Taxonomic structure as an indicator of anthropogenic transformation of flora: The Case Of the southern part of the Melekess-Stavropol region (Samara Trans-Volga region)

Ivanova A V 1 and Kozlovskaya O V 2

1 Samara Federal Research Scientific Center RAS, Institute of Ecology of Volga River Basin RAS, Togliatti, Russia
2 Samara State Technical University, Samara, Russia

E-mail: savenkoov@mail.ru

Abstract. The results of anthropogenic impact can be traced on different components of the ecosystem. The vegetation cover is the basic component. Higher vascular plants make up an essential part of it. The flora of Samara Oblast can be characterized as the flora of legumes, since the Fabaceae family ranks third in the spectrum of families. However, not all territories in its composition have similar characteristics. Earlier, we analyzed the features of the flora of the Low Trans-Volga province using the example of the Melekess-Stavropol region. Its territory has a low-lying flat relief and significant economic development. As a result of human economic activity, most of the territory has been plowed and deforested. The flora of the southern part of the area is distinguished by the abundance of representatives of the Brassicaceae and Rosaceae families. The family Fabaceae is represented here by a relatively small number of species. Within the framework of this study, we consider local floras of various sizes corresponding to the middle part of the Melekess-Stavropol physical-geographical region (Suskan group) and the southern part (Togliatti group). Each of these groups, considered when taking into account the forest massifs in its composition, which, among other things, have a small area, exhibits the Rosaceae type of flora. At the same time, the indigenous fraction of the Suskan floristic group, excluding forest flora, shows the Cyperaceae type. The Rosaceae-type of flora can be considered as corresponding to the natural conditions of the studied area. The abundance of the Brassicaceae family can be explained by a significant anthropogenic transformation of the territory, which manifests itself, in particular, as an adventitization of the flora.

1. Introduction

Taxonomic features are the most important in the description of flora. As a rule, the main features of the flora are reflected in the head part of the family spectrum, which contains 10–15 families. Since the families in the spectrum are ranked according to the number of species, the head part contains most of the species of the studied flora [1]. In some literature, the triad of leading families is separately considered, including an indication of their share in the flora.

One of the first botanists who turned to the analysis of the family spectrum was K.K. Klaus, professor of chemistry at Kazan University, an outstanding Russian scientist of the 19th century. He studied: the Kazan flora, the flora of the Sergievsky waters, the Sarepta colony and the Caspian steppes [2]. He suggested that the family, which is in third place in the spectrum, be taken as a
characteristic for flora "in any locality" [2]. Based on the results of his research, Klaus concludes that "the vegetation of the Caspian steppe should be called haze flora, and Sergievskaya - leguminous flora" [2]. Thus, it is likely that he was the first researcher to draw attention to the third member of the family spectrum as a characteristic of the flora.

A.P. Khokhryakov proposed to distinguish the type of flora according to the third member of the first triad. The type of flora characterizes the corresponding territory within which a floristic “zone” is distinguished [3]. Referring to the paper by of L.I. Malyshev [4], Khokhryakov classifies extra-Arctic Eastern Europe as a “legume zone”, within which there may be regional and local Cyperaceae-type and Rosaceae-type floras.

When making an inventory of the flora of any territory, the researcher deals with a list of species, which is gradually replenished. The general list of flora should contain the species of all possible ecotopes of a given area, and in some repetition [5]. At some point, the list of species begins to correspond to the concept of "flora", i.e., its parameters reach the values of those of the regional flora. One of these parameters is the number of species in the floristic list, which identifies the type of flora characteristic of a given area. To a certain extent, this value correlates with the total possible number of species in the flora.

On the example of various territories of the Samara Trans-Volga region, the authors previously showed that the type of flora is finally established when there are 400–700 species in the sample [6, 7]. This number of species corresponds to an area of 400–800 km$^2$ for the Samara Trans-Volga region [8].

