Florogenetic signals with increasing tourist activity in the Pribaikalsky National Park

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Abstract. The article is devoted to the topical issue of studying and conservation of biodiversity of the unique natural territory of the western shore of Lake Baikal, which is located in the northern part of the Small Sea. Small Sea. The increase in tourist flow will change the habitats habitats of red-listed and endemic species of the Pribaikalsky National Park (PNP). National Park (PNP). Climatic and edaphic characteristics of the study area are given. Ecological characteristics and floristic richness ecological characteristics and floristic richness of the habitats of plant species in the PNP. Habitats of plant species in the PNP. Describes plant communities successional type plant communities in anthropogenically disturbed areas are described. Causes of anthropogenic impact and recommendations for restoration of natural communities are given. Restoration of natural communities. An assessment is made observed changes and the effect of human activity. Materials of the research are applicable for creation of informational basis for decision-making on prevention of negative consequences of construction of tourist facilities and ecological safety of Lake Baikal.

1 Introduction

The floristic richness of plant communities is important for the self-sustaining strategy of natural landscapes. The florogenetic signal is the information contained in the vegetation cover of a particular area and is related to its biodiversity and ecological features. This signal can be studied using a variety of methods, including studying the species composition of vegetation, examining its phytosociological structure, analysis of biogeocenoses, etc. [1-4]. An important source of information on the florogenetic signal can be scientific articles, publications in specialized journals and reports on the results of expedition research. The relevance of this information is that it helps to understand the

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mechanisms of interaction of plant life with the environment and the principles of vegetation cover formation in specially protected areas. Statistical data on the tourist flow to Lake Baikal show that it has been growing annually for the last few years, that recently it has been growing annually by 40%. More than 3 million people visited Lake Baikal in 2023 about two thirds of this flow came to the Pribaikalsky National Park. As a result, of recreational activities can fragment or destroy the habitats of organisms of fauna and flora, resulting in changes in species richness, abundance and community structure. Deviations in composition and structure from the native state at a given point in time will allow the determination of species richness, abundance and community structure. State at a certain point in time will allow to determine, the degree of disturbance of communities of the study area and, accordingly, the conservation of natural complexes. Assessment of the state of biodiversity is carried out by the assessment of the state of biodiversity is carried out in several key groups, which are good indicators of the state of natural conservation of landscapes. The state of natural conservation of landscapes: the basis for the changes in of plant communities are based on vascular plants [5,6]. Purpose of the work: to analyze the observed changes in biodiversity in the Pribaikalsky National Park, to create an informational basis for the prevention of negative consequences anthropogenic activities on territory Pribaikalsky National Park.

2 Materials and Methods

The program of biological monitoring works in Pribaikalye in 2019-2020 consisted of two stages: field studies and desktop processing of collected materials. The first stage field research - collection of information on the existing infrastructure of the site, field surveys of the site, collection of data on plant communities, search for rare plant species, detailed study of the flora. The second stage – cameral works on determination of the collected material, development of nature protection recommendations and preparation of the final report. Recommendations and preparation of the final report. Field work was carried out in the summer period of 2021-2022. In the course of research descriptions and visual assessment of vegetation were carried out on sample areas with the area of 100 square meters within the recreational zone, selected depending on the differences in topography, biotope, and vegetation cover representative of the study area as a whole. A census of the species composition of the flora of the surveyed area with collection of herbarium material of those plants, the species belonging to which needed to be specified.

3 Results and Discussion

B In the zone of influence of the facility, ruderal communities and unbroken vegetation clusters were identified at sites near buildings, dirt paths and road slopes. slopes of the highway. All steppe cenoses of the strip adjacent to the survey area are at different stages of pasture digression, which is expressed in the impoverishment of the species composition, presence, and in some places significant abundance of weed species plants. On a significant area in the adjacent strip the vegetation cover is destroyed due to regular passage of motor vehicles outside the main route. The adjacent area includes the Zama Lake, a wide pebble spit from the the rocky slopes of Cape Aral with a channel between the Olkhon Island and Baikal, and to the northern, is bounded from the west by a highway with the village of Zama,. Visited area in the form of a pebble spit separating pebble spit up to 20 m wide and about 1200 m long, the coastline along the eastern and southern parts of the lake 800 m long is 4.0 ha. Landscapes are categorized as terraces and plumes fine soddy-grass steppes (Daurian type) on soddy-meadow, chestnut soils and black soil of podzolized and ordinary

soils, sometimes on residual and meadow solonts. The area is categorized under the recreational use classification of the following «settlement» conformity class. The area is characterized by a markedly altered and in some places natural looking nature, human presence is evident only by structures on the western bank, remains of buildings, visible traces of cattle grazing. The condition of vegetation is satisfactory, with noticeable replacement by synanthropic species. The level of use of the territory during the day is high, the level of level of difficulty is low and there is no risk of occupancy. A significant factor utilization of the coastal strip is the presence of a road network for the passage of vehicles, the village of Zama, recreation centers.

