Diversity and geographic origin of *Gymnospermeae* represented in Russia's botanical gardens in various climatic conditions

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Abstract

The main task of the researchers includes information support for the coordination of efforts to mobilize genetic resources of plants in Russia. The analysis of collections of Russian botanical gardens encompasses: estimation of taxonomical diversity of collections in relation to the world diversity of plants; evaluation of the influence of key climatic factors on the spatial distribution of genetic resources of vascular plants. According to the Information System «Botanical collections of Russia» 474 species of Gymnospermeae belonging to 62 genera, 15 families, 12 orders, 6 classes and 4 divisions are cultivated in 67 botanical gardens. Species from the Northern hemisphere are dominant: Asia (35%), North America (25%) and Europe (8%). According to Takhtajan's Floristic Regions of the World, Conifers are represented in 29 floristic regions with the following predominance: East-Asia (22%), Madrean (10%), Circumboreal species (9%). 362 of the species grow in the open ground, 289 grow in greenhouses and 177 grow in both. We also studied the influence of minimum winter temperature, frost-free period duration and summer temperatures on collection diversity. The analysis of species according to geographical origin allows to correlate their natural habitat with the cultural one and to give recommendations for cultivation and conservation in botanical gardens.

Keywords

Botanical gardens of Russia, geographic origin, *Gymnospermeae*, influence of a climate, information technologies

Introduction

Botanical gardens are multi-functional institutions: collecting plants, they preserve them from extinction and create collections for scientific research as well as education, they create reserve banks of genetic resources of plants which are suitable for practical use in various areas; these plants are adapted to new habitats. In Russia the latter task is very relevant due to insufficient diversity of plant species valuable for household use (Vavilov, 1992) and insufficient biodiversity of plants in general (Barthlott *et a*l., 2000). N.I. Vavilov's Institute of Plant Industry has been dealing with useful genetic resources since the times of Nicolay Vavilov, botanical gardens are involved in work with numerous wild species, medical and ornamental plants.

According to the data of the Information-Analytical System "Botanical collections of Russia" (IAS) (http://garden.karelia.ru) collections of the Russian botanical gardens represent more than 24,000 species and 25,000 cultivars of vascular plants (Prokhorov, Nesterenko, 2001). IAS was created for the comparative analysis of botanical collections. The analysis of collections of Russia's botanical gardens includes evaluation of the taxonomic diversity of botanical gardens in relation to the worldwide diversity of plants as well as an assessment of the effects of key climatic factors on the spatial distribution of genetic resources of vascular plants.

The Information-Analytical Center of the Council of Botanical Gardens of Russia began its work on summarizing and pinpointing prospects for the introduction of plants in Russia from representatives of *Gymnospermeae*. The analysis of the gymnosperms collections data performed by Yu Karpun, A. Bobrov and M. Romanov showed that synonyms and misspellings in cultivar names make 18 percent of the total number of taxa.

Gymnospermeae are widely spread throughout the world mainly in temperate and subtropical latitudes of both the Northern and Southern hemispheres. In Russia more than 60 species of the following genera grow in the wild: *Taxus* (2 species), *Pinus* (13), *Picea* (8), *Larix* (9), *Abies* (8); *Juniperus* (23), *Platycladus* (1), *Microbiota* (1) belonging to three families of *Taxaceae*, *Pinaceae*, *Cupressaceae* (Cherepanov, 1995). 474 species, 70 infraspecific taxa and 675 cultivars are cultivated in collections of 67 botanical gardens. 15 families are represented: *Araucariaceae, Cephalotaxaceae, Cupressaceae, Cycadaceae, Ginkgoaceae, Gnetaceae, Ephedraceae, Pinaceae, Podocarpaceae, Sciadopityaceae, Stangeriaceae, Taxaceae, Taxodiaceae, Welwitschiaceae, Zamiaceae.* 62 of 87 genera are exhibited in the collections. As for large families, it refers to *Cupressaceae* and *Pinaceae* (Fig. 1). *Pinus sylvestris* L., *Thuja occidentalis* L., *Picea ab*ies (L.) H. Karst., *Pinus sibirica* Mayr are cultivated in more than 50 botanical gardens (Fig. 2). *Larix sibirica* Ledeb., *Picea pungens* Engelm., *Picea glauca* Regel, *Juniperus sabina* L., *Abies sibirica* Ledeb., *Pseudotsuga menziesii* (Mirb.) Franco and *Picea pungens 'Glauca'* are more rarely represented in the collections.

