The water content was statistically significantly dependent on "management" ($U = 88.7$, $n_1 = n_2 = 44$, $P < 0.001$). The effects of "habitat" ($U = 784.5$, $n_1 = n_2 = 44$, $P = 0.13$),"year" ($U = 862.5$, $n_1 = n_2 = 44$, $P = 0.38$) and all interactions of the factors were not statistically significant.

On the sites where frequently repeated mowing was conducted, the grass was kept at a height of 6–9 cm during the whole growing season. In May of both years (Figure 6), the regrowth in the steppe was larger than in the steppe meadow, especially in 2015, when the weather was unusually warm and rainy. The total regrowth for the en-

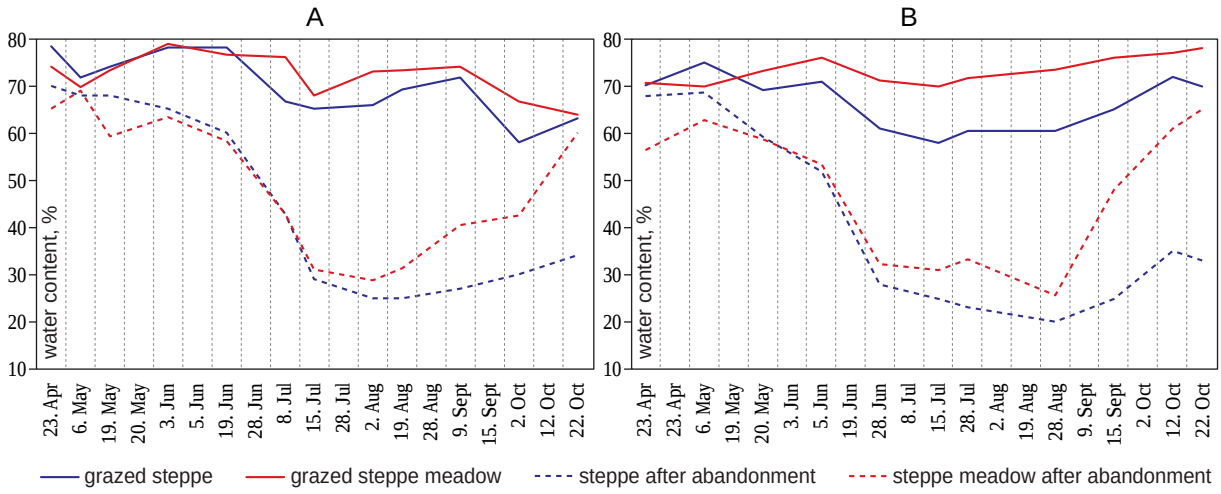

Figure 5: Water content of plant biomass during the growing seasons of 2012 (A) and 2013 (B) in the grazed and abandoned communities.
Slika 5: Vsebnost vode v rastlinski biomasi med rastno sezono 2012 (A) in 2013 (B) v pašenih in opuščenih združbah.

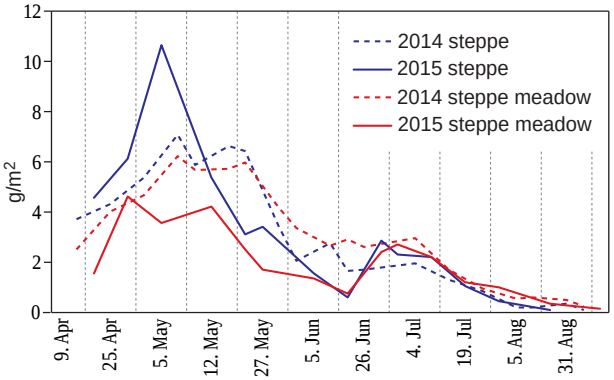

Figure 6: Daily plant regrowth during the growing seasons of 2014 and 2015 in the communities with frequently repeated mowing.
Slika 6: Dnevni prirastek med rastnima sezonama 2014 in 2015 v združbah s pogosto košnjo.