Indicators of the ecological condition of the natural area were surveyed. Conservation indicators show how successful are the conservation measures and how well or poorly the nature at the recreational use site nature is in good or poor condition at the recreational use site. Load indicators indicate the intensity of human activity - e.g., the extent of utilization of renewable natural resources, the succession of plant communities, and the number of plant species. Plant communities and the number of plant species. During the observed period, 17 tent sites along the southern shore of Lake Zama and 5 sites on the shingle spit, 7 exits to the water. The indicator for assessing the achievement of the objective «The favorable status of species and habitats is ensured». Favorable status of species and habitats, landscape diversity, habitats function, as an integrated ecological network is the improved status of the number of species. The recreational capacity of the territory is estimated, to be 190 people (up to 10 people in 19 parking lots). Corrective factors are the extent of the spit at the flood lake, frequent presence of grazing cattle and horses, presence of pebble beach, length (more than 1500 m).

In accordance with Art. 17 of the Federal Law of 01.05.1999 No. 94-FZ "On Protection of Lake Baikal" (State registration of objects having a negative impact on Lake Baikal). Lake Baikal (State registration of objects that have a negative impact on the environment of the Baikal natural territory) the recreation center is a part of the Baikal natural territory. Impact on the environment of the Baikal natural territory) the recreation center may be categorized, as Category IV of objects that do not have a noticeable environmental impact. The facility is subject to federal environmental supervision. Activities at the recreation center are associated with the appearance of production waste, finished food products and dishes belonging to the V class of hazard. Within the boundaries of the recreation zone, indigenous plant communities have been destroyed. B At present, the vegetation is represented by regenerative successions.

The following plant communities have been identified:

- Narrow-leaved mint meadow.
- Kostretsovye steppe meadow.
- Grass-grass- dandelion meadow.
- Wheatgrass meadow.
- Grass-grass-grass-wormwood steppe.
- Artemisia leymus steppe.
- Artemisia-grass-grass-grass steppe.
- Leymus steppe.
- Oxeye-mixed grass-grass steppe.
- Hard sap-sedge steppe.
- Cold wormwood steppe.
- Fragments of winged sagebrush steppe.
- Larch steppe steppe steppe grassy-grassy-grassy steppe.
- Rhododendron larch forest.

In the investigated area around the tourist centers, unenclosed pioneer vegetation groups, thickets of the plant groupings, thickets of ruderal species and communities of a mixture of steppe and ruderal plants were described. To the west, north, and partially east of the campground. is adjoined by pine-larch rhododendron forest, and from the south by a grassy-grass steppe. A total of 142 species of vascular plants were recorded on the territory, in 34 families.

Table 1. List of species of vascular plants on the territory of the tourist base of the village Zama.

