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Spatial Pattern and Age Range of Cenopopulations *Medicago* L. in the Conditions of Gullying of the Southern Part of the Central Russian Upland.

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ABSTRACT

The study deals with the spatial pattern and the age range of cenopopulations *Medicago* L. in the conditions of gullying of the southern part of the Central Russian Upland. Landscape-climatic conditions of habitats (ecotops) of gully landscapes without crops of chalk form the conditions for introduction of new synanthropic species, such as species of the genus *Medicago*. There are species of all ages in the most part of the cenopopulations alfalfa, revealed in these conditions; also they have continuous nature of distribution of species according to the age groups that can indicate the stability of their adaptive micro evolutionary changes. Adaptive processes shown up in local cenopopulations alfalfa are aimed at preserving species with morphological, biochemical and other properties similar to those possessed by calciphile endemic vegetation. There is a formation of a certain "carbonate" ecotype of cenopopulations, close to cultural forms in a number of morphological features, which has a pronounced type of competitive stress-tolerant adaptive strategy. In this regard, the observed adaptive micro-evolutionary processes in phytocenosis on calcareous soils allow us to consider the cretaceous south of the Central Russian Upland as a secondary anthropogenic microcenter of shaping *M. varia* Mart. It is possible in practice to make an effective selection of legume species for creation of highly competitive and environmentally sustainable cenopopulations on calcareous soils.

Keywords: alfalfa (*Medicago varia* Mart.), secondary (anthropogenic) microcenter, *mf*-mutation, cenopopulations, age range, spatial pattern, calcareous soils, gullying, gully landscapes

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INTRODUCTION

There are important integrated features which allow evaluating the adaptive hereditary capacity and competitiveness of cenopopulations in conjunction with the environmental conditions [1-3]. Such features are their age range and spatial pattern. Ontogenetic diversity of populations resulting from long-term observations reflects the dynamic processes occurring in the system "soil-plant-community" when interacting with habitats, course of rehabilitation and dying of species, indicates the rate of change of generations, successional processes, etc [4,5]. In this regard the populations *Medicago*, common on calcareous soils in natural communities are of greatest interest to both environmental studies and possible material for the creation of productive varieties resistant to the heavily eroded calcareous soils and outcrops of chalk in the conditions of the region [6-12].

The aim of the study was examining of the spatial pattern and the age range of cenopopulations *Medicago* L. in gully landscapes of the southern part of the Central Russian Upland.

OBJECTS AND METHODS OF STUDYING

Methodological basis of the research is the doctrine of the centers of origin and diversity of cultivated plants [13]. Geobotanical studies were conducted in the Belgorod region (2002-2013 years). To assess the ecological state of alfalfa blue *M. varia* in the conditions of gullying with chalk outcrops there were selected reference stationary points with local cenopopulations which were considered as the model: 1) Volokonovsky district: tract Plyushevka, outcrops of chalk, farm Evdokimov; outcrop, the low-slope part, the border with steppe communities, gully fan of chalk eluvium, village Upper Lubyanka; 2) Valuysky district: tract White Mountain, outcrops of chalk, the low-slope part, gully fan of chalk eluvium, village Vatutino; 3) Alexeyevsky district: outcrop, gully fan of chalk eluvium, village Varvarovka; 4) Veydelevsky district: outcrops of chalk, gully fan of chalk eluvium, village Salovka; 5) Novooskolsky district: Kogaysky ravine, outcrops of chalk, gully fan of chalk eluvium, village Bogorodskoye. There were studied the area of cenopopulations (m^2), the absolute number of species (units), the instance saturation (density) (per m^2), the age structure of local cenopopulations. Observations, surveys and data processing were carried out according to standard procedures [6,7].

RESULTS AND DISCUSSION

In the plant communities of cretaceous outcrops of the Belgorod region cenopopulations *M. varia* were clearly acclimated to habitats associated with human activities: they grow in the gully landscapes near the fields, which had been previously used in the system of soil and farm crop rotations. The most frequently in the early 90-ies of the last century these fields used to grow perennials, occupying 50% or more in the structure of crop rotation.

Formation and further development of cenopopulations *M. varia* in contrasting conditions of gully landscapes can be explained by the fact that these habitats (ecotopes) are similar to foothills with gravelly soil, from where cultural alfalfa traces its beginnings (e.g. the Central Asian region, the North Caucasus, the Mediterranean), but it has the particular features in the conditions of calcareous soil of erosive landscapes of the region.

It is noteworthy that in geobotanical descriptions made by Taliev V.I. one hundred years ago alfalfa blue growing on chalky outcrops is not mentioned even once [14]. This may indicate a relatively recent wide distribution of these species in the region. Currently, as our study showed, *M. varia* can be found in plant communities of steppe, meadow and calciphile erosive landscapes [6,7].

A crucial factor for cenopopulations *M. varia* in the complicated conditions of environments is a combination of resources at a particular point of habitats (ecotopes). The micro-landscape in the conditions of gullying is well-formed that influences on the spatial distribution of the species. Cenopopulations of alfalfa blue are concentrated in the mouths of gullies with gully fans of chalk eluvium, and in the current ravines, i.e. in the conditions of more humid habitat on gravelly soils. The spatial pattern of cenopopulations *M. varia* at the stationary points in the gully landscapes of the Belgorod region is presented in Table 1.

The area of studied cenopopulations widely varied - from 200 m² to 8000 m² and averaged 1983.3 m² (Cv = 153.7%). The largest area of cenopopulations was found near the village Evdokimov and the village Varvarovka. The characteristic feature for all habitats is the random group arrangement of species of alfalfa. The group size varied, but the clusters of 10-30 units in number were observed more often. Isolated units were rare. The number of species in populations averaged 226.3 units and this figure changed in a fairly narrow range (Cv = 11.8%), which indicates their homogeneity and uniformity. The cenopopulation near the village Salovka was the most numerous.

