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CLASSIFICATION OF FLORA OF AGROPHYTOCENOSES GROWING IN THE SOUTHWEST OF THE CENTRAL RUSSIAN UPLAND (RUSSIA)

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ABSTRACT

The classification of biological objects and systems reflect their theoretical concepts, identifying structural features and properties. A wide variety of anthropogenically transformed floras of the developed industrial and agrarian regions, needs the creation of a classification scheme that would reflect the features of their formation. This newly developed classification makes it possible not only to identify the structural features and genesis of the flora of agrophytocenoses, its influence on the development of regional flora, but also to make a probabilistic forecast for the development of different topological level floras.

The study of the flora of the southwest of the Central Russian Upland helped to distinguish types of anthropogenic transformation of the flora that share common features of structure and development. One of the distinguished types of flora is the flora of agrophytocenoses, in which, due to its heterogeneity, various classes, species, subspecies, and groups of flora are formed. Based on the study of 83 fields of agricultural crops and analysis of the similarities and differences in their species compositions and structures, a classification of the flora of agrophytocenoses of the region is created. The results indicate that the main factors contributing to the formation of various classes, species, subspecies and groups of flora of agrophytocenoses at different levels of their organization are type of ownership (agricultural holdings, farms, long-fallow lands); gricultural technologies for a particular crop (row crops and continuous sowing crops) and spatial differentiation of the vegetation cover in agricultural crops cultures.

Keywords: Anthropogenic transformation; flora; agrophytocenoses; segetal species; classification.

INTRODUCTION

The classification of biological objects and systems reflect their theoretical concepts, identifying structural features and properties [1]. It organizes information about objects, provides a definition of concepts, and helps find a suitable form of their assessment and the relationship between them [2]. Currently, many methodological and procedural additions, modifications, and innovative developments and approaches to the analysis of anthropogenically transformed floras have been introduced into the modern analysis of floristic data [3,4,5,6]. A wide variety of anthropogenically transformed floras of the developed industrial and agrarian region in the southwest of the Central Russian Upland (Belgorod Region, Russia), requires the creation of a classification scheme that would reflect the features of their formation. To date, a large number of attempts have been made to classify various flora and ecosystems according to multiple criteria: the method of formation, morphological parameters, lithological and agrochemical properties of the soil, and moisture conditions [7,8,9,10,11,12]. There are also various classifications of anthropogenic ecosystems developed [13,14,15]. The role of adventive and synanthropic species in modern florogenetic processes as a result of the creation of a network of anthropogenic ecotopes was assessed [16,17]. The floras we have studied are complex multicomponent and multifactor structures that are formed according to their own laws, although the general regularities in anthropogenically transformed complexes remain unchanged.

MATERIALS AND METHODS

A general assessment of the floras and determination of their place in the presented classification scheme had been carried out empirically. The studied floras were distinguished in the empirical space of the main gradients of their formation: depending on the structures and species composition of the floras, the degree of their anthropogenic transformation, the common origin and factors that determine their development at different level of ecosystem formation. Along these main hypothetical axes, which determine the features of the formation and specificity of the floras within the general type of anthropogenically transformed flora, there is a differentiated formation of various classes, subclasses and groups of floras of a lower rank occurs. Observance of the genetic principle of the classification of objects and their assessment in terms of the degree of their anthropogenic transformation is a criterion of its reliability and naturalness. Floras of agrophytocenoses differ in the degree of anthropogenic transformation and in their genesis, and form completely different branches of anthropogenically trinformational floras, stability of structures and directions of their development. The similarities and differences in the processes of temporal dynamics and modern states of floras and their structures at different levels were also considered. All this made it possible to present a general classification scheme for agrophytocenosis floras in the form of a diagram reflecting primarily their genesis, acting factors of flora formation and the degree of anthropogenic transformation of floras at different hierarchical levels.

The objects of study were the floras formed in the following crops: *Beta vulgaris* L., *Echinaceae purpurea* (L.) Moench, *Fagopirum esculentum* Moench, *Glycine max* (L.) Merr., *Helianthus annuus* L., *H. tuberosus* L., *Medicago sativa* L., *Onobrychis viciifolia* Scop., *Pisum sativum* L., *Trifolium sativum* L., *Triticum aestivum* L., *Zea mays* L. and long-fallow areas of fields being no more subject to anthropogenic influence.