Family name	Species name	Area	Individual groups	Abundance on the Drude scale	Projective coverage as a percentage
Pinaceae	Larix sibirica Ledeb.	W		sol	2
Pinaceae	Pinus sibirica Du Tour	W		sol	3
Pinaceae	Pinus sylvestris L.	W		sol	3
Poaceae	Achnatherum sibiricum (L.) Keng ex Tzvelev	A			5
Poaceae	Agropyron cristatum (L.) P. Beauv.	A		sol	3
Poaceae	Agrostis trinii Turcz.	A		sol	4
Poaceae	Bromopsis inermis (Leysser) Holub	W	I	sol	5
Poaceae	Bromopsis karavajevii (Tzvelev) Czer.	A		sol	5
Poaceae	Critesion brevisubulatum (Trin.) A. Love - *Hordeum brevisubulatum* (Trin.) Link	A	I	sol	4
Poaceae	Elymus sibiricus L.	A	I	sol	4
Poaceae	Elytrigia repens (L.) Nevski	W	W	cop1	25
Poaceae	Festuca lenensis Drobov	A			4
Poaceae	Festuca ovina L. s.str.	W			3
Poaceae	Festuca rubra L. s.str.	W			5
Poaceae	Koeleria cristata (L.) Pers. s.str.	W		sol	1
Poaceae	Leymus chinensis (Trin.) Tzvelev	A		sp	4
Poaceae	Poa angustifolia L.	W		sol	4
Poaceae	Poa botryoides (Trin. ex Griseb.) Roshev.	A		sol	2
Poaceae	Poa palustris L.	W		sol	2
Poaceae	Stipa krylovii Roshev.	A		sol	3
Cyperaceae	Carex argunensis Turcz. ex Trev. s. str.	A		sol	2
Cyperaceae	Carex duriuscula C.A. Meyer	E		sp	7
Cyperaceae	Carex korshinskyi Kom.	A		sp	4
Cyperaceae	Carex pediformis C.A. Meyer	E		sol	3
Alliaceae	Allium ramosum L.	A		sol	2
Alliaceae	Allium senescens L.	E		sol	2
Alliaceae	Allium splendens Willd. ex Schultes et Schultes f.	SS		sol	1
Alliaceae	Allium stellerianum Willd.	SS		sol	1
Iridaceae	Iris humilis Georgi	E		sp	7
Salicaceae	Populus suaveolens Fischer	A		sp	5
Betulaceae	Betula pendula Roth.	E		sp	7
Urticaceae	Urtica cannabina L.	SS	W	sp	4
Urticaceae	Urtica dioica L.	E	W	cop1	15
Polygonaceae	Aconogonon angustifolium (Pallas) Hara	A		sp	5
Polygonaceae	Aconogonon divaricatum (L.) Nakai ex Mori	A	I	sol	3
Polygonaceae	Persicaria maculosa S.F. Gray	E	W	cop1	10
Polygonaceae	Polygonum aviculare L.	E	W	cop1	15
Polygonaceae	Rumex acetosella L.	E		sp	7
Polygonaceae	Rumex pseudonatronatus (Borb.) Borb. ex Murb.	E	W	cop1	10
Polygonaceae	Rumex thyrsiflorus Fingerh.	E		sol	3
Chenopodiaceae	Chenopodium album L.	E	W	cop1	12
Caryophyllaceae	Arenaria meyeri Fenzl - *Eremogone meyeri* (Fenzl) Ikonn.	SS		sol	3
Caryophyllaceae	Cerastium arvense L.	E		sol	3
Caryophyllaceae	Dianthus versicolor Fischer ex Link	E		sol	3
Caryophyllaceae	Silene amoena L. - *S. repens* Patrin.	A		sp	4
Caryophyllaceae	Stellaria dichotoma L.	SS		cop1	10
Ranunculaceae	Delphinium grandiflorum L.	A		sol	3
Ranunculaceae	Leptopyrum fumaroides (L.) Reichenb.	SS	W	sp	4
Ranunculaceae	Pulsatilla patens (L.) Mill.	E		sp	5
Ranunculaceae	Pulsatilla turczaninovii Krylov et Ser.	A		sol	1
Ranunculaceae	Thalictrum foetidum L. s. l.	E		sp	5
Papaveraceae	Chelidonium majus L.	E	W		10
Papaveraceae	Papaver nudicaule L.	SS		sp	5

