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DESCRIPTIVE STUDY OF THE FLORA OF THE "RELIC OAKS" LANDSCAPE RESERVE (EASTERN SIBERIA) IN THE CONTEXT OF THE PROTECTED AREA IMPORTANCE FOR MAINTAINING BIODIVERSITY

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Abstract

The article shows the importance of specially protected areas for preserving the gene pool of rare and useful plants in Siberia on the example of the "Relic oaks" state landscape reserve. The landscape reserve is located on the territory of Eastern Siberia (Russia), on the two large floristic areas of Holarctic: Circumboreal and East-Asian. During the study, 696 species of higher vascular plants have been identified in the territory of the landscape reserve. The prevailing families are following: Asteraceae, Poaceae, Ranunculaceae, Rosaceae, Cyperaceae, Fabaceae, Caryophyllaceae, Brassicaceae, Apiaceae, and Scrophulariaceae. In the territory of landscape reserve, 4 floral complexes were identified: alpine, forest, steppe and meadow-alluvial, as well as 10 chorological groups. The feature of the flora was prevalence of forest and steppe plant species with the East Asian type of habitat. By the number of species, herbaceous plants in the landscape reserve dominate over arboreal plants, and shrubs have the largest share among arboreal plants. The spectrum of life forms of plants shows the climatic conditions of the territory at the border of large floral areas and zones of vegetation. On the studied territory, there are 171 species of higher vascular plants (24.5% of the total flora composition in the landscape reserve), are rare and protected in various regions of Siberia.

Key words: Eastern Siberia, Trans-Baikal Territory, Relic Oaks State Reserve, Flora, Taxonomy, Chorology, Life form, Rare plants.

Introduction

The main treasure of Siberia is taiga - the largest area of extratropical forests (Syroechkovskiy & Rogacheva, 1999) characterized by rich and diverse resource potential and gene pool of plants that are of interest for various sectors of the economy.

Many species of plants of the natural flora of Siberia have polyfunctional purpose. There are many species that contain the most valuable biologically active substances, which may be used in medicine, food industry and fodder production. Many species of the natural flora feature high decorative qualities, frost and drought resistance, which makes them promising in tree and shrub planting and landscape architecture.

However, active economic development of territories, construction of settlements, roads, mining and oil-and-gas industry enterprises are being done in many regions of Siberia for many years. As a result, the areas occupied by natural landscapes are significantly reducing. Many plant species are becoming rare and petering out. Since biodiversity is considered to be the main condition for the stability of any ecosystem and the biosphere as a whole, its preservation is the most urgent problem of the modern ecology (Rands *et al*., 2010; Raven *et al*., 2011; Zlobin *et al*., 2013; Convention on Biological Diversity, 2012).

The most efficient way to preserve biodiversity is organizing specially protected natural territories. In Siberia, there are today over 240 protected natural areas of main categories (nature reserves, national and natural parks, landscape reserves), 577 natural landmarks and 19 botanical gardens and arboretum parks (Kalikhman *et al*., 2012), the main mission of the is to preserve biodiversity of the Siberian flora. As a rule, in the protected areas there is no anthropogenic burden, thus allows studying the biology and ecology of the species in their natural habitats, and monitoring their populations over long periods of time.

Specially protected areas established at the junction of floral kingdoms or zones of vegetation play the role of "sanctuaries" - clusters of rare species (Zlobin *et al*., 2013). Very often SPNRs (Specially Protected Natural Reservations) are established with the aim of preserving specific species of plants located at the border of the habitat or isolated from the main habitat of the populations of often relict nature.

This article shows the data about studying the flora of the "Relic oaks" protected landscape established with the aim of preserving local population of *Quercus mongolica* Fisch. ex Ledeb. isolated from the main habitat of the species (Chernova, 2016). This territory is located at the border of two major floristic regions of Holarctic, and at the border of two vegetation zones - the forest and forest-steppe ones.

The territory of the "Relic oaks" state nature reserve is located in middle latitudes between 52°57'-52°32' N and 119°58'-120°21' E, in Eastern Siberia, and belongs to the Pacific ocean basin. In the administrative-territorial division of the Russian Federation, the reserve is located in the South-East of the Transbaikal region, in the area bordering the People's Republic of China.