Geographic origin of cultivated species was defined based on the Floristic Regions of the World (Takhtajan, 1986) shown in the map (Fig. 3). According to the Biodiversity Information Standards his approach is regarded as the Prior Standard (http://www.tdwg.org/). Plants belonging to a certain floristic region generally defines the climatic requirements of the species and, consequently, the possibility of its cultivation in one or other climatic conditions in the open ground or in greenhouses.

Nowadays 362 species of the collections are cultivated in the open ground, 289 species are grown in greenhouses, and 177 species are grown in both. According to the geographic origin, species of *Gymnospermeae* of East Asian and Madrean areas dominate (Fig. 4). Species of Circumboreal and Iranian-Turan areas (41) are also well represented in the open ground, in greenhouses – the area of Guyana highlands (22). Mediterranean species (13) can be cultivated in the open ground in the south of Russia, in greenhouses they can be grown everywhere.

We studied climatic preferences of the cultivated plants for each floristic area using 5 climatic characteristics: the average annual minimum temperature (HZ); duration of frost-free period (FF) – which determines the duration of vegetation, duration of sun light (SL) related to efficiency of photosynthesis, the annual number of days with temperature higher than 30C (HT) – the factor that limits the spread of frost-resisting species to the South; average temperature in July (JT) – the parameter defining intensity of vegetation for many species. **Error! Reference source not found.** gives characteristics of climatic zones as well as the number of botanical gardens in each of them.

The average annual minimum temperature and frost-free period are the most significant climatic factors for the arboreal species. Hardiness zones are determined according to Rehder, 1949 and hardiness zones maps (Plantideas.com, 2003). There are 9 determined hardiness zones from HZ1 to HZ9 in the territory of Russia (while botanical gardens are located in 8 zones excluding HZ8). HZ1 which coincides with the subarctic climate is considered to be the coldest zone; HZ9 including the Black Sea coast to the south of Tuapse is the warmest zone in the territory of Russia. Also there are 8 determined frost-free period zones (FF) in the territory of Russia (Kobisheva *et al*., 2001) which define duration of the vegetative period. Botanical gardens are located in FF3– FF8 zones.

The diagrams (Fig. 5, Fig. 6) show climatic preferences of species of Asian and North American flora. We could observe similarity of distribution of East-Asian and Iranian-Turan species which are most completely represented in botanical gardens of middle and southern latitudes. Circumboreal species of both continents are better exhibited in botanical gardens in the North of Russia in zone HZ3-HZ4, FF4 where successful cultivation of other floristic area species lacks

duration of the vegetation period. The clearest preferences are represented by the species of Madrean which collections are mostly located in botanical gardens of Sochi. In this case it is difficult to define which factor is the decisive one. Species of the Rocky Mountains are quite plastic, which is natural for plants of mountainous regions; they are cultivated in many botanical gardens.

Many species are cultivated far beyond the climatic borders of their natural habitat. On the one hand, it witnesses their high plasticity; on the other hand, it speaks about the role of botanical gardens in evolution of plants. The plants cultivated in marginal climatic conditions are interesting for selection.

The goal of our future research is to define in detail climatic preferences of species which are not exhibited in collections of Russia's botanical gardens and to model climatic habitats in the territory of Russia. Botanical gardens located in a certain habitat have the biggest opportunities for successful cultivation of a species.

