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The Results of Plant Monitoring in the Semistozhki Area of Stavropol Region

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Abstract

Preserving biodiversity is a global problem that was reflected in the Convention on Biological Diversity which appeared in 1992. The adoption of the Convention was an answer for the intensified problem of a significant reduction in the diversity of genetic resources. Botanical gardens are the main centres for preserving the biodiversity of plants that solve the problem of preserving the gene pool. One of the main tasks of botanical gardens is to monitor plant populations in their natural habitats *in situ*. This paper describes the monitoring of the current state of peonies and sedges in the Semistozhki area of Andropov district in the Stavropol region. The research determines the growing locations and the belongingness of species to plant associations in the vegetation variety of Stavropol region. It also determines the species that may be treated as rare due to their limited distribution area. The territory is marked by the presence of *Paeonia tenuifolia* L., which is a tertiary relict, and *Paeonia biebersteiniana* Rupr., which is subendimic for Stavropol region. Rear species with low numbers which are not threatened by grave danger of extinction are also present. *Carex hordeistichos* Vill. and *c. otrubae* Podp. species in the area are small in number. Their populations in the area are inadequate with young, vegetative and strong specimens lacking. The limiting factors are represented by human agricultural activities. Several specimens of a narrow-leaved peony of pink colour and a big number of petals were planted on an experimental stretch of the botanical garden to continue the analysis *ex situ*.

Keywords: biodiversity, peony, species, sedge, Semistozhki area, soils.

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1. Introduction

The number of species of the world flora has been decreasing dramatically in recent decades due to significant changes in nature caused by anthropogenic influence. The plant diversity was long considered inexhaustible. However later it became obvious that this perception was wrong. Nowadays, some species and even entire plant associations are lost, and others are on the edge of extinction. One of the main tasks in the protection of flora is the preservation of the genetic resources of plants. Botanical gardens play an important role in preserving and enhancing the floral biodiversity, as well as the variety

of ornamental crops. They were determined by a time-tested approach of comparative studies of genetic resources in the form of monotype and multitype collections, species, forms, and breeds. Botanical gardens also play an important role in promoting the ideas of protecting rare and endangered species by demonstrating them on special plots of land and in collections *ex situ*. (Recommendations about ornament flowers and plants).

Preserving biodiversity is a global problem. The Convention on Biological Diversity was accepted in 1992 at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro. This step was made in relation to the acute problem of a significant decrease in the diversity of genetic resources. The extinction of species is connected with both natural (climatic changes) and anthropogenic factors, the number of which is constantly increasing. The preservation of biodiversity is an obligatory condition for the stable development of the biosphere [2]. Botanical gardens are one of the main centres for preserving the biodiversity of plants that solve the problem of preserving the gene pool of plants [3]. One of the most available ways to accomplish this task is the monitoring aimed at recording and analysing results. In the modern period, the works on the protection of plants were initiated by the 1972 decree aimed at accounting the USSR species of plants which needs protection. The decree was adopted by the All-Union Botanic Society and the Scientific Committee of the USSR Academy of Sciences in terms of rational use, transformation and protection of plants (the Red Book of Stavropol region). Currently, the work continues according to the program of fundamental scientific research of the state academies of sciences for the 2013--2020 period. The work is aimed at searching, mobilizing and preserving genetic resources of domestic plants and their wild relatives for studying, keeping and using the biodiversity of domestic crops. The most effective method for preserving plant resources is the protection of species in nature and natural habitats where there are optimal conditions for growth and reproduction. However, the preservation of biological resources in the natural environment becomes almost impossible due to the ever-increasing anthropogenic influence. That's why the development of methods for saving plant resources in a cultural form is an important problem. This essence of this form is in transferring some limited population to the plots of land in botanical gardens (in this case these are *Paeonia tenuifolia* L., *p. biebersteiniana* Rupr., *carex hordeistichos* Vill., *c. otrubae* Podp.

The state of the biotic community was analysed in 2014 and 2016 in the area of Semistozhki (Piket and Visla mountains) in the vicinity of Vorovskolesskaya settlement in the Andropov district of the Stavropol region.