The topography of the study area is dominated by middle altitudes, in some places - by low-mountain relief dissected by river valleys and their tributaries. The climate in the territory is distinctly continental. Summer lasts 3.5-4, winter - 6 months, the frost-free period is 2.5-3.5 months (the average of 97 days). Winters are cold, with average January temperature of -30.1°C. Summer is relatively warm, average July air temperature is 18.9°C. The average annual temperature is -2.9°C. The height of snow cover ranges from 10-15 cm (in dry winters) to 25-30 cm (in snowy winters) (Weather, 2017). The negative

value of the average annual temperature contributes to the widespread development of shallow (1-2.5 m) permafrost (mostly on the Northern slopes and in the river valleys).

In accordance with the biogeographical zoning (Takhtajan, 1978), this area is situated at the border of two major floristic regions of Holarctic: Circumboreal and East-Asian, and belongs to the region with predominance of the southern taiga. The flora of this region is rich with East-Asian species, some of which are met only here (*Quercus mongolica*, *Siphonostegia chinensis* Benth., *Cypripedium shanxiense* S.C.Chen) (Korsun *et al*., 2012; Chernova, 2012; Chernova *et al*., 2016; Nobis *et al*., 2016).

Materials and Methods

The article presents the data about taxonomic composition, geographical analysis of flora in the "Relic oaks" landscape reserve and the spectrum of life forms of identified species.

Vegetation of any area is mainly reflected by its floristic structure (Shaheen *et al*., 2016). The basis of studying the floristic structure of the landscape reserve were the data of long-term field research of the area (2008-2013), as well as some herbarium collections in Siberia (IRK, Irkutsk, NSK, Novosibirsk). Names of the species were updated by The Plant List electronic database (The Plant, 2017). During the analysis of flora, the classic methods proposed in works of V.M. Shmidt (1980), L.I. Malyshev (1975) were used.

Studying life forms is a critical aspect of floristic research, since the range of life forms is closely associated with climatic conditions and topography of the studied region (Sarmiento & Monasterio, 1983; Duran & Hamzaoglu, 2002; Mack, 2003; Battalha & Martins, 2004; Carvalho da Costa *et al*., 2007; Malik *et al*., 2007). Life forms of plants were allocated based on types of perenating buds location (Raunkiaer, 1934), or based on the complex of morphological features of above-ground and underground organs of plants (Serebryakov, 1962, 1964; Barkman, 1988).

In our work we relied on works of I.G. Serebryakov (1962, 1964) who regarded a life form as integrity of adult individuals of a certain species in specific vegetation conditions that had a certain habitus. In allocation of life forms, various biological and morphological characteristics of plants are taken into account: growth form, life duration, nature of root systems, etc. Life forms of lythrum-like, horsepine-like and fern-like plants are not considered in the I.G. Serebryakov's system, therefore, focusing on a number of authors (Shorina & Ershova, 1990; Prudnikova & Chepinoga, 2012), we regarded them as herbaceous polycarpous plants.

Geographical analysis is another part of the floristic studies, which shows geographical distribution of species and their environmental adaptation (Esmailzadeh *et al*., 2006), as well as regularities of flora formation in any territory. These data are valuable for identifying centers of phytodiversity, preservation of species in danger of extinction and recovery of disturbed plant communities (Gonzalez & Martin, 2006). The geographical analysis of the flora uses the scheme of dividing units into floristic complexes and ecological-geographical elements developed by L. I. Malyshev & G. A. Peshkova (1984).

Results and Discussion

Taxonomic composition: The studied landscape reserve is characterized by rich phytodiversity (Chernova, 2016). In the relatively small area of slightly over 30 thousand hectares, we detected 696 species and subspecies of higher vascular plants that belonged to 5 divisions, 8 classes, 94 families and 347 genera. Species distribution by major systematic groups is characteristic of the circumboreal floristic region (Table 1).

Division Pinophyta is represented by 5 species that constitute less than 1% of the entire flora in the territory, but play an important ecological role in many plant communities of the landscape reserve. The basis of the flora consists of species of metasperms (95.7%), of which 72.0% are dicotyledonous plants, 23.7% are Monocotyledonous plants (Table 1).