Field studies used a routine floristic examination technique with field documentation, herbarium collection and subsequent critical-systematic cameral processing of the collected material. During the study of the species diversity of flora complexes and plant communities, the morphological-ecological-geographical method was used. The scientific and theoretical basis for a critical analysis of the species composition is the monotypic concept of the species as a geographical race. This approach more accurately reflects the specifics of a small regional or local flora.

In various regions of the Belgorod region, we examined fields of wheat (17 fields in total), soybean (15), corn (15), sunflower (12), beetroot (5), alfalfa (4), buckwheat (4), pea field (2), fields of *Echinicea purpurea* (L.) Moench and *Helianthus tuberosus* L. (1 field each), as well as

long-fallow areas (7). We assessed the similarities and differences in the flora forming in various agrophytocenoses and analyzed them using traditional methods of comparative floristics.

RESULTS AND DISCUSSION

The classification of agrophytocenosis floras should be based on the peculiarities of the action of natural and anthropogenic factors and the degree of their intensity, evaluate the types of economic activity, consider the features of the species composition and structures of the floras, the spatial differentiation of the vegetation cover and the dynamics and succession orientation of its formation.

Official statistics distinguish three categories of farms in the agricultural sector of the Russian economy: 1) agricultural enterprises, 2) households, and 3) peasant farms.

The scientific literature has made attempts to move away from the formal criterion in distinguishing agricultural enterprises (on the basis of the organizational and legal structure) and develop a "real" typology based on their actual role in agricultural production relations. There are two large groups of agricultural enterprises: Capitalist and pseudo-capitalist. The first includes agricultural holdings, equity enterprises, farms and commodity households. Agricultural holdings are understood to mean powerful vertically integrated structures, including both production, processing, and sales of products. The term "equity enterprises" covers collective enterprises of various kinds, organized on the basis of former collective and state farms.

The study of the agrophytocenosis flora of the Central Russian Upland established its taxonomic and typological structure. The flora of agrophytocenoses includes 326 species from 45 plant families. In agrophytocenoses, for the first time in the region, we noted species and their new locations. The most interesting are:

**Amaranthus graecizans* L. s. str.: 50°35′50″N, 36°03′42″E, Borisovsky district, Borisovka settlement, start of the detour, a sunflower field, 13.IX 2018, V.Z., found by A. Sukhorukov (MW). - In Central Russia, the species is defined as a rare alien plant from Central Asia. Given for the Kostroma and Yaroslavl regions.

Anagallis arvensis L.: 50°36′44,78″N, 36°21′14,00″E, Yakovlevsky district, environs of the Fedorenkov farm, wheat field, 6.V 2018, B.Z. (MW). - Given for the Shebekinsky district (Voznesenovka village). Exotic. In the Belgorod region the species is found at the northern boundary of the range (Elenevskii et al. 2004).

Eriochloa villosa (Thunb.) Kunth (found by A. Sukhorukov): 1) 50°52′59,86″N, 36°28′39,06″E, Prokhorovsky district, turn to Luchki village, a soybean field, large amount on its outskirts and individuals in the center, 31.VI 2018, V.Z. (MW); 2) 50°49′19,89″N, 36°36′35,87″E, Yakovlevsky district, environs of Nepkhaevo village, a soybean field, several individuals on the sidelines, 31.VII 2018, V.Z.; 3) 50°48′30,09″N, 36°29′47,55″E, Yakovlevsky district, Krapivinskie Dvory village, a wheat field, several individuals on the sidelines, 31.VII 2018, V.Z.; 4) 50°42′28,99″N, 35°24′29,13″E, border of Rakityansky and Borisovsky districts, near Trefilovka village, a sunflower field, spaced plants in the entire field, 15.VIII 2018, V.Z. - Most of the findings of the species are made within the agricultural fields of the region. An actively spreading species in the region. (Tokhtar V.K., Kurskoi A.Iu., Zelenkova V.N. New data on the flora of the Belgorod region (based on 2018 data) // MOIP Bulletin, Department of Biology, 2019. - V. 124. - Issue 3. - P. 67-69).