Our work supports the targets of the Council of Botanical Gardens of Russia to organize and coordinate research work of botanical gardens in the area of plant cultivation in various environmental conditions as well as to coordinate activities of botanical gardens in the field of conservation and mobilization of plant genetic resources.

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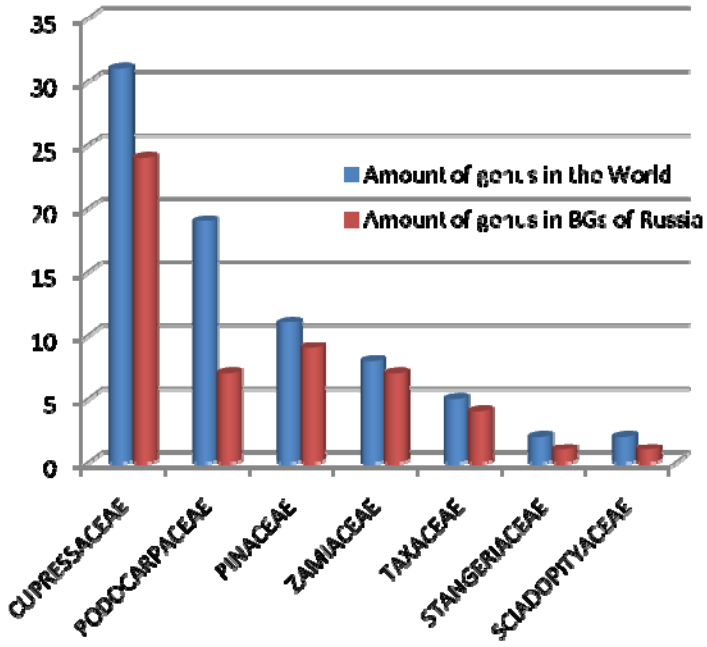

Fig. 1. Genus diversity of *Gymnospermae* in the world and in Russia

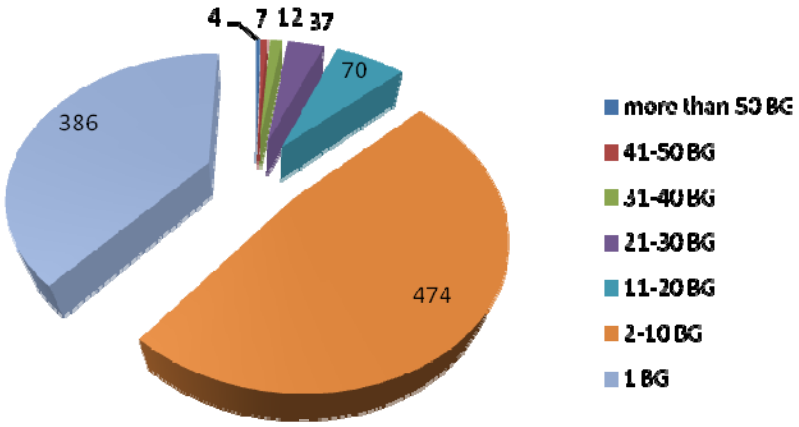

Fig. 2. Frequency of occurrence of *Pinopsida* taxa in botanical gardens (BG)of Russia.

