doi: 10.25750/1995-4301-2023-3-081-087

The factors of forming the floristic structure of railway stations embankment (on the example of the Republic of Bashkortostan)

© 2023. S. A. Gareeva[1] ORCID: 0000-0002-7591-6262,
A. F. Khusainov[2] ORCID: 0000-0003-4116-1890, L. M. Abramova[3] ORCID: 0000-0002-3196-2080,
[1]Bashkir State Pedagogical University named after M.Akmullah,
3-a, Oktyabrskoy revolucii St., Ufa, Russia, 450008,
[2]Ufa Multidisciplinary Professional College,
100/3, Rossiyskaya St., Ufa, Russia, 450100,
[3]Ufa Federal Research Centre of the Russian Academy of Sciences,
71, Prospekt Oktyabrya, Ufa, Russia, 450054,
e-mail: khusainovasa@mail.ru

Railroad embankments are special types of ruderal ecotopes in human-transformed areas. Railways are active channels for transzonal plant migration and are open to colonization by alien plant species. The aim of the research was to identify the factors of formation as well as the comparative analysis of the activity of partial floras species at six railway stations of the Republic of Bashkortostan located in three natural and climatic zones of the Southern Urals: the forest-steppe Cis-Urals, the steppe Trans-Urals and the Mountain-Forest Urals. The total flora comprised 288 species of vascular plants, including: 125 at the Kandry station, 124 at Buzdyak, 105 at Beloretsk, 128 at Inzer station, 157 at Sibai, 115 at Almukhametovo. A four-point scale of species activity was used for the comparative analysis of the flora of railway stations. It is shown that 21 species are found in all zones with the same degree of activity ("often" and "very often"). 125 species of vascular plants occur exclusively on the railway embankments of one of the studied stations. The flora of railway stations have similarities from 0.50 to 0.71 on the Sørensen-Czekanowski coefficient, which is provided by a common core of anthropotolerant species with a wide ecological amplitude. The differences reflect the zonal nature of vegetation and are formed through the participation of native flora species adapted to the specific substrates of railway embankment. Also the contribution of accidental drift of plant seeds is significant. The contribution of the zonal factor in various natural and climatic zones differs: the less difference between the railway ecotopes and the landscape and vegetation conditions of adjacent natural areas of the respective natural zone, the higher the participation of apophytic species in the forming of partial flora, and vice versa.

Keywords: Southern Urals, railway embankments, plant migration, flora, species activity, Sørensen-Chekanowski coefficient, zonal factor.

УДК 581.524 (470.57)

Факторы формирования флористической структуры насыпей железнодорожных станций (на примере Республики Башкортостан)

**© 2023. С. А. Гареева[1], к. б. н., доцент, А. Ф. Хусаинов[2], к. б. н., доцент,
Л. М. Абрамова[3], д. б. н., профессор, г. н. с.,**
[1]Башкирский государственный педагогический университет им. М. Акмуллы,
450008, Россия, г. Уфа, ул. Октябрьской революции, д. 3-а,
[2]Уфимский многопрофильный профессиональный колледж,
450100, Россия, г. Уфа, ул. Российская, д. 100/3,
[3]Уфимский федеральный исследовательский центр Российской академии наук,
450054, Россия, г. Уфа, пр. Октября, д. 71,
e-mail: khusainovasa@mail.ru

Железнодорожные насыпи – это особые типы рудеральных экотопов на трансформированных человеком территориях. Железные дороги являются активными каналами трансзональной миграции растений и открыты