Maximum density of cenopopulation was observed near the village Upper Lubyanka, which had simultaneously the lowest total area. The instance saturation (density) of alfalfa averaged 0.5 units / m² and there also was large level of index variability (Cv = 81.4%).

To study the influence of ecological factors on the age range we analyzed the ontogenetic state of species in local cenopopulations of alfalfa changeable. The immature and virginal condition of species was treated as one group of vegetative plants. The predominance of a certain age group of plants in the sample allows us to characterize the stability of cenopopulations in the ecological conditions as it stands. Each age range has its own morphological, physiological and biochemical characteristics affecting the relationships of species with eco-phytocenotical environment. In the conditions of optimal growth of cenopopulations there is a typical normal statistical distribution of ratio of species of different age [7,9].

The analysis revealed the influence of particular conditions on the ontogenetic spectrum of studied cenopopulations. Four studied cenopopulations had samples of all ages and continuous nature of distribution of the species according to age groups. The two of them were discrete: there were absent senile species in the cenopopulations of the village Vatutino, and there were absent plantlets and juvenile species in the populations of the village Salovka.

Bimodal ontogenetic spectrum had two peaks: the first - in the virginal part of the spectrum, the second - closer to its senile part and was discovered in cenopopulations of the village Evdokimov. In this locality there were 33.4% of the species in virginal state, 23.7% of species were older generative and 17.1% of species were sub-senile. This ratio shows the active self-renewal process, as well as sustainability of the local cenopopulation in time.

Cenopopulations which have dominated generative plants and the balanced proportion of species in all other states are referred to normal cenopopulations. In our study we referred to normal such cenopopulations as: alfalfa changeable of the village Upper Lubyanka, the village Vatutino and the village Bogorodskoye. The generative plants (g1, g2, g3) dominated in these cenopopulations and accounted 67.1%; 67.2% and 73.3% respectively. Sub-senile and senile condition of species in the cenopopulations was weak. The centered spectrum of the cenopopulations indicates their stable status in the plant community.

As our study showed, the right-side ontogenetic spectrum indicating the weakness of renewing process was discovered in the cenopopulations of the village Varvarovka and the village Salovka. The groups of species in a senile state - 39.4% and 38.5% respectively dominated in these habitats. In the cenopopulation of the village Salovka the proportion of species in a virginal state (p, j, V) was 7.3%, and in the cenopopulation of the village Bogorodskoe was found 2.1% of vegetative plants and the absence of species of the age p, j. Our observations of these local cenopopulations within three years indicate their instability and gradual loss of phytocenosis.

Reproductive effort is considered in modern phytocenology as one of the most informative and comprehensive genetically determined indicators, which determine the dependence of the level of production process both from the state of species in the cenopopulations, and from the eco-cenotic situation [7, 9].

High seed productivity and consequently reproductive effort was discovered in specimens of cenopopulations of the village Evdokimov and the village Vatutino. The cenopopulation of the village Upper Lubyanka had noticeable trend increasing the productivity of the total phytomass due to increasing power of the development of the root system, which was reflected at the magnitude of reproductive effort towards its reduction.

There was revealed a general trend of the specimens of cenopopulations of the village Varvarovka, the village Salovka and the village Bogorodskoye towards reducing the amount of phytomass, seed production, and as a result, reproductive effort.

There were discovered the plants *M. varia* having severe manifestation of multifoliolateness – *mf*-mutation – from 0.2 to 3.2%. Manifestation of *mf*-mutation in combination with morphological changes indicates “founder effect” and confirms the hypothesis of the formation of the secondary anthropogenic microcenter *M. varia* on the southern part of Central Russian Upland.

CONCLUSION

Landscape-climatic conditions of habitats (ecotops) in the conditions of gully landscapes with chalky outcrops form the conditions for the introduction of new synanthropic species, such as species of the genus *Medicago*. They are not only among the most valuable species in economic terms, but also in the most cases they determine the amount of biological capacity of erosive agricultural landscapes.

In these conditions the most established cenopopulations *M. varia* have species of all ages, continuous nature of distribution of species according to the age groups, that indicates the stability of their adaptive micro evolutionary changes. Adaptation processes revealed in local cenopopulations *M. varia* have the aim of preserving species with morphological, biochemical and other properties similar to those possessed by calciphile endemic vegetation. There is the formation of cenopopulations of a certain "carbonate" ecotype, close to cultural forms in a number of morphological features, while having a pronounced type of competitive stress-tolerant adaptive strategy.

In this regard, the observed micro-evolutional adaptive processes in the phytocenosis on calcareous soils allow us to consider the cretaceous south of the Central Russian Upland as a secondary anthropogenic microcenter of shaping *M. varia*. It is possible from practical point of view an effective selection of legume species for creation of highly competitive and environmentally sustainable cenopopulations on calcareous soils.

Table 1: Spatial pattern, Indicators of overall productivity and Reproductive effort of cenopopulations *M. varia* at the reference stationary points

Features	On average	Cv*, %
Area, m ²	1983.3	153.7
Abs. number of species, units.	226.3	11.8
Instance saturation (density), units/m ²	0.50	81.4
Overground phytomass of species, g abs. dry matter	35.2	35.2
Total phytomass of species, gabs. dry matter	48.3	20.1
Number of seeds, unit/1 plant	1027.2	68.9
Reproductive effort, %	2.71	10.5
Number of specimens having <i>mf</i> -mutation, %	1.64	37.2

Note: *Cv - variability ratio

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