

The possibility of comparing the flora of Siberian cities

Boris Andreyev^{1*}, *Saule Mamyrova*²

¹Kuzbass botanical garden, Federal Research Center of Coal and Coal Chemistry SB RAS, 650065, Kemerovo, Russia

²Department of biodiversity and bioresources, Kazakh National University of Al-Farabi, 050040, Almaty, Kazakhstan

Abstract. The article examines the possibility of comparing checklists of flora of cities based on a number of characteristics: the year of the settlement's foundation, the area and population at the time of collecting materials, the timing of research, the method of collecting materials, the revealed complexity of the ecotopological structure of the city and the number of species. The factor determining the possibility of comparing lists of flora species of cities is the approach to its study, since the method determines the researcher's attitude to the object. Under the influence of the formed attitude to the object of research, the interpretation of factors significant for plants takes place.

1 Introduction

The flora of the city is formed under the influence of both purposeful and accidental human activity. Biotic and abiotic factors influence on each other and on the plant communities that have formed and are changed on the territory of the city. The purpose of any research is to reflect objective reality in accordance with the scientific and technical development of mankind. The objects of research are elements of complex systems, which include subsystems. Depending on the degree of display of the complexity of the system, the degree of approximation to truth will depend on on the approach to its study [1]. A complex artificial city system, including semi-natural and handmade ecotopes, it is important to display both the chronological structure (division into building areas by time of creation) and the ecotopological structure (division of the territory depending on the purpose of human creation) [2]. The choice of method to the collection of material depends on the purpose of the research, material support and possession of information about the entire range of developments in the field of scientific interest. The completeness of the display of reality depends on the degree of identification of the diversity of habitats of the studied territory [3] and the adequacy of the volume of collected materials [4]. To compare the flora of different cities, it is necessary to have sufficient basis for this.

* Corresponding author: b.g.andreev@mail.ru

2 Material and methods

The main conditions of comparability in this work are the date of foundation, the area and the population of the city at the time of the study, the year of completion of the work, which reflects the nature of human economic activity in the study area – objective factors. Subjective factors influencing the possibility of comparing floras are the method, the duration of the collection of materials, the attraction of herbarium collections of various dates, the degree of display of the complexity of the urban environment. As a result of the combination of objective and subjective factors in conducting the study, the number of species detected.

The analysis used data from dissertation studies of the flora of the following Siberian cities: Tomsk [5], Barnaul [6], Ulan-Ude [7], Omsk [8], Rubtsovsk [9], Tyumen [10], Irkutsk [11], Krasnoyarsk [12], Zarinsk [13], Biysk [14], Sosnovoborsk [15], Kyzyl [16], Abakan [17] (Table). Flora of Kemerovo has studied by the method of model areas (82 model areas, each 6.25 Hectares, within which the composition of vascular plants was revealed three times during the field season). Materials were collected in April–October 2021–2023.

3 Results and discussion

The cities under consideration differ in the date of foundation and the degree of preservation of the historical part. Tomsk, Barnaul, Omsk, Tyumen have the historical parts of the city with established plant communities have been preserved for a long time. From other side in Kemerovo proto-urban settlements were transformed several times during the development of the city, which led to repeated violation of plant communities. The list also includes young cities such as Sosnovoborsk.

The areas of cities differ significantly from each other, but there were no significant differences between the number of species living in them (at $p=0.05$). The list of analyzed cities includes both regional centers and small satellite cities created for economic needs.

Among the cities with a fully identified flora there is the largest city – Omsk, the large cities group includes Barnaul, Tyumen, Irkutsk, Krasnoyarsk, Kemerovo, Tomsk, Ulan-Ude. A big city is Rubtsovsk, Kyzyl and Abakan. A small is Zarinsk and Sosnovoborsk. It is incorrect to take the number of inhabitants of a settlement as the only basis for comparison, since it reflects, first of all, the degree of infrastructure development, but not the nature of economic activity, and as a result, the nature of the violation of soil cover and the regime of plant cultivation.