Family name	Species name	Area	Individual groups	Abundance on the Drude scale	Projective coverage as a percentage
Brassicaceae	Alyssum lenense Adams	E		sp	4
Brassicaceae	Arabis pendula L.	E	W	sp	5
Brassicaceae	Clausia aprica (Stephan) Korn.- Tr.	E		sol	3
Brassicaceae	Descurainia sophia (L.) Webb. ex Prantl	E	W	cop1	12
Brassicaceae	Draba nemorosa L.	E	I	sp	5
Brassicaceae	Erysimum hieracifolium L.	E		sp	4
Brassicaceae	Isatis oblongata DC.	SS		sol	2
Brassicaceae	Lepidium ruderale L.	E	W	sol	4
Brassicaceae	Noccaea cochleariformis (DC.) A. et D. Love - *Thlaspi cochleariforme* DC.	A		sol	3
Brassicaceae	Ptilotrichum tenuifolium (Stephan ex Willd) C.A. Meyer	SS		sol	3
Brassicaceae	Sisymbrium heteromallum C.A. Meyer	A		sp	4
Crassulaceae	Aizopsis aizoon (L.) Grulich. - *Sedum aizoon* L.	A		sp	5
Crassulaceae	Orostachys malacophylla (Pallas) Fischer	A		sol	3
Crassulaceae	Orostachys spinosa (L.) C.A.Meyer	A		sol	2
Saxifragaceae	Saxifraga spinulosa Adams.	A		sp	4
Rosaceae	Chamaerhodos altaica (Laxm.) Bunge	SS		sp	4
Rosaceae	Chamaerhodos erecta (L.) Bunge	A		sol	3
Rosaceae	Chamaerhodos grandiflora (Pallas ex Schultes) Bunge	SS		sol	2
Rosaceae	Cotoneaster melanocarpus Fischer ex Blytt	E		sol	2
Rosaceae	Pentaphylloides fruticosa (L.) O. Schwarz	E		sol	2
Rosaceae	Potentilla acaulis L.	A		sp	5
Rosaceae	Potentilla bifurca L.	E	P	cop1	15
Rosaceae	Potentilla evestita Th. Wolf	A		sol	3
Rosaceae	Potentilla nivea L. - *P. arenosa* (Turcz.) Juz.	E		sol	3
Rosaceae	Potentilla norvegica L.	E	W	sol	3
Rosaceae	Potentilla paradoxa Nutt. ex Torrey	E	W	sol	2
Rosaceae	Potentilla sericea L.	A		sol	3
Rosaceae	Potentilla tanacetifolia Willd. ex Schlecht.	SS		sol	3
Rosaceae	Sanguisorba officinalis L.	E		sp	4
Rosaceae	Spiraea media Franz Schmidt	E		sp	5
Fabaceae	Astragalus austrosibiricus Schischkin	SS		sol	2
Fabaceae	Astragalus inopinatus Boriss.	SS		sol	2
Fabaceae	Lathyrus humilis (Ser.) Sprengel	A		sol	3
Fabaceae	Lupinaster pentaphyllus Moench. - *Trifolium lupinaster* L.	E		sp	5
Fabaceae	Oxytropis coerulea (Pallas) DC.	SS		sol	3
Fabaceae	Oxytropis strobilacea Bunge	SS		sol	3
Fabaceae	Oxytropis turczaninovii Jurtzev	SS		sol	1
Fabaceae	Trifolium pratense L.	E	I	cop1	20
Fabaceae	Vicia cracca L.	E		cop1	17
Fabaceae	Vicia nervata Sipl.	SS		cop1	10
Geraniaceae	Geranium pratense L. s. str.	E		sp	6
Geraniaceae	Geranium sibiricum L.	E	W	sp	7
Polygalaceae	Polygala tenuifolia Willd.	A		sp	5
Violaceae	Viola brachyceras Turcz.	A		sol	2
Violaceae	Viola dissecta Ledeb.	A		sol	2
Onagraceae	Chamerion angustifolium (L.) Scop.	E		sp	4
Umbelliferae	Bupleurum scorsonerifolium Willd.	SS		sol	3
Umbelliferae	Carum carvi L.	E		sol	3
Umbelliferae	Ferulopsis hystrix (Bunge) Pimenov	SS		sol	2
Umbelliferae	Kitagawia baicalensis (Redow. ex Willd.) Pimenov	SS		sol	1
Ericaceae	Rhododendron dauricum L.	A		cop1	15
Ericaceae	Vaccinium vitis-idea (L.) Aurorin	E		cop1	23
Primulaceae	Androsace incana Lam.	SS		sp	4
Primulaceae	Androsace lactiflora Fischer ex Duby	A		sol	3
Primulaceae	Androsace septentrionalis L.	E		sol	2
Limoniaceae	Goniolimon speciosum (L.) Boiss.	E		sp	4
Convolvulaceae	Convolvulus arvensis L.	E	W	sol	3
Boraginaceae	Amblynotus rupestris (Pallas ex Georgi) M.Popov ex Serg.	SS		sol	2
Boraginaceae	Lappula consanquinea (Fischer et Meyer) Guerke	E	W	sol	2
Lamiaceae	Leonurus deminutus V. Krecz.	E	W	sol	3
Lamiaceae	Phlomis tuberosa L.	E		sol	3