The ratio of monocotyledonous and dicotyledonous plants (1:3) characterizes the flora of the landscape reserve as the flora of temperate regions of Holarctic. The proportion of the flora in the landscape reserve as a whole, showing the ratio of the number of families, genera and species, is expressed as 1:3.7:7.4. The flora of the landscape reserve is represented by 19 families, the level of species variety of which is higher than in the proportion. The share of these families is 508 species (73% of the total flora composition of the landscape reserve).

Being at the border of floristic areas, the territory of the "Relic oaks" landscape reserve was affected by various floras, which has been reflected in the taxonomic structure. By the set of prevailing families, flora of the "Relic oaks" landscape reserve is close to the typical flora of the boreal floristic region (Tolmachev, 1974); however, it also has its peculiarities (Table 2).

Table 1. The ratio of the main systematic flora groups in the "Relic oaks" landscape reserve.

Systematic group	Number			% of the total number		
	Families	Genera	Species	Families	Genera	Species
Lycopodiophyta	1	1	4	1.1	0.5	0.6
Equisetophyta	1	1	7	1.1	0.3	1.0
Polypodiophyta	8	12	14	8.4	3.5	2.0
Pinophyta	3	4	5	3.2	1.1	0.7
Magnoliophyta	81	329	666	86.2	94.8	95.7
Magnoliopsida	62	259	501	66.0	74.4	72.0
Liliopsida	19	70	165	20.2	20.4	23.7

Table 2. The spectrum of prevailing families of the flora of the "Relic oaks" landscape reserve.

Rank	Family	Number of species	% of the total number of species
1	Asteraceae	75	10.8
2	Poaceae	59	8.5
3	Ranunculaceae	51	7.3
4	Rosaceae	49	7.0
5	Cyperaceae	41	6.0
6	Fabaceae	34	4.9
7	Caryophyllaceae	23	3.3
8	Brassicaceae	22	3.2
9	Apiaceae	21	3.0
10	Scrophulariaceae	19	2.7

The Cyperaceae family in the studied flora loses its leading position, and the high rank of families Ranunculaceae and Rosaceae indicates strong influence of the nemoral flora.

The largest 10 families in the flora of the landscape reserve are the following: Asteraceae, Poaceae, Ranunculaceae, Rosaceae, Cyperaceae, Fabaceae, Caryophyllaceae, Brassicaceae, Apiaceae, and Scrophulariaceae, which account to 394 species (56.7% of total diversity) (Table 2).

The number of families that contain 5-7 species in the flora of the landscape reserve is 13 (79 species; 11.4%). 30 families contain 2-4 species (77 species, or 11%). The number of single-species families is 32 (4.6% of the total number of species). The abundance families with few species characterizes the flora of the landscape reserve as medium-boreal, which indicates complexity of the process of florogenesis, the significant role of migration in it, and predominance of allochthonous trends in the origin of the flora (Malyshev & Peshkova, 1984).

Ecological and geographical analysis: For the territory of the "Relic oaks" landscape reserve, 4 floral complexes have been allocated: alpine (Al), forest (Fr), steppe (St), meadow-alluvial (MA), and 10 geographic elements that reflect the peculiarities of its flora formation. 4% of species of the entire flora at the landscape reserve belong to adventive species, which may indicate the absence of strong anthropogenic burden on the communities in the protected area.

The analysis of the flora of the reserve on floristic complexes showed that the composition of the flora was dominated by forest and steppe plants (Fig. 1).

The fairly wide variety of species of forest and steppe origin illustrates well the transitional situation of the territory at the border of the forest-steppe and taiga zones. The forest complex is represented by three zonal groups dominated by light-coniferous group (169 species; 25%); the preboreal group is twice less numerous (67 species; 10%); and the smallest group is coniferous (24 species; 4%).

The landscape reserve is located in the zone predominated by southern taiga, where light-coniferous group is the richest in species (Types of, 1961). Preboreal forests occupy small areas and do not form a wellexpressed belt (Malyshev & Peshkova, 1984). Therefore, the composition of this group is small; however, it 2.5 times exceeds the number of species in the dark coniferous group, for which the climatic conditions of the southern taiga zone are limiting factors.