On the territory of Samara Oblast, the Fabaceae type of flora is revealed. The same can be said about most of the physical and geographical regions that are part of it in whole or in part [9]. However, the flora of the province of the Low Trans-Volga region [10] in this sense differs in some features, which we considered separately [11]. The Melekess-Stavropol region, which is part of the province, turned out to be rather heterogeneous in terms of taxonomic indicators. The floristic groupings identified on its territory, corresponding to local floras, differ in the third member of the family spectrum. We should pay special attention to the southern part of this territory. We characterized its flora as a mixed type or Brassicaceae-type, the presence of which is not mentioned by A.P. Khokhryakov.

Additional studies of the flora of the southern part of the Melekess-Stavropol physical-geographical region made it possible to characterize it more fully as a territory that has a certain uniqueness of flora in comparison with those of the forest-steppe and steppe parts of the Trans-Volga region.

2. Materials and Methods

2.1. Natural conditions
The Melekess-Stavropol low-plain area of pine forests on hilly sands is part of the territory of the forest-steppe province of the Low Trans-Volga region [10]. The region is located in the area of a tectonic trough and is a terraced low-lying plain, which is part of the ancient valley of the Volga River. [12]. The northern border of the region starts from the source of the Bolshoi Avral River and runs along its bed to the Kondurcha River; the eastern border coincides with the course of the Kondurcha river, and in the southeast of the Sok river; the western and southern borders are formed by the shores of the Kuibyshev reservoir. The southern part of the region covers the boundaries of Samara Oblast, as well as settlements from the Chuvash Suskan to the village of Ryazanovo in the north and the villages of Divny and Vishenka in the east, belonging to Ulyanovsk Oblast (figure 1).

The flattened low-lying relief in combination with the relative youth and uniform composition of the rocks determines a lesser variety of morphosculptural ornamentation, as well as a more arid climatic environment than in the Volga region.

The vegetation is of a forest-steppe nature. With regard to the Ulyanovsk Trans-Volga region, it is noted that "there is a typical and indigenous forest-steppe, but with large islands of forest" [13]. At present, most of this territory has been transformed due to human economic activities: plowing,
deforestation, overgrazing, the organization of summer cottages, the construction of a network of roads, etc. A. V. Stupishin describing the Melekess-Stavropol region indicates that "significant tracts of forest were destroyed, and the land was turned into agricultural land" [10]. There are also similar oral statements by local residents.

Regarding the flora of this territory, we should note some depletion in species compared to the Right Bank. It is determined by the relative geological youth and a lesser variety of geological structure [13, 14].

2.2. Initial data and processing

Within the framework of this study, the authors consider local floras of various sizes corresponding to the middle part of the Melekess-Stavropol physical-geographical region (Suskan group) and the southern part (Tgliatti group).

The list of species compiled for the Suskansky nature reserve [15] is the basis of the considered flora of the Suskan group. The Suskansky reserve is located in the north of the Stavropolsky municipal district of Samara Oblast and borders on Ulyanovsk Oblast. The total area of the reserve is 40 thousand hectares. The following settlements are located on the territory of the reserve: Vyselki, Belozerk, Khrayashchevka, Nizhnee Sancheslevo, Chuvashsky Suskan, Lopatino, Verkhny Suskan. In the last decade, the survey of this area was carried out by the staff of the Laboratory of Problems of Phytodiversity of the Institute of Ecology of the Volga River Basin RAS under the guidance of prof. S.V. Saksonov. The last survey of the territory was in 2020. In total, the authors used 15 lists of higher vascular plants. We marked the geographical location of the survey sites on the map-scheme in the form of points (figure 1). Some of the geographic points were visited two or three times per season. Only actually found plant species are included in the lists. The lists have both a different number of species (70-515) and a different phytocoenotic confinement: the surveyed territory included various plant communities. The combined list, including the flora of all geographical points, represents the Suskan local flora, which has its own individual features.

**Figure 1.** Location of research points on the territory. Green - points containing forest areas, red - points in which there were no forests
The Togliatti floristic group is represented by the flora of the city of Togliatti [16]. It includes long-term studies of both the territory of the city itself and the forests of the Green Zone. The flora of the Uzyukovsky pine forest was described separately [17] and subsequently supplemented [18]. The flora of the Yagodinsky forest massif has not yet been published; it is represented by a separate list from the FD SUR electronic database [19].