Family name	Species name	Area	Individual groups	Abundance on the Drude scale	Projective coverage as a percentage
Lamiaceae	Schizonepeta multifida (L.) Briq.	A		sol	3
Lamiaceae	Thymus baicalensis Ser.	SS		cop1	35
Scrophulariaceae	Linaria vulgaris Miller	E		sp	6
Scrophulariaceae	Pedicularis rubens Stephan ex Willd.	A		sp	5
Scrophulariaceae	Veronica incana L.	E		sol	2
Plantaginaceae	Plantago depressa Willd.	A		sp	4
Plantaginaceae	Plantago media L.	E	P	cop1	10
Rubiaceae	Galium boreale L.	E		sp	4
Rubiaceae	Galium verum L.	E		sp	5
Valerianaceae	Patrinia sibirica (L.) Juss.	A		sol	3
Asteraceae	Achillea asiatica Serg.	A		sp	5
Asteraceae	Artemisia commutata Besser	A			8
Asteraceae	Artemisia dracunculus L.	E		sp	7
Asteraceae	Artemisia frigida Willd.	E		sp	6
Asteraceae	Artemisia gmelinii Weber ex Stechm.	A		sol	1
Asteraceae	Artemisia monostachya Bunge ex Maxim.	SS		sol	3
Asteraceae	Artemisia palustris L.	A	P	sp	8
Asteraceae	Artemisia scoparia Waldst. et Kit.	E	W	sp	5
Asteraceae	Artemisia sieversiana Willd.	E	W	sp	6
Asteraceae	Artemisia tanacetifolia L.	SS		sol	3
Asteraceae	Artemisia vulgaris L.	E	W	cop1	12
Asteraceae	Aster alpinus L.	A		sp	4
Asteraceae	Chrysanthemum zawadskii Herbich - *Dendranthema zawadskii* (Herb.) Tzvelev	A		sol	3
Asteraceae	Erigeron acris L. = *E. acer L.*	W		sol	3
Asteraceae	Fornicium uniflorum (L.) Zuev - *Rhaponticum uniflorum* (L.) DC.	A		sol	2
Asteraceae	Heteropappus altaicus (Willd.) Novopokr.	A		sp	4
Asteraceae	Leontopodium ochroleucum subsp. conglobatum (Turcz.) V. Khan.	SS		sol	5
Asteraceae	Scorzonera austriaca Willd.	E		sol	3
Asteraceae	Sonchus arvensis L.	E	W	sp	4
Asteraceae	Taraxacum printzii Dahlst.	SS			7
Asteraceae	Youngia tenuifolia (Willd.) Babc. et Stebbins	A		sp	4

Designations in the table: Area: E – is a wide-area species, distributed circumpolarly or in Eurasia; A – Asian species; SS – is a species with a habitat in the south of Siberia, entering Northern Mongolia; EN – endemic. Individual groups: W – is a weed plant; I – is an adventitious plant; P – pasture is a plant that increases its abundance under high pasture or recreational load.

On the site, habitats of two rare plant species were identified: Cotoneaster brilliant - endemic to the Baikal region, listed in the Red Book of the Russian Federation (category 3) and the Red Book of the Irkutsk Region (category 3); Dwarf lily – listed in the Red Book of the Irkutsk region (category 3) [7-9].

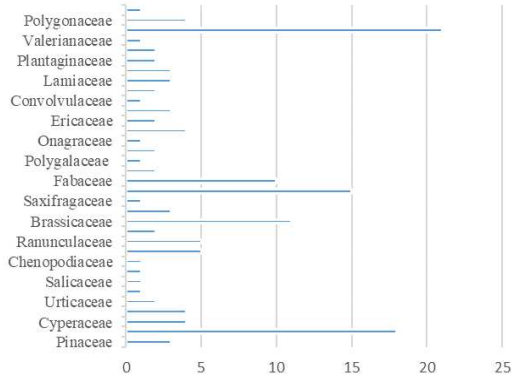

Fig.1. Diagram of the relationship between classes and species of vascular plants on the territory of the tourist base of the village Zama.

Floristic research in the Baikal natural area iscarried out by various scientific and environmental organizations and rather intensively by various scientific and nature conservation organizations and groups [10]. Comparative assessments of this natural territory in botanically are not comforting. The construction of new objects The construction of new recreational facilities is still at the planning stage, and the vegetation communities are already experiencing significant stresses associated with the consequences of organized tourism. organized tourism. The already existing flow of motorized tourists to a warm lake where they can relax and swim and to a healing spring with mineral water that can be drunk has had a noticeable impact on the fragile Siberian flora [11].