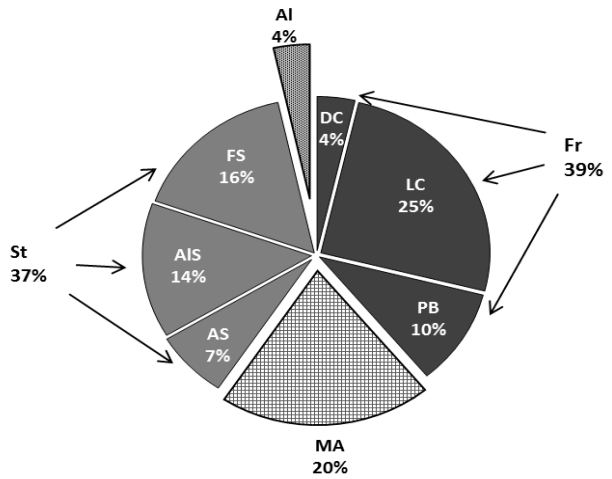

Fig. 1. Distribution of flora species in the "Relic oaks" landscape reserve by floral complexes and zonal groups.
Note: Complexes: St - Steppe; Al - Alpine; Fr - Forest; MA - Meadow-alluvial.
Zonal groups: AS - Actually steppe; AlS - Alpine steppe; FS - Forest-steppe; DC - Dark coniferous; LC - Light coniferous; PB - Preboreal.

The second place is occupied by the steppe complex (St) - 248 species, or 37% of the overall composition of the flora of the landscape reserve. The steppe parts of the landscape reserve do not occupy significant space and are limited, as a rule, by steep steppe-like southern slopes, as evidenced by the high share of the forest-steppe species (107 species; 16%), which is about half of the steppe floral complex (Fig. 1). The territory of the landscape reserve borders the forest-steppe zone, therefore, the high percentage of forest-steppe species here is quite natural. The group of alpine-steppe species is more than one third of the total species in the steppe complex (94 species; 14%), which corresponds to the alpine landscape of the landscape reserve. The share of actual steppe species does not reach one fourth (47 species; 7%).

The meadow-alluvial complex is azonal; it is presented by 135 species (20% of the total flora). The overall low percentage of meadow-alluvial species allows assessing the complex alpine terrain in the territory of the landscape reserve, where development of meadow phytocenoses is limited by narrow river valleys and the alpine nature of river flows. The low share of meadow-alluvial species is also associated with the development of permafrost along river valleys (Malyshev & Peshkova, 1984).

The alpine complex is represented by the least number of species (23 species, 4%), which indicates mid-mountain and lowland nature of the landscape reserve territory. In addition, within the forest-steppe belt, alpine and mountain belt group ceases to have its landscape value (Malyshev & Peshkova, 1984), so its share in the flora of the territory is significantly reduced.

In geographical spectrum, 10 chorological groups have been found (Table 3).

The analysis of the flora of the landscape reserve by geographical elements (chorologic groups) showed that the dominant group consisted of the species, the main habitat of which was in the East-Asian floral area. The East-Asian element is markedly predominant in the flora of the landscape reserve (240 species; 34.5% of the species diversity), especially in the steppe (109 species; 15.7%) and forest (92 species; 13.2%) floral complexes.

Table 3. The ecology-geographical characteristic of flora in the "Relic oaks" landscape reserve.

Habitat (chorologic group)	Floral complexes					Total species	% of the total number of species
	Al	St	Fr	MA	AD-RU		
CP	9	15	47	54	28	153	22.0
EuA		31	39	25	1	96	13.8
AA	3	2	10	6		21	3.0
NA	6	17	28	7		58	8.2
NE	1	1	12	1		15	1.1
EA	1	109	92	36	1	240	34.5
ES		2	6	2		10	1.5
GA	1	14	14			29	3.9
SS	1	42	12	2		57	8.2
CA	1	15		1		17	2.4
Total species	23	248	260	135	30	696	
% of the total number of species	3,3	35.6	37.3	19.4	4.4		100

Note: Habitat (chorologic group) of plants: CP - Circumpolar or boreal Holarctic; EuA- Eurasian; AA - American-Asian; GA - General Asian; NA - North-Asian; SS - South-Siberian and Mongolian; CA - Central Asian; NE - North-East-Asian; EA - East Asian; ES - Euro-Siberian.
Complexes: St - Steppe; Al - Alpine; Fr - Forest; MA - Meadow-alluvial; AD-RU - Adventive-ruderal species

The second place in terms of the number is taken by wide-habitat circumpolar species (153 species; 22.0%), which predominate in the meadow-alluvial (54 species; 7.8% of the total flora composition) and the forest (47 species; 6.8%) complexes, especially in the light coniferous group. Slightly inferior in terms of the number of species are also wide-habitat Eurasian species (96 species; 13.8%), which prevail in the forest and the steppe complexes.