All used floristic lists are stored in the FD SUR database [19]. The authors were able to construct taxonomic spectra for the considered floristic samples using this database.

For the territory of the Melekess-Stavropol landscape region, several types of anthropogenic factors of influence on vegetation can be distinguished (Table 1).

**Table 1.** The main factors of anthropogenic transformation of the flora of the Melekess-Stavropol landscape region

| Factors of anthropogenic transformation | Objects                                                                                      |
|----------------------------------------|--------------------------------------------------------------------------------------------|
| Agriculture (plowing)                  | Agricultural Fields, Pastures, hayfields, livestock keeping places, watering places          |
| Stock raising                          | Technogenic Fires, Fields, pastures, hayfields, etc.                                        |
| Construction and operation of linear structures | Roads, power lines, pipelines Fields, pastures, hayfields, etc.                              |
| Functioning of residential and industrial complexes | Settlements of various status, temporary economic facilities, etc.                          |
| Military training grounds and other facilities | Settlements of various status, special facilities, military training grounds                   |
| Recreational                           | Recreational Territories for recreation of the population                                    |

3. Results and Discussion

Both groups of flora under consideration have both common and individual features. According to the map in Fig. 1, one can notice that there are a lot of forests in the southernmost part of the territory. This is reflected in the names of the analyzed floras themselves. The territory from which the Suskan flora is described contains only separate small preserved fragments of forest communities.

The total flora of the Suskansky reserve, containing 515 species, demonstrates the Brassicaceae type (table 2), while its adventitization is 21.2%. This is a fairly high percentage, which is observed in floras that include settlements or, generally speaking, a high anthropogenic disturbance. The sample of indigenous flora according to this list is 406 species and already corresponds to the Cyperaceae-type, which was mentioned by A.P. Khokhryakov [4].

Let us mention that only the Fabaceae family is present in the head part of the spectrum of the general flora; the Rosaceae family appears only in the indigenous part. The exclusion of adventive species from the sample changes the position of other families as well. The share of Brassicaceae and Chenopodiaceae is decreasing. In this connection, the share of Fabaceae, Apiaceae, Lamiaceae, and Caryophyllaceae is increasing; they occupy higher positions in the spectrum.

The flora of the combined sample, which includes data on treeless areas, retains the distribution according to types: Brassicaceae-type in the general flora and Cyperaceae-type in the indigenous flora. However, the size of the legume family has increased significantly, since the descriptions cover areas of local meadow steppes and other ecotopes. Rosaceae are found at the head of the spectrum of the general flora.
Potentilla heidenreichii, P. impolita

Among legumes, this sample continues to lead. As a result of an increase in the sample, and in addition, a more complete spectrum analysis helps to complement changes in sample composition (table 3). Genus Carex continues to lead. As a result of an increase in the sample, and in addition, a more complete coverage of the existing ecotopes, some typical genera appear in the head part: Galium and Veronica. Among legumes, this sample includes species of the genus Astragalus: A. cicer, A. sulcatus, and A. varius. The genus Vicia is represented by V. angustifolia, V. cracca, V. sepium, V. tenuifolia, and V. tetrasperma. The Rosaceae family is also increasing in number from 15 to 29 species; including Potentilla heidenreichii, P. impolita and P. norvegica.