Our taxonomic analysis of flora in various crops identified a number of patterns in their formation. Representatives of the families *Asteraceae* and *Poaceae* with a high content of species of the families *Brassicaceae, Caryophillaceae, Fabaceae,* and *Lamiaceae*, which is characteristic of both the regional and all Holarctic flora, predominated in most spectra of the families of the studied floras. At the same time, the role of the families *Apiaceae, Cyperaceae, Euphorbiaceae*, which traditionally rank high in the regional flora, significantly decreases in crop sowing [18]. The spectra of families of agricultural crops closest to the region and relatively even in terms of number of species were recorded for the crops *Triticum aestivum, Helianthus annuus,* and *Glycine max,*

which is apparently due to the high diversity of habitats these crops grow in.

High biodiversity and similarity of the spectrum of families with the regional one is also characteristic of long-fallow lands. Under these conditions, as in the crops of *Trifolium sativum*, a significant number of species of the family *Chenopodiaceae* are represented. This is due to succession processes occurring within the long-fallow lands. We also noted a number of spectra untypical of regional flora, significantly differing in the number of species in several families compared to the most of crops. These include, for example, sunflower crops, in which the family *Fabaceae* (18 species, 13.5%) ranks second after *Asteraceae* (37 species). Representatives of the family *Rosaceae* move up compared to the regional spectrum in the crops of *Glycine max* and *Triticum aestivum,* which is apparently due to the presence of wild representatives of this family in forest shelterbelts. The specificity of the spectrum of the flora families formed in the crops of *Pisum sativum* is in the high ranks of the families *Chenopodiaceae* and *Polygonaceae* [18,19,20].

Our studies found that the floras of agrophytocenoses significantly differ from each other and represent two large relatively homogeneous groups of flora that are formed depending on the type of agricultural producers, which include agricultural fields: Flora of fields of large agricultural holdings and small farms.

The flora of agricultural holdings has much less species composition than the flora of the fields of farms formed due to the active use of herbicides and intensive agricultural technologies. Flora of farms is the most weeded by wild-growing and alien species, characterized by a fairly high species richness in comparison with the flora of agricultural holdings fields. The third class of flora of agrophytocenoses in the region includes the flora of long-fallow areas, which also depend on the type of management and land use. Under these conditions, the effect of anthropogenic influence is suspended and the vegetation cover develops towards the restoration of natural plant communities. The study of model floras of long-fallow areas indicates that their succession processes occur extremely slowly and the composition of the flora remains the same annually and does not differ during one growing season. Therefore, we assigned all these groups of flora to separate classes of a general type of anthropogenically transformed flora — the flora of agrophytocenoses in the southwest of the Central Russian Upland.

We divided all classes of agrophytocenosis floras into two species: row crops (corn, sunflower, beets) and continuous sowing crops (wheat, soy, buckwheat, peas). For row crops, the depleted flora is characteristic, often represented by the families A*maranthaceae, Chenopodiaceae* and *Poaceae.* Continuous sowing cultures have a more diverse flora. Here, in the spectrum of families, species of the families *Asteraceae, Poaceae, Lamiaceae, Rosáceae, Chenopodiaceae, Brassicaceae, Convolvulaceae* are fairly well represented. The stability of floras formed under these conditions can vary due to the presence of a significant number of migrating alien species. Multiple crops develop a peculiar structure of life forms (Table 1).

Floras of agrophytocenoses are usually located in lowland areas. Therefore, water and wind erosion has the least effect on the addition of flora of this type. At the same time, it should be noted that they are all very diverse in terms of the conditions they are formed in and their specificity depending on their different classes and species of flora. At the same time, they are characterized by a certain generality, which is determined by the spatial differentiation of the vegetation cover under these conditions.

The spatial differentiation of agrophytocenosis floras is quite mosaic due to:

- Differences in microclimatic conditions,
- Its infrastructure,
- Features of the applied agricultural technologies: the presence of forest shelterbelts, a network of unpaved roads, irrigation tanks, irrigation canals and systems, difficult to cultivate areas,
- Intra-production division of various process agricultural enterprises,
- The presence of warehouses, storage facilities,

- The presence of industrial waste on the territory, etc.