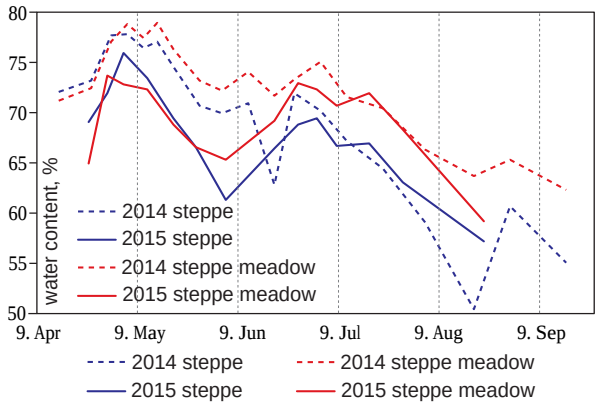

Figure 7: Water content of the plant biomass during the growing seasons of 2014 and 2015 in the communities with frequently repeated mowing.
Slika 7: Vsebnost vode v rastlinski biomasi med rastnima sezonama 2014 in 2015 v združbah s pogosto košnjo.

tire growing season in 2014 amounted to 397.13 g/m^2 for the steppe meadow and 355.2 g/m^2 for the steppe (dry weight); in 2015, the figures were 227.05 and 305.5 g m^2, respectively. As for the average daily growth (Figure 6), both communities had similar figures (except in May 2015) and similar fluctuations during the growing season.

The water content on the mown sites (Figure 7) was similar to that of the grazed ones (Figure 5). Almost throughout the season, except the first half of May, the water content was slightly higher in the steppe meadow: on the grazed sites, the mean values in 2012/2013 were 72.8±3.7 vs. 68.4±6.3%; on the mown sites in 2014/2015, they were 70.6±5.1 vs. 68.1±6.9%.

We recorded that the duration of the growing season in 2009–2016 ranged from 189 to 231 days. The longest period of active plant growth was registered at the site "grazed steppe meadow" and the shortest at the "steppe after abandonment" (219±14 vs. 101±9 days, n=8). The growing season on the sites "grazed steppe" and "steppe meadow after abandonment" was usually interrupted by a drought in the second half of the summer (Figure 8); this happened seven times between 2009 and 2016. The completion of the growing season on the sites where frequent mowing was conducted occurred at approximately the same time as in the respective grazed communities.

Growing season and fattening period of marmots

As shown in Figure 8, the period of intensive feeding of animals started after the onset of the growing season; it was shortest for adult males and non-reproductive fe-

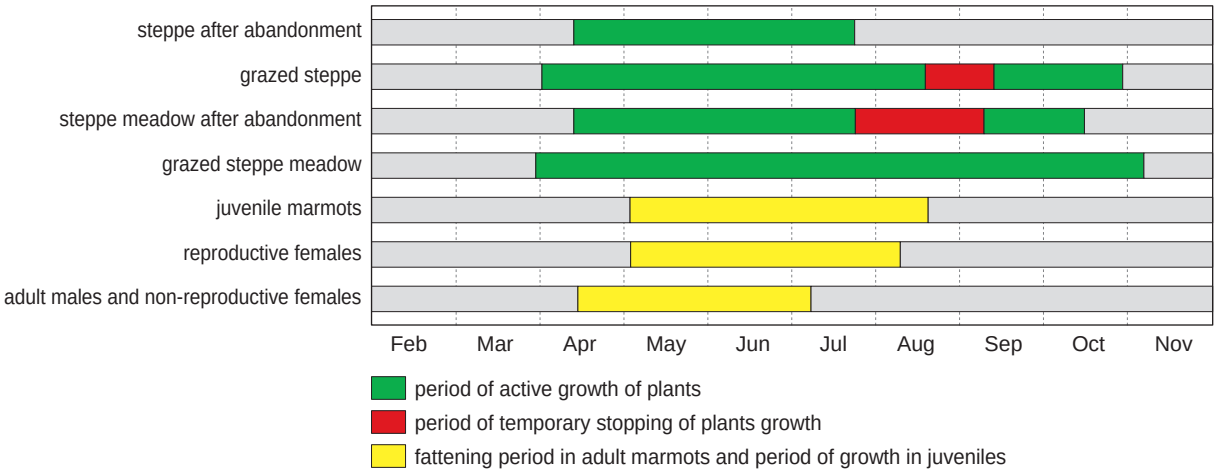

Figure 8: Mean terms and lengths (2009–2016) of the fattening period of marmots with different reproductive status and age in comparison with the growing season (from start of active growth to senescence of vegetation) in the grazed and abandoned habitats.
Slika 8: Povprečen začetek in trajanje obdobja (2009-2016) debeljenja svizcev z različnim reproduktivnim statusom in starostjo v primerjavi z rastno sezono vegetacije (od začetka do prenehanja rasti vegetacije) na pašenih in opuščenih habitatih.