The fourth place in the composition of the flora of the landscape reserve belongs to the species with South Siberian and North Asian habitats. Most species of South-Siberian habitat are represented by the steppe floral complex (42 species; 6.0%), especially of the mountain-steppe group (27 species). The species of the North Asian habitat predominate in the forest complex (28 species).

The presence of species with American-Asian habitat (21 species; 3.0%) points to the ancient relation between floras of Asia and America.

Analysis of the zonal and geographical structure of the flora in the landscape reserve points to its substantial heterogeneity, arising from the common influence of various floral complexes in Eastern Siberia. Most important for its formation at the present stage are East Asian, circumpolar and Eurasian species of the forest, steppe and meadow-alluvial complexes.

Analysis of life forms: Life forms of plants in the flora of the landscape reserve are represented by arboreous, semiarboreous and herbaceous plants (Table 4).

Table 4. Biomorphological structure of the flora of the "Relic oaks" landscape reserve.

Life form of plants	Total species	% of the total number of species
Arboreous plants	67	9.6
Semiarboreous plants	15	2.2
Ground grass	603	86.6
Polycarpous herbs	514	74.0
Monocarpous herbs	89	12.6
Aquatic grasses	11	1.6

In the landscape reserve the herbaceous plants by the number of their types dominate over arboreous plants, and among arboreous plants the greater share belongs to shrubs, which is typical of the boreal region of Holarctic (Serebryakov, 1962; Tolmachev, 1974).

The composition and structure of herbaceous polycarpous plants most distinctly reflect the soil and climatic conditions of an area. This group includes 74% of plant species of the landscape reserve (Table 4).

The dominant groups among herbaceous plants are often short root plants. They cover 149 species (29% of the herbaceous polycarpous plants; 21.4% of the total composition of the flora of the landscape reserve) (Fig. 2).

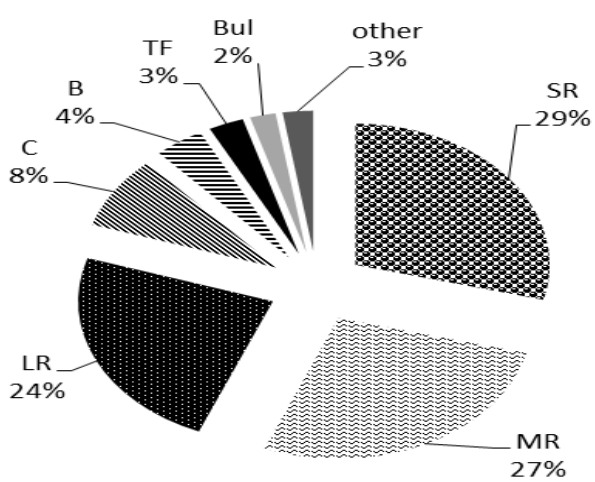

Fig. 2. Distribution of herbaceous polycarpous plants in the flora of the "Relic oaks" landscape reserve.
Note: SR - Short-rooted, MR - Medium-rooted, LR - Long-rooted, C - Cespitose, B - Brush-rooted, TF - Tuber-forming, Bul - Bulbaceous plants, etc. - Other types of life forms.

The second place by abundance belongs to tap root plants - 140 species (27.0% of herbaceous polycarpous plants; 20.1% of the total composition of the flora in the landscape reserve). Since tap root polycarpous plants are characteristic of soils with deep groundwater and

extreme climatic conditions (Gorshkova, 1966), the plants of this life form are dominating the steppe floral complex of the landscape reserve. There are 122 species of long-rooted plants (24.0% of herbaceous polycarpous plants; 17.5% of the overall composition of the flora of the landscape reserve).