для заселения чужеродными видами растений. Целью исследований было выявление факторов формирования и сравнительный анализ активности видов парциальных флор шести железнодорожных станций Республики Башкортостан, расположенных в трёх природно-климатических зонах Южного Урала: лесостепном Предуралье, степном Зауралье и Горно-лесном Урале. Общая флора составила 288 видов сосудистых растений, в том числе: на станции Кандры – 125, Буздяк – 124, Белорецк – 105, Инзер – 128, Сибай – 157, Альмухаметово – 115 видов. Для сравнительного анализа флор железнодорожных станций использовали четырёхбалльную шкалу активности видов. Показано, что во всех зонах с одинаковой степенью активности («часто» и «очень часто») встречается 21 вид. 125 видов сосудистых растений встречаются исключительно на железнодорожных насыпях одной из изучаемых станций. Флоры железнодорожных станций имеют сходство от 0,50 до 0,71 по коэффициенту Съёренсена-Чекановского, которое обеспечивается общим ядром антропотолерантных видов с широкой экологической амплитудой. Различия отражают зональный характер растительности и формируются за счёт участия видов местной флоры, приспособленных к произрастанию на специфических субстратах железнодорожных насыпей. Значителен также вклад случайного заноса семян растений. Вклад зонального фактора в разных природно-климатических зонах различен – чем меньше отличия железнодорожных экотопов от ландшафтно-растительных условий прилегающих естественных участков соответствующей природной зоны, тем выше участие апофитных видов в сложении парциальной флоры и наоборот.

Ключевые слова: Южный Урал, железнодорожные насыпи, миграция растений, флора, активность видов, коэффициент Съёренсена-Чекановского, зональный фактор.

Railway embankments are special, isolated types of ruderal ecotopes in human-transformed areas. Railway embankments are most often composed of crushed hard rock, gravel, a mixture of gravel and sand, or other ballast materials. The distinctive features of these anthropogenically formed substrates include irregular and insufficient moisture supply, excessive insolation, mobility, vibration and wind currents from passing trains, the use of herbicides to destroy unwanted vegetation, as well as a more favorable temperature background during the growing season, exceeding the ambient temperature by 0.5–4.0 °C [1].

Railways are anthropogenically transformed technogenic ecotopes, similar to the heap dumps of mining enterprises [2], since during their construction the vegetation is completely destroyed and the formed embankments are overgrown with newly introduced, often alien, plants. The role of railway transport, as an important factor in the transfer of plants to new territories, is great and these processes are not well understood, which determines the relevance of this work. The floras of railways became the objects of research by domestic [3–10] and foreign scientists [11–15].

The purpose of our research was to identify the factors of formation and comparative analysis of the activity of species of partial floras of railway embankments within stations in three natural and climatic zones of the Republic of Bashkortostan (RB) – Cis-Ural forest-steppe (Cis-Urals), Mountain-forest (Mountain Urals) and Trans-Ural steppe (Trans-Urals) zones.

Materials and methods of research

On the territory of the Republic of Bashkortostan from west to east there are railway branches of the Bashkir branch of the Kuibyshev (KubZhD) and South Ural (SUZhD) railways, which cross three natural and climatic zones – the Cis-Urals, the Mountain Urals and the Trans-Urals.

The studies were carried out for 9 years, 2 railway stations were surveyed in each zone. The material was collected on the railway embankments of the stations Kandra, Buzdyak, Beloretsk, Inzer (KubZhD), Sibay, Almukhametovo (Southern Railway). The characteristics of the natural and climatic conditions of the study areas are given in Table 1 [16].

The collection of material was carried out by the traditional route method for floristic research, during which more than 500 herbarium sheets were collected. The railway track within the boundaries of the station was examined,

Table 1

The characteristics of the natural and climatic conditions of the studied areas

Parameter	Cis-Urals	Mountain Urals	Trans-Urals
Average annual precipitation, mm	450	550	350
The amount of precipitation during the growing season, mm	200	250	185
Average annual temperature, °C	2.8	1.0	1.8
The sum of active temperatures, °C	2300	1600	2010
Hydrothermal coefficient	1.2	1.5	1.0
Zonal confinement	forest-steppe	mountain-forest	steppe

Table 2

Systematic composition of the railway embankments flora in three natural and climatic zones of the Republic of Bashkortostan

Taxonomic categories	Natural and climatic zone			
	Cis-Urals	Mountain Urals	Trans-Urals	total
	number			
Species	161	156	191	288
Genus	124	112	124	181
Family	32	32	31	39
Main systematic groups	number of species			
Equisetophyta	1	1	undetected	1
Magnoliophyta:	160	155	191	287
Liliopsida	25	25	25	40
Magnoliopsida	135	130	166	247