males and longest for juveniles. Besides, adult males and non-reproductive females began the intensive feeding earlier than reproductive females and juveniles (the difference was 20±7 days).

The average duration of the period of active plant growth differed significantly between all the sites (Kruskal-Wallis test, H = 25.5, df = 3, P < 0.001). The differences in the average end dates of the active feeding period of different marmot groups as well as in the onset of the vegetation rest at the different sites were also statistically significant (one-way ANOVA, F = 80.9, df = 6, 49, P < 0.001). The "grazed steppe meadow" was characterised by the longest period of active plant growth, which covered the periods of intensive feeding of three groups of marmots ($LSD_{0.05}$ = 12.45, P < 0.001). In both communities "after abandonment", such covering did neither occur for reproductive females nor for juveniles ($LSD_{0.05}$ = 12.45, P < 0.01). In the "grazed steppe", the covering was recorded six times in eight years for reproductive females and four times for juveniles.

Discussion

According to estimates of marmot specialists, the aboveground phytomass in habitats of these rodents ranges from about 22 g/m^2 (in case of golden marmots, Blumstein & Foggin 1997) to about 800 g/m^2 (in case of yellow-bellied marmots, Frase & Armitage 1989). It was shown that in poor habitats (average total aboveground productivity from 21.9 g/m^2 to 51.1 g/m^2) of high alpine meadows, the probability of weaning juveniles was associated with the overall food ability of the previous year, and there was a significant positive relationship between the early season food resources and the proportion of years in which a group reproduced (Blumstein & Foggin 1997). The estimated amounts of total regrowth obtained by us for the entire growing season ranges between 200 g/m^2 and 400 g/m^2. The maximum and minimum values of the average daily regrowth in the studied communities as well as the difference in dynamics between 2014 and 2015 may be explained by differences in weather conditions. Obviously, the mass of food in the steppe marmot habitats is enough to meet the needs of the animals as it is considered by other authors (Mashkin 1997). In this research we focus not so much on the total mass of food, but on its quality, which may be expressed by water content. It was observed in experiments (Ronkin & Tokarsky 1993) that marmots selected younger and thus juicier parts of plants with water content of no less than 70%. If converted to a dry weight of the food, the animals selected parts, which contained more protein (16.0 vs. 9.2%), nitrogen-free extract (NFE) (56 vs. 46%), and energy (1586.4 vs. 1418.1 kJ/100 g) than the rejected parts. Considering the dynamics of the water content, the "grazed steppe meadow" is the most favourable. In contrast, the water content in the vegetation on both sites "after abandonment" decreases rapidly, i.e., the vegetation ages, and its nutritional quality drops.

The degree of correspondence between the growing season of food species and the fattening period of marmots with different reproductive status and age essentially affects reproduction in marmots (Bibikov 1989). It was found that precipitation, length of growing season and

length of winter were the major factors affecting reproduction and survival of yellow-bellied marmots in the Upper East River Valley, Colorado (USA) (Schwartz & Armitage 2002, Armitage 2013). On a basis of energy allocation by yellow-bellied marmots, Melcher et al. (1989) showed that a necessary minimum fat deposit was crucial for the survival of juveniles during hibernation and that the total energy demand was highest for reproductive females. In our study a longer growing season in grazed habitats provided periods of foraging activity for juveniles and reproductive females that allowed them to continue foraging when vegetation in abandoned habitats was already unsuitable as food. The "steppe after abandonment" becomes mature in June, and their growing season corresponds to the fattening period of adult males and non-reproductive females only. The "steppe meadow after abandonment" has a longer growing season, but the vegetation period is interrupted in the summer. To survive the first hibernation, juveniles need a longer and uninterrupted growing season. Cattle grazing prolongs the growing season, which is extremely beneficial for the survival of juveniles.