Various groups of agrophytocenosis floras differ depending on the nature of the spatial differentiation of the vegetation cover in various ecotopes. They are heterogeneous and can be subdivided according to the proposed classification of flora into determinant and indifferent floras, depending on the degree and specificity of the impact of the anthropogenic factor. The first includes flora formed under a clearly defined main anthropogenic factor that determines the process of development of vegetation cover and dramatically changes the environment. As a rule, the spatial differentiation of flora determinants is more rigidly determined by the anthropogenic factor and is expressed in the differences in species compositions and communities along its gradient in the zones of anthropogenic impact intensity.

Indifferent floras are formed in conditions impossible to isolate one dominant factor, and especially the zones of its intense impact. The projective vegetation cover under such conditions is quite high and uniform throughout the territory. The spatial differentiation of flora-indifferents along the anthropogenic gradient is not expressed. Differentiation of vegetation into zones along the gradient of the anthropogenic factor is absent or not expressed.

The spatial differentiation of agrophytocenosis floras in the case of irrigation networks is centripetal, varying along the gradient of wetting factors. Edaphic factors, microclimatic changes in humidity and temperature have a significant effect on the formation of these floras.

Within hard-to-cultivate fields there are natural areas such as hills, rocky soils, inconvenience, slopes, and in some cases mounds preserved in these territories, as well as anthropogenic territories: the area under power transmission towers, warehouses, water bodies, etc. They play role of refugiums, which preserve fragments of natural flora, sometimes extremely rare species for the region. The plant growth conditions can vary greatly. Therefore, even the orientation of the succession processes of the vegetation formed here may not coincide in some cases. Here, floras are formed, which can develop zonally, with succession dynamics characteristic of it with a predominance of syngenesis processes. The determining conditions for the formation of vegetation cover include the properties of the substrate. The spatial differentiation of the vegetation cover differs significantly in the fields where hydro-engineering ecotechnical systems for using water in agricultural production processes are built. Therefore, the structure of the floras formed under these conditions can bear the imprint of mesophytism or even hydro- and hygrophyticity. The dominant species are those with an ecological amplitude resistant to waterlogging, salinization, and chemical pollution (Fig. 1).

Fig. 1. Spatial differentiation of plants in agrophytocenosis with belts of *Phalacroloma annuuum* (L.) Dumort. thickets as a dominated species of weeds

According to the degree of anthropogenic transformation, the taxa of flora defined for the classification are different. The most transformed flora are those forming in the territories of agricultural holdings, where the conditions for the formation of vegetation are the most extreme. This class of agrophytocenosis floras, as a whole, refers to highly transformed flora. Restoring flora to their original natural state here is in most cases impossible without specially conducted remediation measures. Flora formed in farms and various private farms that are capable of partial self-healing underwent moderate anthropogenic transformation. As the vegetation cover develops, the flora gradually turns into a more stable structure, in which the formed local communities most tolerant to growing conditions are adjacent to groups of adventitious and weed species.

Table 1. The ratio of the life forms of plants of flora of agrophytocenoses according to I. G. Serebriakov (1962) (%) in crops

Life forms	The presence of various life forms in crops (%)												
	Buckwheat	Soybean	Long-fallow areas	Sunflower	Wheat	Corn	Pea	Beetroot	Alfalfa	Clover	Echinacea	Sainfoin	Sunchoke
Annual	23.10	36.84	29.92	37.90	41.73	43.87	45.83	40.98	36.06	35.29	32.00	31.37	35.71
Herbaceous polycarpous plant	61.50	42.98	53.54	45.16	45.21	40.81	29.16	34.69	52.45	47.05	46.00	50.98	42.85
Herbaceous monocarpous plant	12.80	15,78	12.59	9.67	10.43	11.22	25.00	10.20	9.83	17.64	16.00	15.68	1.78
Wood	0.00	2.63	3.14	4.83	1.73	2.04	0.00	4.08	1.63	0.00	4.00	0.00	3.57
Shrub	2.60	1.75	0.00	1.61	0.86	0.00	0.00	0.00	0.00	0.00	0.00	1.96	0.00
Subshrub	0.00	0.00	0.78	0.80	0.00	2.04	0.00	0.00	0.00	0.00	2.00	0.00	0.00