One of the most urgent problems in environmental research is the identification of the anthropogenic factor in the pollution of natural fresh waters. Lake Baikal is characterized by spatial-temporal heterogeneity in the development of plankton (patching phenomenon), including microorganisms. In view of the absence of a permanent system of monitoring observations of microbial indicators for Lake Baikal, we can conditionally accept the given values as indicators of the quality of Baikal water. The available data show that the microbial background of Lake Baikal is heterogeneous and depends largely on the districtof the lake, inflowing tributaries, on the use of the reservoir and coastal zones by humans. Microorganisms are able to respond to the entry of pollutants into ecosystems by producing restriction endonuclease enzymes. It was established that antibiotic-resistant strains were detected at all stations located in places of recreational location. The number of strains isolated from the water of the coastal zone of Lake Baikal in the area of the village of Zama are resistant to six or more antibiotics. This amounted to 12.2%, and in the area of Baikalsk and Slyudyanka – 17.3% of the number of studied bacterial strains [12].

To reduce the negative impact on the vegetation cover it is necessary to Implement the recommendations of ecologists: passage and travel of employees and recreationists only on existing sidewalks and roads; provide a resting regime in the non-recreational areas for the natural process to take place. Areas, which are not recreation sites, for the natural process of restoration of vegetation cover; to exclude littering of the territory of the campground household garbage; observe fire safety. Measures to restoration of natural communities or some of their lost properties - species diversity; exclude littering of the territory of the resort with household garbage; observe fire safety. properties, such as species diversity, longevity, individual plant associations: restoration of disturbed natural ecological systems by planting or sowing of herbaceous plants, shrubs; removal of alien plants; elimination of alien plants; and alien plants; elimination of unauthorized picnic sites, recreation areas and trails.

4 Conclusion

The vegetation cover on the territory of the PNP has been transformed, due to long-term anthropogenic impact: construction of buildings and communications, exploitation of Anthropogenic impact: construction of buildings and communications, exploitation. Currently, the vegetation is at the stage of restoration. Available protected and rare plant species, especially the population of dwarf lily, require careful management of the species' habitats, which are recommended to be preserved by fencing and fencing. It is recommended to conserve by fencing and introductions to less technologically affected areas. To preserve Baikal water, the construction of treatment facilities is recommended.

References

1. S.A. Timokhina, N.V. Frizen, N.V. Vlasova, V.V. Zuev, N.K. Kontonyuk, K.S. Baykov, Flora of Siberia V. 6 Portulacaceae - Ranunculaceae (Nauka, Siberian Publishing Co, Novosibirsk, 1993)
2. O. A. Belykh, G. D. Rusetskaya, Forestry Bulletin, **23**, **1**, 5–13 (2019)
3. V.M. Starchenko, G.F. Darman, Red Data Book of Amur Region: Rare and endangered species of animals, plants and fungi : Official edition. - 2nd edition, revised, revised and supplemented. Blagoveshchensk : Far Eastern State Agrarian University, 363 (2020)
4. S.V. Pushkarsky, V. G. Pashinsky, T.N. Povetyeva, N.V. Nesterova, N.N. Gaidamovich, Vegetable Resources, **42**, **2**, 115–119 (2006)
5. T.V. Karyagina, E.A. Gukasova, D.I. Bairamashvili, Plant Physiology, **58**, **4**, 611– 616 (2011)
6. O.A. Pokhabova, Structure of cenopopulations and morphological features of *Thalictrum minus* L. of different ecological and phytocoenotic confinement in Southern Baikal Region, Plant resources, **28**, **2**, 14 (1992)
7. V. Dushenkov, I. Raskin, Plant Physiology, **55,** 624–628 (2008)
8. T.B. Karyagina, O.A. Gaevskaya, E.A. Gukasova, T.V. Timchenko, D.I. Bairamashvil, Plant Physiology, **54**, 300–305 (2007)
9. S.S. Bhojwani, M.K. Razdan, Plant tissue culture: theory and practice, a revised edition/ Amsterdam, Lausanne, New York, Oxford, Shannon, Tokeo: Elsevier, 767 (1996)
10. R.A. Dixon, N.L. Paiva, Plant Cell. **7**, 1085–1097 (1995)
11. I.A. Tarchevskii, Signaling systems of plant cells (Nauka, Moscow, 1993)
12. E.V. Verkhozina, V.A. Verkhozina, O.A. Belykh, Bulletin of Baikal State University, **33**, **4**, 755–761 (2023)