In general, grazing affects other characteristics of the food base, too. First of all, it has an impact on the species composition. Forbs, which are common in heavily grazed areas, are the basic food species for marmots, i.e. the plants eaten by these rodents during all the active season (Ronkin & Savchenko 2000). Another important characteristic is the ratio between the palatable and the non-palatable part of the vegetation. A simultaneous increase in grass height and decrease in water content means a decrease in the proportion of palatable vegetation on the sites "after abandonment". In this case marmots experience a food deficiency starting in mid-June, i.e. before the end of the growing season.

Probably, this lack of food is the main cause of a decline in the number of reproductive females and an even more drastic decrease in the number of surviving juveniles. Due to the relatively long lifespan of steppe marmots, the process of settlement depletion after abandonment of grazing is relatively slow. In addition, this process is slowed down by migration (as a result of the lack of free home ranges) of marmots from favorable parts of the settlement. Even though, the abandonment of grazing in the entire territory of a settlement will inevitably lead to a complete depopulation of those settlements in 5–7 years. This term is determined by the fact that the proportion of reproductive females declines to 5% as they reach the age of 5 years (Mashkin 1997).

The most successful part of the settlement occupies heavily grazed habitats with mainly mesic non-senescent vegetation of low height, which has a prolonged vegetation season and constant regrowth as well as an abundance of food species. The "grazed steppe" does not support the completion of the fattening in reproductive females and juveniles every year: Two times in eight years, the second half of both the growth period of juveniles and the fattening of reproductive females were interrupted by a temporary interruption of plant growth. However, in grazed part of the settlement, most of the marmots' home ranges include both communities. On the one hand, this provides the fattening of all the groups of marmots, and on the other hand, it explains the prevailing influence of the "management" factor on the number of individuals in marmot families. Like grazing, frequently repeated mowing reduces the height of the grass, promotes regrowth and prolongs the active growing season. The duration of the growing season is similar to that of grazed sites and covers the fattening periods of all groups of marmots.

Obviously, on a larger scale (of a whole settlement or population), only grazing can maintain vegetation characteristics necessary for the reproduction of steppe marmot populations. However, frequently repeated mowing can serve as a substitute for intensive grazing at a smaller scale comprising at least the most favorable parts of a settlement. Taking into account the tendencies in the development of livestock farming, it is easier to realise such a frequent mowing than to reintroduce the former grazing regimes. The use of this practice allows maintaining the vegetation characteristics necessary for the steppe marmot reproduction. The patchy pattern of mowing will not only support the marmots' nutritional needs, but also take into account the requirements of other grassland dwellers, which are reported to respond negatively to mowing (Polchaninova 2004, Cizek et al. 2012, Mazalová et al. 2015). This approach supports the idea of zoning practice (Vassilev et al. 2011) and promotes the application of a practice that is heterogeneous in space and time (Török et al. 2016).

Conclusions

Grazing prolongs the period of active plant growth and supports a regrowth during periods of intensive feeding of all the age groups of marmots. Abandonment of grazing negatively influences the persistence of the steppe marmot settlements. In abandoned habitats, the vegetation period ends before the end of the active feeding of reproductive females and juveniles. This is the cause of reduction in reproductive success, which determines the decrease of the population density and may result in a complete depopulation of settlements in the future. At a larger scale, only grazing can maintain vegetation characteristics necessary for the reproduction of steppe marmot populations.

However, frequenty repeated mowing with a lawnmower at a cutting height of 6–9 cm prolongs the vegetation period and maintains a water content in the plants similar to that of grazed habitats throughout the active season of steppe marmots. We recommend this practice to save the marmots' food base in the most favorable parts of marmot settlements. In general, considering not only the needs of marmots, but also other species of flora and fauna, we suggest that spatially and temporally heterogeneous (patchy) management practices may be useful.

Acknowledgments

The authors would like to thank Orsolya Valkó as the Co-ordinating Editor. The authors are grateful to two anonymous reviewers and Orsolya Valkó for the editing the manuscript and for the recommendations, comments and improvements of former drafts of the paper. We also thank the family of Alex Zalyvadniy (Vancouver, Canada) for the improvement of the English text. We would like to express our sincere gratitude to Dr. Aiko Huckauf for the professional linguistic editing, and the Eurasian Dry Grassland Group (EDGG) for possibility to publish this paper.