Table 3

Indicators of the railway embankment floristic richness at the stations in three natural and climatic zones of the Republic of Bashkortostan

Zone	Station name	Flora options									
		1	2	3	4	5	6	7	8	9	10
Cis-Urals	Buzdyak	124	101	31	1.2	4.0	3.6	17.1	1.5	46.0	37.1
	Kandry	125	98	26	1.3	4.8	3.8	15.3	1.8	45.6	32.8
Mountain Urals	Beloretsk	105	83	28	1.3	3.8	3.0	16.3	1.8	39.0	32.4
	Inzer	128	99	29	1.3	4.4	3.4	18.9	1.5	34.4	32.0
Trans-Urals	Almukhametovo	115	84	26	1.4	4.4	3.2	15.6	1.4	46.1	42.6
	Sibay	157	111	29	1.4	5.4	3.8	12.7	2.1	42.6	32.5

Note: Flora options: 1 – number of species; 2 – number of genera; 3 – number of families;4 – average number of species in the genus; 5 – average number of species in the family; 6 – average number of genera in the family; 7 – % of Monocotyledons in the flora; 8 – ratio of the number of Asteraceae/Poaceae species; 9 – proportion of adventitious species; 10 – proportion of terophytes.

including a ballast prism, roadsides, embankments of abandoned branches and the territory of stations, the main covering of which is crushed stone soil with wooden and reinforced concrete sleepers.

Plants were identified according [17–21], species names are given according [22].

For a comparative analysis of the floras of railway stations, the concept of "species activity" was used, expressed through the occurrence of a species [23, 24], for which a four-point scale was used [25]: "very often" (4 points), if the species occurs widely throughout the territory stations and numerous in typical habitats; "often" (3 points) if the species is found in all or almost all of the habitats indicated for it throughout or almost throughout the territory of the station; "rarely" (2 points), when the probability of finding it in suitable habitats is low, and it is noted not at all stations; "very rarely" (1 point), when species are singly recorded in one or several points.

To compare the floras of the embankments of railway stations, the Sørensen-Czekanowski similarity coefficient was used.

Results and discussion

Table 2 shows the taxonomic and systematic characteristics of the flora of railway station embankments in three climatic zones of the Southern Urals. The analysis showed that 288 species from 181 genera and 39 families were registered in the flora. The largest number of species was noted at the stations of the Southern Urals Railway (Trans-Urals) – 191 species, the smallest – at the stations of the Mountain Urals (156 species). This is due to the fact that the natural conditions of the Trans-Urals (high summer temperatures, excessive insolation, lack of moisture, stony soils) are close to the conditions formed on the technogenic substrates of railway embankments, which contributes to the survival of ovules of steppe and petrophytic plant species on them, and the conditions of the Mountain Urals – on the contrary, they differ from them to the greatest extent, therefore it is difficult for plants of the forest zone to adapt to this substrate. The overwhelming dominance of angiosperms and dicotyledonous plants was

Table 4

Plant species with high activity (in points) in all climatic zones

Species	Activity at railway stations					
	Kandry	Buzdyak	Beloretsk	Inzer	Sibay	Almukhametovo
Artemisia austriaca	3	3	3	3	3	3
Bromopsis inermis	3	3	3	3	3	3
Echium vulgare	3	3	3	3	3	3
Pastinaca sylvestris	3	3	3	3	3	3
Melilotus officinalis	3	3	3	3	3	3
Conyza canadensis	4	4	3	3	3	3
Poa pratensis	4	4	2	2	3	3
Dracocephalum thymiflorum	3	3	2	2	2	2
Setaria pumila	3	3	2	2	2	2
Setaria viridis	3	3	2	2	2	2
Inula britannica	3	3	2	2	2	2
Convolvulus arvensis	3	3	3	3	2	2
Taraxacum officinale	3	3	3	3	2	2
Lappula squarrosa	3	3	2	2	3	3
Potentilla argentea	3	3	2	2	3	3
Elytrigia repens	3	3	3	3	4	4
Calamagrostis epigeios	2	2	3	3	4	4
Chenopodium album	3	3	2	2	4	4
Puccinellia distans	3	3	2	2	4	4
Polygonum aviculare s.l.	3	3	2	2	4	4
Lactuca serriola	2	2	2	2	3	3

Note: activity (occurrence; in points): 4 – very often, 3 – often, 2 – rarely, 1 – very rarely.

revealed, higher spore plants are represented by a single species – *Equisetum arvense* L.