The monitoring in Semistozhki area included the observation of rare species, such as fern leaf peony (*Paeonia tenuifolia* L.), Bieberstein peony *(p. biebersteiniana* Rupr., sedges (*carex hordeistichos* Vill, and *c. otrubae* Podp.). The found species also included sage (*salvia nutans* L.), bellevalia sarmatica (*bellevalia sarmatica* (Georgi) Woronow), centaury (*centaurea czerkessica* Dobrocz. & Kotov.) and etc. [8--10]. Andropov district belongs to the zone with unstable wetness. Summers are mild. Snow depth is 10--12 cm with snow cover melting at the beginning of March. The growing season starts at the end of March or the beginning of April. The hydrothermal factor is 1.1--1.3 with frost-free period lasting for 180--190 days while the sum of virtual temperatures reaches 3000--3200 ˚C. In winter the temperature goes down to --32 ˚C with 500--600 mm of precipitation per year. Soil cover in the area is complex. However, the dominant role belongs to alkaline black soils in combination with alkaline soils of lumpy and chunky structure on the upper level, high density of alkaline soil level and its good capability for swelling. The thickness of the humus horizon is up to 88 cm. The content of the humus is 5.25 % at the surface while its stock in a one-meter layer is 388 tonnes per hectare. The slopes of depressions caused by ancient erosion are characterized by a significant erosion roughness with a lot of draws, ravines, and rills [4, 6].

2. Methods and Materials

The nature of work is expeditionary, stationary and laboratory. The study was carried out along the route that permits maximum coverage of different relief features with the marked specificity of plant associations. The work was carried out in different seasons that permitted to observe plants on different stages of growth. The grown locations of species were determined by point mapping based on native data using SAS.Planet.Release.141212 program. Systematic descriptions and new combinations were given according to the International Code of Botanical Nomenclature (2001).

The study of species composition in the plant association was done with the help of a standard method of geobotanical sites [7]. The first step involved an exploratory study of plants. Next, the general features of relief and plant association were studied. After the population was identified it was marked using GPS navigator or associations with visible orienting points. Then, study plots (10 x 10 m) were laid out through the territory of a found population using the transect method or, in some cases, randomly encompassing the most characteristic plant communities. The ecological characteristic of habitat was also determined. It included relief features, soil types, salinization, wetness characteristic, light patterns. To study the age-related conditions of populations the following notation

was used: plantlets (pl), juvenile plants (j), immature (im), generative (g), senile (s). Sozological studies of rare species were carried out by analysing protection categories and the conservation status of a species. The population size was determined the following way: direct count (used only for small populations of 1--100 specimens), visual appraisal using a direct scale (1--10, 10--50, 50--100, 100--500, 500--1000 and more than 1000 specimens). The estimated number is $C = S \times n$, where S is total area while n is average density. The population density indicates the number of plants per area unit. It was determined by the calculation made on sample areas with a subsequent estimation of an average figure -- n. In the case of rare species, the age structure of a population was studied using the following notation: plantlets (pl), juvenile plants (j), immature (im), generative (g), senile (s). To determine the phenological phases the following notations were used: plantlets -- pl.; sprouts (new young shoots) -- s.; vegetation state -- veg.; heading -- hed.; blossom -- b.; fruiting -- f.; immature seeds -- is.; mature seeds -- m.; seeds fall -- sf.; dying after seeds fall -- dy.; the death of shoots -- dth.; dead shoots -- d.

The viability of a population was determined visually using the following scale: 1 point -- vegetative part of plants is poorly developed, plants don't blossom and don't bring fruits; 2 points -- vegetative part of plants is developed, but is still below a norm, plants don't blossom and don't bring fruits; 3 points -- plants are well-developed, but they don't blossom and don't bring fruits; 4 points -- plants are developed, but blossom and fruiting is inactive with a small number of young specimens; 5 points -- plants are well-developed, blossom, bring fruits and have a lot of new growth.