References

Abaturov, B. D. 2006: Pastbishchniy tip funktsionirovaniya stepnykh i pustynnykh ekosistem (Grazing type of functioning of steppe and desert ecosystems). Ouspekhi Sovremennoy Biologii 126(5): 435–447. [In Russian].

Armitage, K. B. 2013: Climate change and the conservation of marmots. Natural Science 5(5A): 36–43.

Arnold, W. 1990: The evolution of marmot sociality: I. Why disperse late? II. Costs and benefits of joint hibernation. Behavioral Ecology and Sociobiology 27: 229–246.

Baranova, A., Schickhoff, U., Wang, S. & Jin, M. 2016: Mountain pastures of Qilian Shan: plant communities, grazing impact and degradation status (Gansu province, NW China). Hacquetia 15(2): 21–36.

Bassano, B., Peracino, V., Pecacino, V. & Montacchini, F. 1996: Diet composition and feeding habitats in a family group of alpine marmot (*Marmota marmota*) – preliminary data. In: Le Berre, M., Ramousse, R. & Le Guelte, L. (eds.): Biodiversity in Marmots. International marmot Network, Moscow, Lyon, pp. 135–140.

Bibikov, D. I. 1989: Surki (The Marmots). Agroprom Press, Moscow, 255 pp. [In Russian].

Blumstein, D. T. & Foggin, J. M. 1997: Effect of vegetative variation on weaning success, overwinter survival, and social group density in golden marmots (*Marmota caudata aurea*). Journal of Zoology, London 243: 57–69.

Chovankova, B. & Soltesova, A. 1988: Trophic base and nutritional activity of the alpine marmot (*Marmota marmota latirostris* Kratochvil, 1961). Zbornic prac o TANAP-e 28: 71–135.

Cizek, O., Zamecnik, J., Tropek, R., Kocarek, P., & Konvicka, M. 2012: Diversification of mowing regime increases arthropods diversity in species-poor cultural hay meadows. Journal of Insect Conservation 16(2): 215–226.

Dengler, J., Janišová, M., Török, P. & Wellstein, C. 2014: Biodiversity of Palaearctic grasslands: a synthesis. Agriculture, Ecosystems & Environment 182: 1–14.

Frase, B. A. & Armitage, K. B. 1989: Yellow-bellied marmots are generalist herbivores. Ethology Ecology & Evolution 1: 353–366.

Herrero, J., Garsia-Gonzalez, R. & Garcia-Serrano, A. 2002: Research on the alpine marmot (*Marmota marmota*) in the Spanish Pyrenees. In: Armitage, K.B. & Rumiantsev, V. Yu. (eds.): Holarctic marmots as a factor of biodiversity. ABF P. H., Moscow, pp. 190–197.

Lenti Boero, D. 1996: Space and resource use in Alpine marmots (*Marmota marmota* L.). In: Le Berre, M., Ramousse, R. & Le Guelte, L. (eds.): Biodiversity in Marmots. International Marmot Network, Moscow, Lyon, pp. 175–180.

Lenti Boero, D. 2001: Occupation of hibernacula, seasonal activity, and body size in a high altitude colony of Alpine marmots (*Marmota marmota*). Ethology Ecology & Evolution 13: 209–223.

Mashkin, V. I. 1997: Yevropeyskiy baybak: ekologiya, sokhraneniye i ispol'zovaniye (The European bobak: Ecology, Conservation and Use). Kirov Regional Press, Kirov, 160 pp. [In Russian].

Massemin, S., Gibault, C., Ramousse, R. & Butet, A. 1996: First data on the alpine marmot (*Marmota marmota*) diet. Mammalia 60(3): 351–361.

Mazalová, M., Šipoš, J., Rada, S., Kašák, J., Šarapatka, B., & Kuras, T. 2015: Responses of grassland arthropods to various biodiversity-friendly management practices: Is there a compromise? European Journal of Entomology 112(4): 734–746.