Table 3 reflects the floristic richness of railway embankments within individual stations. Here, the maximum number of species (157) was recorded at the Sibay station in the Trans-Urals, and the minimum (105) was recorded at the Beloretsk station located in the Mountain Urals. In general, the main characteristics of the floras of railway stations are comparable. The proportion of monocotyledonous plants is higher at the Inzer station of the Mountain Urals, and the proportion of adventitious species and terophytes is higher at Almukhametovo station in the arid Trans-Urals.

We have assessed the activity of species at all six surveyed railway stations. Tables 4 and 5 include species with activity at least at one of the stations of at least 3 points. It should be noted that in all partial floras of railway station embankments, species with a low occurrence prevailed, but in each zone, species were noted that, due to their ecological and biological characteristics, dominate and play the main role in the formation of communities.

Table 4 includes only species with high activity (3–4 points) at two or more railway stations. Based on Table 4, it can be seen that 21 species are found in all zones with the same degree of activity ("often" and "very often"). These are species that withstand strong heating of the substrate, aridity and anthropogenic pressure. Most of them are perennials adapted to the conditions of substrate mobility. For example, *Artemisia austriaca* Jacq., *Echium vulgare* L., *Elytrigia repens* (L.) Nevski, *Melilotus officinalis* (L.) Pall., widely distributed in Bashkortostan, belong to this group. At the same time, some species change the degree of activity in different climatic zones – for example, *Calamagrostis epigeios* (L.) Roth, *Chenopodium album* L., *Elytrigia repens* (L.) Nevski., *Puccinellia distans* (Jacq.) Parl, *Polygonum aviculare* s.l. more active in the Trans-Urals are *Conyza canadensis* (L.) Cronq., *Dracocephalum thymiflorum* L., *Setaria pumila* (Poir.) Schult., *S. viridis* (L.) Beauv. and others – in the Cis-Urals, a number of species reduce activity in the Mountain-forest zone. Some of the species with higher activity ("very often") in certain zones are anthropotolerant apophytes, for example, *Poa pratensis* L., *C. epigeios*, some are cosmopolitans, for which optimal edapho-climatic conditions for growth have been created on railway embankments, e. g. *C. canadensis*, *E. repens*.

A number of species, due to their ecological and biological characteristics, are confined to only one natural and climatic zone. So, 4 species gravitate to the Cis-Urals: *Chelidonium majus* L., *Erodium cicutarium* (L.) L'Hér., *Leonurus quinquelobatus* Gilib., *Eragrostis pilosa* (L.) Beauv.; to the Ural Mountains 5 mesophytic meadow and edge species – *Plantago lanceolata* L., *Carex contigua* Hoppe, *Poa palustris* L., etc.; to the Trans-Urals – 15 species typical of the steppes – *Bassia sedoides* (Pall.) Aschers., *Caragana frutex* (L.) C. Koch, *Stipa capillata* L., etc. Only one apophytic species (*Plantago lanceolata* L.) is confined to the Mountain-forest zone, while in other zones the number of these species is much larger.

We have found that 125 species of vascular plants are found exclusively on the railway embankments of one of the studied stations. Most of these species are included in the most common plant communities of the corresponding soil-climatic zones (*Plantago urvillei* Opiz, *Scorzonera purpurea* L. – steppe meadows of the Cis-Urals; *Alopecurus pratensis* L., *Origanum vulgare* L. – meadows and edges of the Mountain forest zone; *Alnus glutinosa* (L.) Gaertn., *Fragaria vesca* L. – forests of the Mountain forest zone; *Plantago salsa* Pall., *Glycyrrhiza korshinskyi* Grig. – meadows on saline soils of the Trans-Urals; *Gypsophila altissima* L., *Stipa lessingiana* Trin. & Rupr. – steppes of the Trans-Urals) and etc. Their appearance on railway embankments is accidental, and most often associated with the proximity of these ecotopes to dissemination sources. However, this group of species grows quite successfully on embankments, which sometimes allows them to be classified as active species. In this group, many species are weed-ruderal plants with a wide range, their appearance depends on the same random pattern of introduction – *Brassica campestris* L., *Rorippa austriaca* (Grantz) Bess., *Ambrosia psylostachya* DC. and others. They are active at the stage of colonization of the substrate free from vegetation. With the restoration of vegetation, these species lose their coenotic role, giving way to apophytes. Possessing low competitive ability, they have low activity rates in certain points.