Some parameters reflecting the anthropogenic impact were also recorded. Each impact factor was estimated visually using a three-point system: 0 points -- no impact; 1 point -- low impact; 2 points -- high impact. Each factor was estimated separately. The following factors were taken into account: construction; ploughing; drainage and building of reservoirs and dams; pasturing; waste pollution; haying; fire; collection and digging out plants.

The height (h) of herb shoots was measured by a measuring scale or rule. The abundance according to Drude [7] was determined visually, using the following notation: Cop^3 -- very abundant; Cop^2 -- abundant; Cop^1 -- quite abundant; Sp -- sparse; Sol -- single (very little); Un -- one specimen in a plot.

The projective cover was determined visually using the horizontal projection of vegetation cover tops in general and its certain species. This helped to objectively determine the quantitative size of vegetation in the areas (100 m^2 and more).

3. Results

The protection category means the level of importance in preserving the genes of a certain species. There are five categories [5].

I. Regional endemics, the proliferation of which is restricted by some locations or they are known from several places. Species in this category should be protected first and foremost regardless of the population state or the accuracy of systematic distinction as such plants form a part of the rare and unique gene pool.

II. Subendemic species the natural habitat of which is extended to adjacent regions, for example, Caucasus and South Caucasus endemic species: Biberstein peony (*paeonia biberschtieniana* Bieb.), centaury (*centaurea czerkessica* Dobrocz. & Kotov), fake iris (*iris notha* Bieb.).

III. Relict species that have diffuse areas in the region and rarely seen outside it: glacial relics, e.g. fine-leaved peony (*paeonia tenuifolia* L.).

IV. Glacial and xerothermic relicts, that cover bigger areas both in the region and outside it: bellevalia sarmatica (*bellevalia sarmatica* (Georgi) Woronow).

V. Species that don't belong to the first four categories but that considered rare because of natural reasons: orchis (*anacamptis morio ssp. picta* (Loisel.) Jacquet & Scappat.).

The monitoring of *Paeonia* and *Carex* population dynamics was carried out in the territory of mount Visla (42°33'60" north latitude, 45°39'51" east longitude, the altitude is 734 m) and mount Piket (42°34'22" north latitude, 44°38'42" east longitude, the altitude is 735 m). The plots were laid on on mount Visla in 2014. The first (42°33'57" north latitude, 44°39'4453" east longitude, the altitude is 666 m) is with the river Nevinka flowing at the bottom. Its stream is marked with small backwaters. The associations that are quite common here are *typha latifolia* + *carex melanostachya*, *carex riparia* -- *carex melanostachya*, *carex riparia* -- *carex melanostachya* + *juncus compressus* + *eleocharis palustris, carex riparia* -- *carex acutiformis.* The population of greater pond sedge is quite common in the territory near the stream of Nevinka river and constitutes the majority of described association where it plays the role of a dominant or a subdominant. It grows in combination with c *phragmites communis* Trin (Cop^2), *typha latifolia* L. (Cop^2), *c. melanostachya* Bieb. (Sp), *juncus compressus* Jacgt (Sp), *c. otrubae* Podp. (Sol), *lythrum salicaria* L. (Sol), *aeluropus littoralis* (Gouan) Parl. (Sp), *catabrosa aquatica* (L.) P. Beauv. (Sp), *sparganium microcarpum* (K.G. Neumann) Raunk. (Sp) и др. *carex hordeistichios* Vill. (Sol) can be very rarely found in the associations of *juncus compressus* [1].

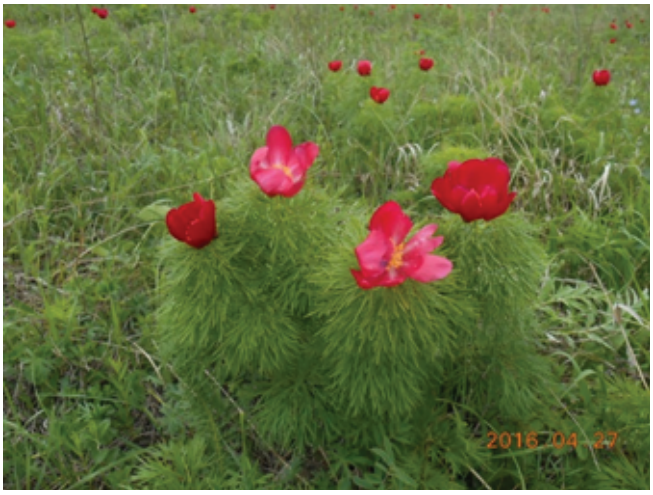

Figure 1: Fine-leaved peony with pink petals.