Melcher, J. C., Armitage, K. B. & Porter, W. P. 1989: Energy allocation by yellow-bellied marmots. Physiological Zoology 62: 429–448.

Mérő, T. O., Bocz, R., Polyák, L., Horváth, G. & Lengyel, S. 2015: Local habitat management and landscape-scale restoration influence small-mammal communities in grasslands. Animal Conservation 18: 442–450.

Nikol`skii, A. A. & Savchenko, G. A. 1999: Structure of family groups and space use by steppe marmots (*Marmota bobac*): preliminary results. Vestnik Zoologii 33(3): 67–72.

Perrin, C., Allainé, D. & Le Berre, M. 1993: Socio-spatial organization and activity distribution of the alpine marmot *Marmota marmota*: preliminary results. Ethology 93: 21–30.

Polchaninova, N. Yu. 2004: Effect of hay-mowing on spider communities of the meadow steppes of the Central forest-steppe (Russia and Ukraine). Arthropoda Selecta. Special Issue No1 (Proceedings of the 21st European Colloquium of Arachnology, St.-Petersburg, 4-9 August 2003): 261–273.

Polchaninova, N., Savchenko, G., Drogvalenko, A., Ronkin, V. & Shabanov, D. 2016: The impact of cattle grazing on cursorial spiders (Aranei) and true bugs (Heteroptera) in steppe gullies of northeastern Ukraine. Agriculture, Ecosystems & Environment 234: 65–71.

Ronkin, V. I. & Savchenko, G. A. 2000: Adaptability of habitats for *Marmota bobak* (*Rodentia, Sciuridae*) related to plant cover structure. Zoologicheskii Zhurnal 79(10): 1229–1234. [In Russian].

Ronkin, V. I. & Savchenko, G. A. 2004: Effect of cattle grazing on habitats for the steppe marmot (*Marmota bobak*) in north-eastern Ukraine. Vestnik Zoologii 38(1): 55–60.

Ronkin, V. & Savchenko, G. 2016: Flora and vegetation of dry grasslands of Northeastern Ukraine, and problems of diversity conservation. Hacquetia 15(2): 49–62.

Ronkin, V., Savchenko, G. & Tokarsky, V. 2009: The place of the steppe marmot in steppe ecosystems of Ukraine: An historical approach. Ethology Ecology & Evolution 21: 277–284.

Ronkin, V. I. & Tokarsky, V. A. 1993: Qualitative and quantitative assessment of feeding habits of bobak, *Marmota bobak*, and long-tailed marmot, *M. caudata* (*Rodentia*, *Sciuridae*) in captivity. Zoologicheskii Zhurnal. 72(2): 93–100. [In Russian].

Schwartz, O. A. & Armitage, K. B. 2002: Correlations between weather factors and life-history traits of yellow-bellied marmots. In: Armitage, K. B. & Rumiantsev, V. Yu. (eds.): Holarctic marmots as a factor of biodiversity. ABF P. H., Moscow, pp. 345–357.

Török, P., Valkó, O., Deák, B., Kelemen, A. & Tóthmérész, B. 2014: Traditional cattle grazing in a mosaic alkali landscape: Effects on grassland biodiversity along a moisture gradient. PLoS ONE 9 (5): e97095.

Török, P., Valkó, O., Deák, B., Kelemen, A., Tóth, E. & Tóthmérész, B. 2016: Managing for species composition or diversity? Pastoral and free grazing systems in alkali steppes. Agriculture, Ecosystems & Environment 234: 23–30.

Valkó, O., Zmihorski, M., Biurrun, I., Loos, J., Labadessa, R. & Venn, S. 2016: Ecology and Conservation of Steppes and Semi-natural Grasslands. Hacquetia 15(2): 5–14.

Vassilev, K., Pedashenko, H., Nikolov, S. C., Apostolova, I. & Dengler, J. 2011: Effect of land abandonment on the vegetation of upland semi-natural grasslands in the Western Balkan Mts., Bulgaria. Plant Biosystems 145: 654–665.

Yarnell, R. W., Scott, D. M., Chimimba C. T. & Metcalfe, D. J. 2007: Untangling the roles of fire, grazing and rainfall on small mammal communities in grassland ecosystems. Oecologia 154: 387–402.