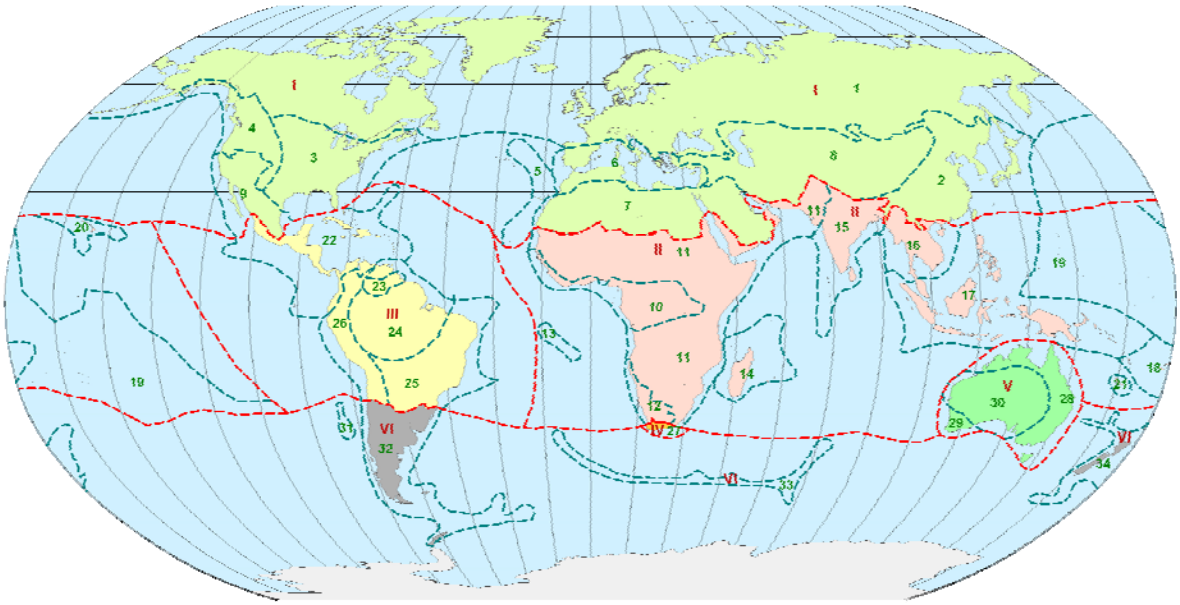

Fig. 3 Map of Froristic Kingdoms and Regions of the World (Takhtajan, 1986) in edition of the Information-Analytical Center of the Council of Botanical Gardens of Russia for GIS-analysis (MapInfo Professional 9.5)
I. *Holarctic Kingdom*: 1. Circumboreal; 2. Eastern Asiatic; 3. Atlantic North American; 4. Rocky Mountain; 5. Macaronesian; 6. Mediterranean; 7. Saharo-Arabian; 8. Irano-Turanian; 9. Madrean (Sonoran)
II. *Palaeotropical Kingdom:* 10. Guineo-Congo; 11. Sudano-Zambezian; 12. Karroo-Namib; 13. Region of St. Helena and Ascension ; 14. Madagascan; 15. Indian; 16. Indo-Chinese; 17. Malesian; 18. Fijian; 19. Polynesian; 20. Hawaiian; 21. Neocaledonian
III. *Neotropical Kingdom*: 22. Caribbean; 23. Region of Guayana Highland; 24. Amazonian; 25. Brazilian ; 26. Andean
IV. *Cape Kingdom*: 27. Cape Region
V. *Australian Kingdom*: 28. North-East Australian; 29. South-West Australian; 30. Central Australian, or Eremaean
VI. *Holantarctic Kingdom*: 31. Fernandezian; 32. Chile-Patagonian; 33. Region of the South Subantarctic Islands; 34. New Zealand