In terms of the duration of the collection of materials, it is necessary to limit personal collections for 2–3 years [2], so as not to increase the list of flora due to species showing low activity, for example ephemerophytes. The list of species of the Barnaul flora has been compiled taking into account herbarium samples for 50 years, Irkutsk – for 125. At the same time, the flora of Tyumen is represented by real and historical flora, for which separate lists are provided. Materials from the collections of herbariums of the Kuzbass Botanical Garden (KUZ) and KemSU (KEM) were used for the city of Kemerovo at the initial stage, but single samples unconfirmed during the study were not included in the list of flora. At the same time, 28%, 230 species of the Kemerovo flora are characterized by low activity. Either they occur singly, or they make a minor contribution to the formation of plant communities, which shows a significant amount of mobile fraction of flora, since these species can either naturalize or disappear from the territory, while it is necessary to give the most complete list for a specific period of time so that the speed of processes can be estimated, for example, the rate of naturalization of species.

According to the method of collecting materials, the works were divided into two groups. The first group of city floras was considered as a single indivisible disturbed territory, to which the method of local flora was applied. Some authors wrote the "traditional route method", which is essentially a procedure [3], but it meant the method of local flora [18], because the research was conducted by the authors in the administrative border of the city. The second group is of greater interest due to its heterogeneity. In the works of I.Ye. Merzlyakova [5], A.V. Sutkin [7] and E.Yu. Khozyainova [10] urban areas were divided into ancient, old, new city and suburbs, which reflects, the chronological complexity of the urban structure. In the work of T.A. Terekhina [6] in Barnaul, natural sites, parks, squares, lawns, construction wastelands, industrial wastelands, littered wastelands and railway tracks were highlighted. In the work of S.V. Ryabovol [12] in Krasnoyarsk, residential quarters, an industrial zone, agricultural land, an infield, an administrative center, and recreational areas are highlighted, while each group is displayed in new and old buildings, i.e. We see an example of displaying both the ecotopological and chronological structure of a settlement. In Sosnovoborsk [15], despite the small area, forest park, water, meadow sanitary protection, multi-storey residential buildings, garages and basements, infield and industrial zone are allocated. O.P. Chebotaryova [17] identifies park, residential multi-storey, residential one-storey, country, industrial zones in the ecotopological structure of Abakan, as well as lays sites along reservoirs. For the large industrial city of Kemerovo, 14 habitat groups were identified: multi-storey residential, single-storey residential, infield, decorative, cemetery, railway, landfill, roadside, industrial, forest, dry meadows, rivers and lakes, flood meadows, rocky outcrops and steep slopes. It reflects not only the diversity of ecotopes created by man, but also and a variety of poorly transformed sites.

4 Conclusion

Based on the combination of the above factors, several groups of comparable flora can be distinguished to 3 groups. The first group: Tomsk, Ulan-Ude and Tyumen, for which it is necessary not just to search for a measure of similarity between general samples, but a pairwise comparison of the selected functional zones, which will lead to a decrease in the measure of similarity of flora, but will be a great approximation to true knowledge. The second group is made up of the cities of Barnaul, Sosnovoborsk, Abakan and Kemerovo, for which only a partial comparison of similar studied functional zones is possible, i.e. the measure of similarity of flora will be incomplete. The third group includes all other cities except Irkutsk and Krasnoyarsk due to significant differences in the dates of the herbarium samples used.

The year of the settlement's foundation, its area and population cannot be sufficient grounds for comparison, since when the values are equal or approximate, the internal complexity of urban areas is not displayed. Instead of the year of creation of the settlement, it is worth using as a basis for comparison the timing of the last violation of the soil cover during the transformation of urban neighborhoods. For a reliable comparison, it is necessary to achieve unity in approaches to the allocation of parts of the city in which economic human activity is carried out, affecting both the soil cover and the species composition of plants. An important condition for comparability is the duration of the collection of materials, when using old materials, periodization and isolation of the stages of formation of the historical flora of the settlement are necessary. Based on the periodization, it is possible to compare the historical flora of cities, taking into account the influence of historical processes.