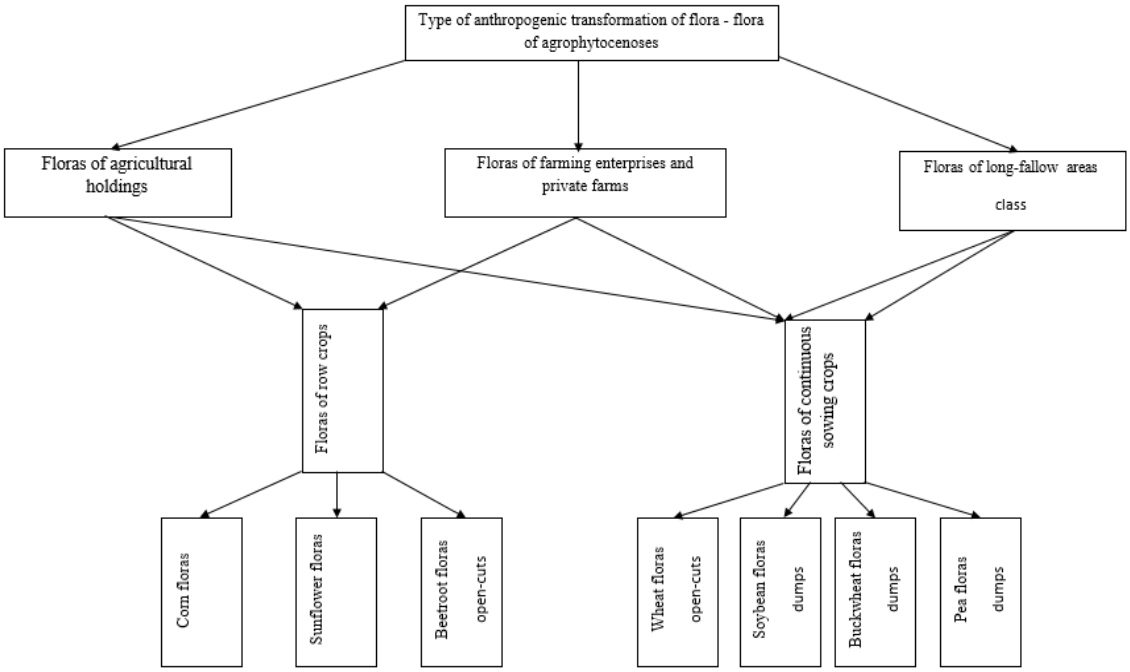

Fig. 2. General classification diagram of flora of agrophytocenoses growing in the southwest of the Central Russian Upland

CONCLUSION

Based on the studies of the agrophytocenosis flora of the southwest of the Central Russian Upland and the examination of 83 agricultural fields in the region, the taxonomic and typological structure of the flora, the spatial differentiation of the vegetation cover was established and the flora of the agrophytocenosis in the southwest of the Central Russian Upland (Russia) was classified. The results indicate that the main factors contributing to the formation of various classes,

species, subspecies and groups of flora of agrophytocenoses at different levels of their organization are:

1. Type of ownership (agricultural holdings, farms, long-fallow lands)
2. Agricultural technologies for a particular crop (row crops and continuous sowing crops)
3. Spatial differentiation of the vegetation cover in agricultural crops cultures.

Thus, our classification of the agrophytocenosis floras of the southwest of the Central Russian Upland, considering data on the degree of their anthropogenic transformation, common origin and the main factors determining their development, allows us to highlight the features of the formation and interconnection of their lower-rank floras.

According to the results of the study, the classification scheme for the flora of agrophytocenoses includes three classes, two species and groups of flora, the number of which is determined by the number of crops grown in the region (Fig. 2). Floras were classified subject to the main factors determining the development of agrophytocenosis floras. At the level of classes, these include the species of agricultural producers. Species of agrophytocenosis floras are determined by the peculiarities of the applied agricultural technologies in the cultivation of row crops and continuous sowing crops, subspecies of agrophytocenosis floras differ from each other depending on the crop grown (Fig. 2), groups of flora are united by similar spatial differentiation of vegetation in them. All these flora are characterized by varying degrees of anthropogenic transformation, features of origin and formation, a peculiar spatial, taxonomic and typological structure, as well as factors determining their development.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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