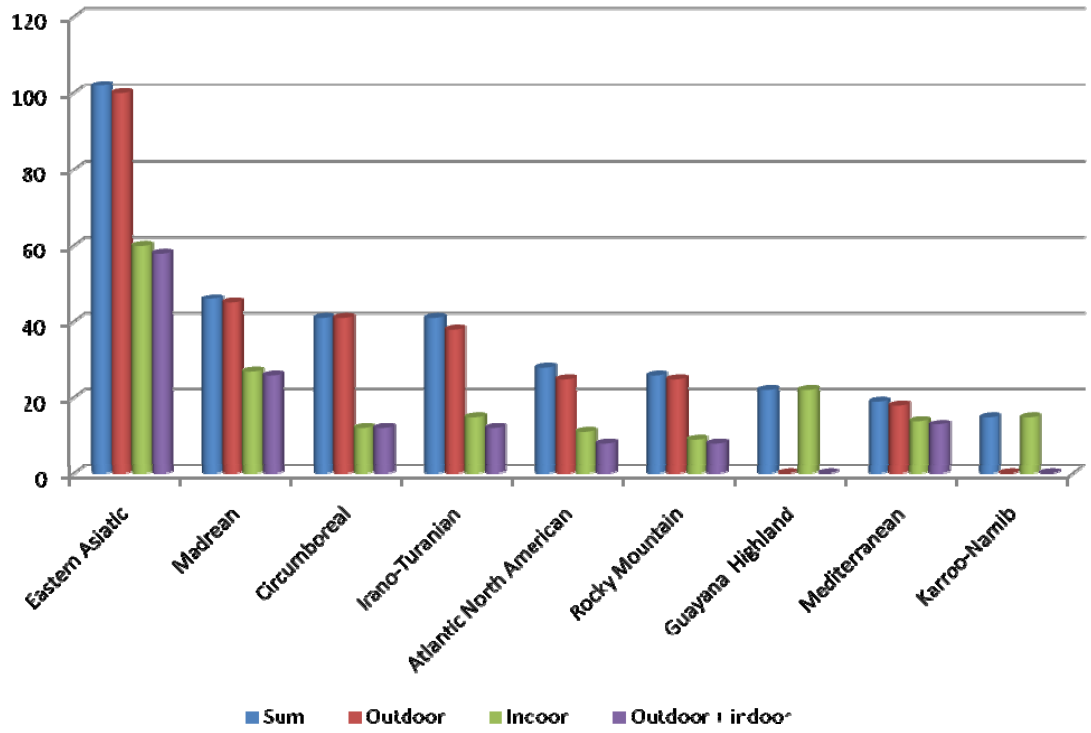

Fig. 4 The main floristic regions (Takhtajan, 1986) of geographical origin of *Gymnospermae* and their representation in botanical gardens of Russia