### Table 3. The heads of the genus spectra of flora in the Suskan group

|   | 1<sup>a</sup> | 2<sup>b</sup> | 3<sup>c</sup> |
|---|--------------|--------------|--------------|
| 1 | Carex (2,5)  | Carex (3,0)  | Carex (2,9)  |
| 2 | Artemisia (1,6) | Artemisia (1,7) | Galium (1,6) |
| 3 | Salix (1,6)   | Salix (1,7)  | Salix (1,4)  |
| 4 | Juncus (1,4)  | Galium (1,5) | Arctium (1,4) |
| 5 | Potamogeton (1,4) | Potamogeton (1,2) | Veronica (1,3) |
| 6 | Chenopodium (1,2) | Veronica (1,2) | Potentilla (1,3) |
| 7 | Ranunculus (1,0) | Juncus (1,1) | Potamogeton (1,0) |
| 8 | Puccinella (1,0) | Epilobium (1,1) | Epilobium (1,0) |
| 9 | Plantago (1,0) | Rumex (1,1) | Poa (1,0) |
| 10| Epilobium (1,0) | Poa (1,1) | Juncus (0,9) |
|   |   |   |    |
|   | Rorippa (1,0) |   |    |
|   | Cirsus (1,0)  |    | Viola (0,9) |
|   | Atriplex (1,0) |   |   |

<sup>a</sup> flora of the Suskansy reserve [15]  
<sup>b</sup> combined selection containing lists of territories without forests  
<sup>c</sup> combined selection containing all lists (including forest ones)
The flora of the general sample, which contains all the lists, is identical in type to the indigenous flora (table 2). The Rosaceae type is established. The first four families do not differ. Further, the differences are as follows: in the indigenous fraction, the share of the families Cyperaceae, Apiaceae, Scrophulariaceae, Ranunculaceae is in the head part. Brassicaceae, on the other hand, reduces the participation rate.

The genus Potentilla appears in the head part of the genus spectrum of flora of the general sample. This genus contains 10 species in the total sample. The following species are added: P. canescens, P. glaucescens, P. heptaphylla, and P. recta. The genus Vicia is the most numerous in the legume family. It includes 7 species, including V. pisiformis and V. sativa. There remain 4 species of astragalus: A. cicer, A. sulcatus, A. varius and A. testiculatus. This allows the spectrum of legumes of this territory to be characterized as "pea", which was indicated earlier [20].

Below we will consider the distribution of the families of the head part of the spectrum of the Togliatti floristic group (table 4). The Brassicaceae family is in third place in the spectrum of flora families of the city of Togliatti. This also indicates a large percentage of adventitization (31.2%), with a significant contribution being made by this particular family. If we consider the specified sample, Brassicaceae are in the first place in the spectrum of families of adventive flora.

The Rosaceae family is in the third place in the spectrum of families of the indigenous fraction of the flora. It also determines the corresponding type of flora in a given area. Brassicaceae in the indigenous fraction fall below the head of the spectrum. The flora of the Uzyukovsky pine forest considered separately also demonstrates the Rosaceae type. This flora has 19.1% of adventitization, which is explained by the presence of settlements, dirt roads on the territory of the forest, and the frequency of its attendance for various purposes.

The combined flora of the city of Togliatti, Uzyukovsky pine forest and Yagodinsky forest shows the Rosaceae type. Obviously, this is the original type of flora that was formed in a given territory in accordance with its natural conditions. The Brassicaceae family is one of the leading ones in the head part of the spectrum of the general flora, but in the indigenous fraction it also disappears from the head part.