Long-rooted plants are usually confined to rather moist and well aerated soils (Ignatyeva & Andreeva, 2008). Long-rooted plants play an important role in forest phytocenoses, where, due to their high plasticity, they may cover significant areas under the forest cover in short time, and form thickets with powerful projective cover (Rysin & Rysina, 1987).

Cespitose (predominant in the composition of the steppe complex) and brush-rooted (predominant in meadow-alluvial complex) plants are represented by the same number of species. Cespitose appearance of steppe grasses helps preserve moisture in the sod during summer droughts (Serebryakova, 1974).

Bulbaceous plants are almost entirely represented by species of the forest complex. Bulbaceous plants are characteristic of arid regions (Serebryakova, 1974) and fully consist of plant species of the steppe floral complex. The remaining types of life forms of polycarpous herbaceous plants are less than 3% of the total number of polycarpous herbaceous plants.

The group of monocarpic plants is 12.6% of the total flora composition in the studied area. The ingress of weed species is negligible (3.6% of the total flora of the landscape reserve) due to the remoteness of the landscape reserve from large settlements and motor roads, and to sparse population of adjacent territories. Most monocarpic plants are semiparasitic steppe, forest and meadow plants.

The small number of aquatic herbs is the consequence of the nature of the terrain and narrow river valleys in the landscape reserve. All main rivers in the landscape reserve are alpine; they are fed by melting snowfields. Lakes and flood-plain lakes, where aquatic flora could have developed, are absent.

The main features of life forms of the flora in the "Relic oaks" landscape reserve (predominance of herbaceous polycarpous plants, among which are short-rooted and tap-rooted plants) show that the species composition of the flora was formed in the conditions of continental climate, low and mid-mountain nature of the terrain, domination of forest landscapes, and availability of many steppe phytocenoses.

Conservation value: The analysis of the “Specially protected natural territories of Russia” and “Plantarium” (Information-analytical, 2017; Plantarium, 2017) electronic databases has shown that 171 species of vascular plants in the flora of the landscape reserve (24.5% of the total composition of the revealed flora) belong to rare and protected species in various regions of Siberia. This is an evidence of the studied area importance for preserving the unique gene pool of the natural flora in Siberia.

Conservation areas, being places of gene pool preservation, are excellent sources of new types of plants that are promising for introduction into the crops. The potential of protected natural areas may be used in the search for sustainable forms featuring good economic qualities for creating agricultural populations. Creation of collections of valuable and rare species of Siberian flora is mainly performed based on regional botanical gardens (Semenova, 2007; Rare plants, 2015; Introduction, 2017).

Since 2012, in the Siberian botanical garden of TSU some valuable and rare types of plants have been studied, which were introduced into the crops from natural populations of the "Relic oaks" landscape reserve: *Aquilegia oxysepala* Trautv. et C.A. Mey., *Aquilegia viridiflora* var. *atropurpurea* (Willd.) Trevir., *Convallaria keiskei* Miq., *Dictamnus albus* L., *Lychnis fulgens* Fisch., *Platycodon grandiflorus* (Jacq.) A. DC., *Quercus mongolica* Fisch. ex Ledeb., *Tephroseris flammea* (DC.) Holub. and others. In case of the successful result of the experiment, protection measures will be developed for the studied plant species ex situ and in situ. The collected data will allow replenishing the gene pool of useful natural flora of Siberia, promising for the introduction into various economy sectors without harming natural areas.

Conclusion

The location of the "Relic oaks" landscape reserve at the border of two large floral regions (Circumboreal and East-Asian) has determined the unique phytodiversity in the territory. In the flora of the landscape reserve, 696 species of higher vascular plants have been identified, some of which are observed only in the landscape reserve in Siberia. The range of life forms shows the position of the landscape reserve at the border of forest and forest-steppe zones of moderate Holarctic. 10 groups of habitats have been identified for the studied plants, among which the predominance of the East Asian group has been detected. The "Relic oaks" landscape reserve was established for preserving the one-of-a-kind population of *Quercus mongolica* in Siberia; it plays an essential role in preserving biodiversity of the region. In this territory, there are 171 species of vascular plants (24.5% of the total flora of the landscape reserve) which are protected in various regions of Siberia.

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