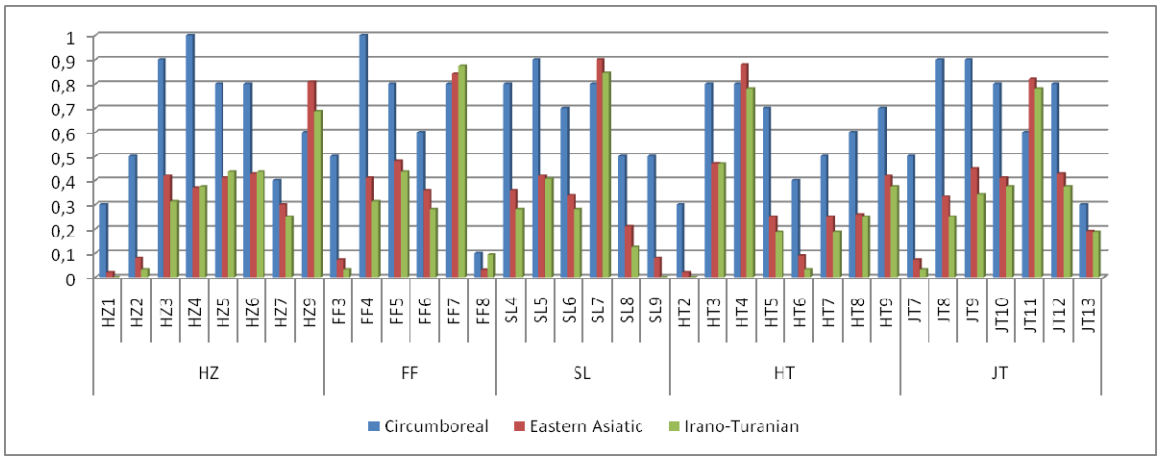

Fig. 5. Distribution of East Asian species throughout climatic zones

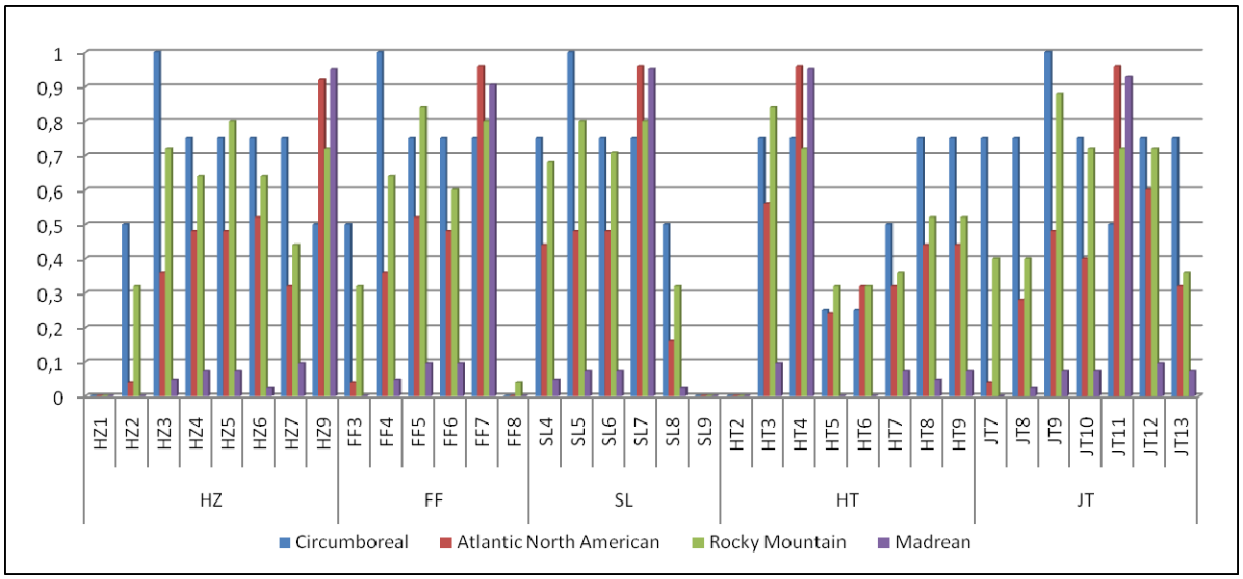

Fig. 6. Distribution of North American species throughout climatic zones

Table 1. The characteristics of climate and the number of botanical gardens (BG) in each zone.

Average minimal annual temperature			Duration of frost-free period			Duration of sun light			Average number of days with air temperature above 30^0c			Average July temperature		
zone	°C	BG	zone	days	BG	zone	hours per year	BG	zone	days	BG	zone	°C	BG
HZ1	< - 45,5	3	FF1	< 45	0	SL3	1200-1400	1	HT2	0-1	10	JT07	12-14	5
HZ2	-40,0 - 45,5	6	FF2	45-59	0	SL4	1400-1600	11	HT3	1-5	42	JT08	14-16	4
HZ3	-34,5 - 40,0	34	FF3	60-89	8	SL5	1600-1800	38	HT4	5-10	35	JT09	16-18	35
HZ4	-28,9 - 34,4	41	FF4	90-119	37	SL6	1800-2000	30	HT5	10-15	13	JT10	18-20	42
HZ5	-23,4 - 28,8	17	FF5	120-149	46	SL7	2000-2200	39	HT6	15-20	6	JT11	20-22	24
HZ6	-17,8 - 23,3	13	FF6	150-179	20	SL8	2200-2400	10	HT7	20-30	8	JT12	22-24	17
HZ7	-12,3 - 17,7	11	FF7	180-199	18	SL9	2400-2600	1	HT8	30-40	4	JT13	>24	4
HZ9	-1,2 - 6,6	6	FF8	> 200	2	SL10	>2600	1	HT9	40-50	12			
									HT10	50-60	1			