| Table 4. The heads of the spectra of flora families in the Togliatti group |
|---------------------------------------------------------------|
| **Flora of Togliatti** | **Flora of Uzyukovsky pine forest** | **Combined flora (Togliatti, Uzyukovsky, Yagodinsky forest)** |
| **general** | **indigenous** | **general** | **indigenous** | **species number** | **general** | **indigenous** |
| 647 | 445 |
| 1 | 1 |
| Ast (15.5) | Ast (16.6) |
| Ast (17.9) | Ast (17.4) |
| Ast (14.4) | Ast (15.0) |
| 2 | 2 |
| Poa (10.8) | Poa (9.9) |
| Poa (8.2) | Poa (8.7) |
| Poa (10.5) | Poa (9.6) |
| 3 | 3 |
| Brass (6.8) | Ros (7.4) |
| Brass (6.2) | Ros (6.2) |
| Ros (7.2) | Ros (5.4) |
| Ros (7.6) |
| 4 | 4 |
| Fab (5.4) | Car (6.1) |
| Car (5.3) | Lam (4.3) |
| Car (4.4) | Lam (4.3) |
| Car (4.2) | Cyp (3.7) |
| 5 | 5 |
| Fab (5.5) | Car (5.8) |
| Car (5.4) | Lam (4.6) |
| Car (4.4) | Lam (4.3) |
| 6 | 6 |
| Fab (4.5) | Car (5.9) |
| Car (4.2) | Cyp (3.7) |
| 7 | 7 |
| Lam (4.5) | Scr (3.6) |
| Lam (4.3) | Api (4.3) |
| Lam (4.2) | Api (3.5) |
| 8 | 8 |
| Pol (3.1) | Api (3.4) |
| Api (3.7) | Ran (3.6) |
| Scr (3.9) | Api (3.5) |
| 9 | 9 |
| Chen (2.9) | Ran (3.4) |
| Ran (3.3) | Scr (3.1) |
| Pol (3.6) | Scr (3.5) |
| 10 | 10 |
| Scr (2.9) | Brass (3.4) |
| Scr (2.7) | Cyp (2.9) |
| Api | Cyp |
| Chen | Ran (3.3)
We should mention that the Fabaceae family is of course present in the head part of the spectra in all cases and is one of the leading ones. However, it does not fall into the third place. The most numerous genus from the family is Vicia (table 5), as well as the flora of the Suskan group.

The difference between the two considered groups – the Suskan and the Togliatti ones - is also manifested in the composition of the genus spectra. The presence of a large number of aquatic and near-aquatic ecotopes of the Suskan group determines here a high position in the genus spectrum of the genera Potamogeton and Juncus, along with Salix and Carex.

**Table 5. The heads of the genus spectra of flora in the Togliatti group**

| Flora of Togliatti | Flora of Uzyukovsky pine forest | Combined flora (Togliatti, Uzyukovsky, Yagodinsky forest) |
|--------------------|--------------------------------|---------------------------------------------------------|
| 1 Carex (1,7)      | Carex (1,7)                    | Carex (1,7)                                             |
| 2 Galium (1,7)     | Galium (1,7)                   | Galium (1,7)                                            |
| 3 Artemisia (1,4)  | Potentilla (1,4)               | Potentilla (1,4)                                        |
| 4 Potentilla (1,4) | Salix (1,1)                    | Artemisia (1,4)                                         |
| 5 Viola (1,4)      | Artemisia (1,4)                | Salix (1,3)                                             |
| 6 Veronica (1,2)   | Geranium (1,2)                 | Viola (1,3)                                             |
| 7 Vicia (1,1)      | Vicia (1,2)                    | Veronica (1,1)                                          |
| 8 Centaurea (1,1)  | Campanula (1,2)                | Vicia (1,1)                                             |
| 9 Polygonum (1,1)  | Centaurea (1,2)                | Polygonum (0,9)                                         |
| 10 Salix (1,1)     | Poa, Ranunculus,               | Centaurea (0,9)                                         |
|                    | Veronica (1,0)                 | Dianthus (0,9)                                          |

**4. Conclusions**

Thus, the anthropogenic transformation of the vegetation cover leads to a change in the main parameters of the flora of the studied area. Significant evenness of the relief in combination with economic development: agricultural activity, as well as the presence of a number of settlements, summer cottages, and roads contributes to the distribution of adventive species. It is the anthropogenic transformation that determines the similarity of the floras located side by side between the two considered groups: the Suskan and the Togliatti ones. The third place in the family spectra of both floras is occupied by the Brassicaceae family. Moreover, each of the sites has its own natural features, which is reflected in the corresponding taxonomic characteristics.

The Suskan floristic group covers a smaller area, there are significantly fewer forest areas, and there are more aquatic and near-water ecotopes. This determines the change from the original flora type to the Cyperaceae type, which is manifested only in the indigenous faction. The Togliatti floristic group covers an area with much more woodland preserved. It has a fairly large area, therefore, despite significant anthropogenic pressure, its flora retained the original natural Rosaceae type.