A different number of species is associated with specific stations in different zones: 43 species at Sibay station, 28 at Inzer, 16 at Almukhametovo, 15 at Kandy, 14 at Buzdyak, and 9 at Beloretsk. Most of all (43 species) occurs at the Sibay station of the Trans-Urals, and less (9 species) at the Beloretsk station of the Mountain Urals. This is due to the fact that in the steppe zone of the Trans-Urals, the introduction of plants from the steppe landscapes surrounding the railroad becomes more important, which is facilitated by the openness of these habitats and the anemochory of many steppe species, and also, possibly, by the fact that there is a grain elevator near the Sibay station, from where diaspores of weeds can be introduced. The survival rate of ovules is also higher here due to the already mentioned similarity of many parameters of the steppe and railway ecotopes in terms of warming, aridity, and rockiness of the substrate. In the conditions of the Mountain Urals, the circle of potential settlers in technogenic ecotopes is narrowed due to the large difference in the conditions of slopes and natural habitats.

Table 5 shows species with a wide variation in occurrence (from 0 to 4) at different stations, which, in our opinion, depend on various, often random, factors. Thus, the absence of the invasive neophyte *Hordeum jubatum* L. at Kandy station is most likely due to the inaccessibility of dissemination sources. The absence of a number of ruderal species at the stations Inzer and Beloretsk, as well as Sibay and Almukhametovo, is explained by the fact that in the mountain forest zone and the steppe Trans-Urals, local species adapted to the soil and climatic conditions of the Mountain Urals and Trans-Urals become more important in the settlement of railway embankments. High persistence of *Amaranthus retroflexus* L., *Cirsium setosum* (Willd.) Bess. at the Sibay station, possibly is due to the proximity to the grain elevator.

The assessment of the similarity coefficient according to Sørensen-Chekanovskiy (Table 6) showed that the partial floras of all the studied stations are quite similar to each other (similarity coefficients are 0.50–0.71).

The relatively high floristic similarity of the stations Kandra and Buzdyak (0.71) is associated with their location in similar natural and climatic conditions of the western Cis-Urals. The lower coefficient of floristic similarity of Almukhametovo and Sibay stations with Inzer station (0.50 and 0.51) is associated with their location in different soil-climatic zones (mountain-forest and steppe).

Thus, the common core tends to be composed of active species, which are most often cosmopolitan or species with a wide ecological range. The differences are associated with the presence of species confined to one station or one or several stations, location in different climatic zones, the nature of the use of the station, the processing of the railway track, and the accidental introduction of plant seeds.

Table 5

Plant species activity (in points) at different railway stations

Species	Activity at railway stations					
	Kandry	Buzdyak	Beloretsk	Inzer	Sibay	Almukhametovo
Hordeum jubatum	–	4	3	3	4	4
Xanthium albinum	3	–	2	2	2	2
Lepidium ruderale	2	2	–	2	3	3
Atriplex tatarica	4	4	3	–	4	4
Geranium sibiricum	3	3	2	2	–	2
Potentilla norvegica	3	3	2	2	–	2
Amaranthus retroflexus	3	3	2	2	3	–
Cirsium setosum	3	3	2	2	4	–
Persicaria lapathifolia	–	–	3	3	2	2
Carduus crispus	3	–	2	2	4	–
Carduus acanthoides	3	3	–	–	4	4
Echinochloa crusgalli	3	3	–	2	1	–
Sonchus arvensis	3	3	2	–	2	–
Kochia scoparia	–	4	2	–	0	4
Amaranthus blitoides	2	–	–	–	3	3
Bromus squarrosus	3	–	–	3	3	–
Centaurea scabiosa	3	3	–	–	3	–
Poa compressa	3	–	–	–	–	3

Note: for the activity scale, see Table 4; a dash means no detected species at the station.