Table. The compared parameters of the flora of Siberian cities

Basis of comparing	City													
	Tomsk	Barnaul	Ulan-Ude	Omsk	Rubtsovsk	Tyumen	Irkutsk	Krasnoyarsk	Zarinsk	Biysk	Sosnovoborsk	Kyzyl	Abakan	Kemerovo
The year of foundation	1604	1730	1666	1716	1892	1586	1661	1628	1748	1709	1971	1914	1675	1701
City area, km ²	160	322	346,5	460	84	490,8	305	348	79,2	291,7	26,6	97,4	112,4	294,8
The population of the city, thousand people	475	580,1	374,8	1132	162,7	510,3	582,5	927,2	48,5	207,4	34,5	115,9	184,8	549,4
Year of completion of the study	1997	2000	2002	2003	2003	2004	2005	2007	2010	2012	2013	2019	2023	2024
The duration of the collection of materials, years	4*	50	5*	4*	10*	5	125	-	4*	-	5*	4*	5*	3*
The method of collecting materials	MA	PF	MA	LF	LF	MA	LF	MA	LF	LF	MA	LF	MA	MA
The number of selected habitat groups	4	8	4	1	1	4	1	12	1	1	7	1	6	14
Number of species	679	857	562	689	493	486	1121	1005	550	702	387	558	695	827

Notes: the duration of the collection of materials "*" includes works that do not specify the dates of collection of the earliest herbarium specimens, the species of which were included in the flora list, MA – the method of model areas, PF – the method of partial floras, LF – the method of local floras, the number of selected habitat groups "1" indicates, that the city is considered as a single indivisible territory disturbed by human activity.

Acknowledgments. The studies is carried out within the framework of State Assignment No. 0352-2019-0015, EGISU AAAA-A17-117041410053-1, on the basis of the funds of the Herbarium of the Kuzbass Botanical Garden (KUZ) No. USU 508667.

References

1. V.S. Stepin, Philosophy of science general problems (Gardariki, Moscow, 2006).
2. N.G. Ilminkikh, Florogenesis in urban area (Izd-vo UrO RAN, Ekaterinburg, 2014).
3. V.V. Alekhin, Methods of field study of vegetation and flora (Narkompros, Moscow, 1938)
4. B.G. Andreyev, A.A. Zverev, Verification of floristic sample adequacy in urban area, in Proceedings of international conference, Botany and botanists in a changing world, Tomsk, Russia, November 14–16 (2023). <https://doi.org/10.17223/978-5-7511-2661-2/3>
5. I.Ye. Merzlyakova, Flora of vascular plants of the city of Tomsk, candidate's thesis (Tomsk, 1997)
6. T.A. Terekhina, Anthropogenic phytosystems of the south of Western Siberia, doctor's thesis (Novosibirsk, 2000)
7. A.V. Sutkin, Flora of vascular plants of the city of Ulan-Ude, candidate's thesis (Ulan-Ude, 2002)
8. M.G. Budanova, Flora of vascular plants of the city of Omsk, candidate's thesis (Tomsk, 2003)
9. T.M. Kopytina, Flora of the city of Rubtsovsk and its surroundings, candidate's thesis (Barnaul, 2003)
10. E.Yu. Khozyainova, Flora of herbaceous plants in an urbanized environment on the example of the city of Tyumen, candidate's thesis (Tyumen, 2004)
11. O.P. Vinkovskaya, Flora of the Irkutsk urban agglomeration and its dynamics over the past 125 years, candidate's thesis (Perm, 2005)
12. S.V. Ryabovol, Flora of the city of Krasnoyarsk, vascular plants, candidate's thesis (Krasnoyarsk, 2007).
13. A.A. Shorina, Flora of the city of Zarinsk and its surroundings, candidate's thesis (Barnaul, 2010)
14. O.A. Chernykh, Flora of the city of Biysk and its surroundings, candidate's thesis (Barnaul, 2012)
15. Yu.V. Kuleshova, Flora of the city of Sosnovoborsk, south of Central Siberia, Krasnoyarsk Territory, candidate's thesis (Ulan-Ude, 2013)
16. R.B. Shanmak, Flora of the city of Kyzyl, candidate's thesis (Novosibirsk, 2019)
17. O.P. Chebotaryova, Flora of the city of Abakan, Republic of Khakassia, candidate's thesis (Tomsk, 2023)
18. A.I. Tolmachev, Methods of comparative floristics and problems of florogenesis (Nauka, Novosibirsk, 1986).