**Funding**

This work was carried out within the framework of the Program of Fundamental Research of the State Academies of Sciences in 2013-2020 (projects nos. AAAA-A17-117112040040-3, AAAA-A17-117112040039-7)

**References**

[1] Schmidt V M 1980 *Statistical methods of comparative floristry* (Leningrad: Publishing house of St. Petersburg University)

[2] Klaus K 1852 *Flora of local and Volga countries* (St. Petersburg)

[3] Khokhryakov A P 2000 Taxonomic spectra and their role in comparative floristry *Botanical journal* 85(5) 1–11
[4] Malyshev L I 1972 Floristic spectra of the Soviet Union The history of flora and vegetation of Eurasia Leningrad pp 17-40
[5] Tolmachev A I 1974 Introduction to plant geography (Leningrad: LSU)
[6] Ivanova A V 2018 Features of the taxonomic structure of the flora of the southeastern part of the Soksky physical-geographical region Systematic and floristic studies of Northern Eurasia: materials of the II Intern. conf. (to the 90th anniversary of the birth of Professor A.G. Yelenevsky) 1 (Moscow: Moscow State Pedagogical University) pp 226-229
[7] Ivanova A V, Kostina N V and Aristova M.A 2020 Dependence of taxonomic parameters of floras on sample size Bulletin of Saratov State University. New series. Series: Chemistry. Biology. Ecology 20(4) 404-416
[8] Ivanova A V and Kostina N V 2015 Identification of the area of the minimum-area of a specific flora taking into account the anthropogenic transformation of the territory Bulletin of Samara Scientific Center of RAS 17(4) 77-80
[9] Ivanova A V, Kostina N V, Rozenberg G S and Saksonov S V 2016 Family spectra of floras of the Volga basin territory Botanical journal 101(9) 1042-1055
[10] Physical and geographical regionalization of the Middle Volga region 1964 Ed A V Stupishin (Kazan: Publishing house of Kazan Univ.)
[11] Ivanova A V, Kostina N V, Lysenko T M and Kozlovskaya O V 2017 Features of the flora of the Melekess-Stavropol physical-geographical Samara Scientific Bulletin 4(21) 47-53
[12] Natural conditions of Kuibyshev oblast 1990 (Kuibyshev)
[13] Blagoveshchensky V V, Pchelkin Yu A and Rakov N S 1978 Plant world Natural conditions of Ulyanovsk oblast (Kazan: Publishing house of Kazan University) pp 227-255
[14] Plaksina T I 2001 Abstract of the flora of the Volga-Ural region (Samara)
[15] Saksonov S V, Savenko O V, Ivanova A V and Koneva N V 2007 Flora of the Suskansky nature reserve in the Samara region (Low Volga region, Melekessko-Stavropol floristic region) Phytodiversity of Eastern Europe 2 125-156
[16] Senator S A, Saksonov S V, Rakov N S, Vasyukov V M, Ivanova A V and Sidayakina L V 2015 Vascular plants of Togliatti and its surroundings (Samara oblast) Phytodiversity of Eastern Europe 9(1) 32-101
[17] Savenko O V, Saksonov S V and Senator S.A 2011 Materials for the flora of the Uzyukovsky forest massif Research in the field of natural sciences and education 2 48-53
[18] Saksonov S V, Senator S A and Ivanova A V 2012 The first addition to the flora of the Uzyukovsky forest massif (Samara Low Trans-Volga region) Structural-functional organization and dynamics of the vegetation cover: materials of the All-Russian. scientific and practical conf. (Samara) pp 92-95
[19] Aristova M A, Rozenberg G S, Kudinova G E, Rozenberg A G, Ivanova A V, Vasyukov V M, Kostina N V and Saksonov S.V Data base "Floristic descriptions of local areas of Samara and Ulyanovsk regions" (FD SUR). Certificate of registration of the database RUS 2018621983 12.11.2018
[20] Ivanova A V, Kostina N V and Vasyukov V M 2020 Taxonomic diversity of the Fabaceae family in the Samara-Ulyanovsk Volga region Ecosystems 23(33) 32-47