Table 6

Indicators of the similarity of the floras of railway stations according to the Sørensen-Czekanowski coefficient

Station name	Kandry	Buzdyak	Beloretsk	Inzer	Sibay	Almukhametovo
Kandy		0.71	0.60	0.58	0.57	0.59
Buzdyak	0.71		0.58	0.57	0.56	0.62
Beloretsk	0.60	0.58		0.66	0.53	0.60
Inzer	0.58	0.57	0.66		0.50	0.51
Sibay	0.57	0.56	0.53	0.50		0.58
Almukhametovo	0.59	0.62	0.60	0.51	0.58	

Conclusion

Thus, railway tracks, being special types of technogenic habitats (mobile gravel substrate, openness, strong warming, insolation, drainage), are constantly open for colonization by ruderal or natural plant species. Railways are active channels for transzonal plant migration. At the same time, a continuous vegetation cover cannot fully form on the railways due to difficult edapho-climatic conditions and constant or regular disturbance.

Partial floras of railway embankments of stations are composed of two components, depending on various factors affecting their composition. First, they have a rather large core of common active species, represented mainly by cosmopolitan and anthropotolerant species, which reflect the anthropogenic impact on this type of vegetation. Secondly, differences in their composition are mainly formed due to the types of local flora adapted to growing on specific railway substrates. These differences reflect the zonal nature of the vegetation surrounding the railways, as well as a number of random factors, which together also have a significant impact on the formation of the floristic composition of each particular railway station. The contribution of the zonal factor in different natural and climatic zones is different – the smaller the difference between the railway ecotopes and the landscape and vegetation conditions of the adjacent natural areas of the corresponding natural zone, the higher the participation of apophytic species in the formation of partial flora and vice versa. For railway floras, the contribution of accidental

skidding is also significant, which in some cases can even exceed the influence of the zonal factor.

The authors are grateful to the head of the UFA herbarium, PhD A.A. Muldashev and PhD, associate professor A.N. Puzyrev for help in species identification.

The work was carried out on the topic "Biodiversity of natural systems and plant resources of Russia: assessment of the state and monitoring of dynamics, problems of conservation, reproduction, increase and rational use" within the framework of the state assignment of the South Ural Botanic Garden-Institute of the South Ural Research Center of the Russian Academy of Sciences, No. 075-03-2022-001 dated 14.01.2022.

References

1. Bulokhov A.D. Termophilous communities of railway embankments in the South Nechernozemye of Russia (within the Bryansk region) // Bulletin of Bryansk department of Russian botanical society. 2017. No. 4 (12). P. 16–28 (in Russian). doi: 10.22281/2307-4353-2017-4-16-28

2. Artamonova V.S., Bortnikova S.B. Soil-like formation in technogenic landscapes: history of study, terminology, modern aspects (review) // Theoretical and Applied Ecology. 2017. No. 1. P. 4–13 (in Russian). doi: 10.25750/1995-4301-2017-1-004-013

3. Skvorcova I.V., Berezuckiy M.A. Railway embankment flora in the Southern Volga height // Povolzhskiy ekologicheskiy zhurnal. 2008. No. 1. P. 55–64 (in Russian).

4. Tolmachev A.I. Methods of comparative floristics and florogenesis. Novosibirsk: Naukova dumka, 1986. P. 11–90 (in Russian).

5. Tret'yakova A.S. The role of railroads in the formation of synanthropic flora in the Middle Urals // Russian Journal of Ecology. 2010. V. 41. No. 2. P. 123–128 (in Russian). doi: 10.1134/S1067413610020037

6. Senator S.A., Nikitin N.A., Saksonov S.V., Rakov N.S. Factors determining the formation of flora of the railways // Izvestia of Samara Scientific Center of the Russian Academy of Sciences. 2012. V. 14. No. 1–1. P. 261–266 (in Russian).

7. Senator S.A., Tohtar' V.K., Kurskoy A.Yu. Materials on the flora of the Belgorod Region railways // Vestnik Udmurtskogo universita. 2016. V. 26. No. 4. P. 50–59 (in Russian).

8. Arepieva L.A. The vegetation on railway embankments of the Kursk Region // Vegetation of Russia. 2017. No. 30. P. 3–28 (in Russian). doi: 10.31111/vegrus/2017.30.3

9. Bochkin V.D., Vinogradova Yu.K. Flora of the railways in Moscow city // Vestnik Permskogo universiteta. 2016. No. 2. P. 89–95 (in Russian).

10. Muldashev A.A., Husainova S.A., Husainov A.F. New finds of adventive plants in the Republic of Bashkortostan // Izvestia of Samara Scientific Center of the Russian Academy of Sciences. 2014. V. 16. No. 1. P. 69–73 (in Russian).

11. Burda R.I., Tokhtar V.R. Invasion, distribution and naturalization of plants along railroads of the Ukainian south-east // Ukrainian Botanical Journal. 1992. V. 49. No. 5. P. 14–18.

12. Vogel P. Bemerkenswerte Pflanzenfunde auf den Bahnanlagen der Deutschen Bundesbahn im Stadtgebiet von Karlsruhe // Carolinea. 1996. V. 54. P. 37–44 (in German).

13. Czarna A. Vascular flora of the railway station in Jarocin (Western Poland) // Roczniki Akademii Rolniczej w Poznaniu. CCCLXXIII. Bot.-Stec. 2005. V. 9. P. 39–46.

14. Alessandrini A. Flora degli ambienti ferroviari. Lo Scalo San Donato a Bologna // Quaderni del Museo Civico di Storia Naturale di Ferrara. 2016. V. 4. P. 37–44 (in Italian).

15. Wrzesie M., Jachuła J., Denisow B. Railway embankments – a refuge areas for food flora, and pollinators in agricultural landscape // Journal of Apicultural Science. 2016. V. 60. No. 1. P. 97–110. doi: 10.1515/jas-2016-0004

16. Kadil'nikov I.P., Cvetaev A.A., Smirnova E.S., Hismatov M.F. Physical-geographical regionalization of the Bashkir ASSR. Ufa: Kytap, 2005. 212 p. (in Russian).

17. The Flora of Eastern Europe. V. 9 / Ed. N.N. Tsvelev. Sankt-Peterburg: Mir i semya-95, 1996. 451 p. (in Russian).

18. The Flora of Eastern Europe. V. 10 / Ed. N.N. Tsvelev. Sankt-Peterburg: Mir i semya; Izdatelstvo SPKhFA, 2001. 670 p. (in Russian).

19. The Flora of Eastern Europe. V. 11 / Ed. N.N. Tsvelev. Moskva, Sankt-Peterburg: Tovarishchestvo nauchnykh izdaniy KMK, 2004. 535 p. (in Russian).

20. The key to higher plants of the Bashkir ASSR. Moskva: Nauka, 1988. 316 p. (in Russian).

21. The key to higher plants of the Bashkir ASSR. Moskva: Nauka, 1989. 375 p. (in Russian).

22. Cherepanov S.K. Vascular plants of Russia and adjacent states (within the former USSR). Sankt-Peterburg: Mir i semya, 1995. 992 p. (in Russian).

23. Yurcev B.A. Theoretical and methodological problems of comparative floristry // Materialy 2 Rabochego soveshchaniya po sravnitel'noy floristike. Leningrad: Nauka, 1983. 270 p. (in Russian).

24. Panasenko N.N. Activity of some invasive species on the territory of the Bryansk region // The study and protection of the flora of Central Russia: Materialy VII nauch. soveshch. po flore Sredney Rossii. 2011. P. 108–111 (in Russian).

25. Baranova O.G., Puzyrev A.N. Synopsis of the flora of the Udmurt Republic (vascular plants). Moskva; Izhevsk: Institut kompyuternykh issledovaniy, 2012. 212 p. (in Russian).