Climbing the plateau, we can see the rich biodiversity of vegetation cover with the length of stand up to 80 cm. It consists of *carex* L., *bellevalia sarmatica* (Georgi) Woronow, *adonis vernalis* L., *centaurea czerkessica* Dobrocz. & Kotov., *poap ratensis* L., *medica gofalcata* L.and other. The total projective cover of *festuca rupicola + vario-herbosum* association is 80--90 %. The results are shown in table 1.

Paeonia tenuifolia L. prevails on the slopes. The species dynamically develops in the population with specimens of all growth stages, except senile. The species is marked with high polymorphism. There are plants with pink, red and crimson colour of petals. There are specimens with red stalks that have a big number of petals -- up to 12 in a flower (8 usually) (fig. 1--3). The number of *paeonia tenuifolia* L. is growing. In one square meter, the number of plants reaches the following amounts: g -- 22 specimens, im -- 8 specimens, j -- 0 specimens in 2014 and 30 specimens in 2016 with the height up to 41.5±2.5 cm. *Paeonia biebersteiniana* Rupr. wasn't found in 2014 while in 2016 single specimens are found in a generative form rarely.

Table 1: Species composition of steppe cenosis of mount Visla (2014 and 2016).

No.	Species	Abundance according to Drude		Occurrence % (n = 15)	
		2014	2016	2014	2016
	Shrub layer				
1	*Crataegus monogyna* Jacq.	Sol	Sol	10	10
2	*Prunus spinosa* L.	Sp	Sol	30	10
3	*Rosa* sp.	Sol	Sol	10	10
	Herb layer				
4	*Achillea tenuifolia* Lam.	Sp	Sp	10	15
5	*Agrimonia eupatoria* L.	Sp	Sp	30	25

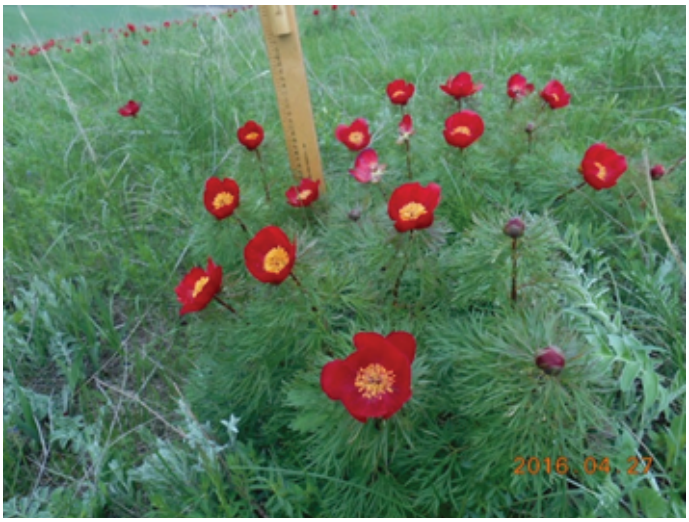

Figure 2: Fine-leaved peony with red stalks.

No.	Species	Abundance according to Drude		Occurrence % (n = 15)	
		2014	2016	2014	2016
6	*Agropyron pectinatum* (M. Bieb.) P. Beauv.	Sp	Sp	65	62
7	*Alopecurus pratensis* L.	Sp	Sp	65	60
8	**Bellevalia sarmatica* (Georgi) Woronow	Sol	Sol	12	5
9	*Brachypodium rupestre* (Host) Roem. & Schult.	Sol	Sp	10	30
10	Briza elatior Sibth. & Smith	Sp	Sp	50	60
11	*Carex humilis* Leys	Sp	Sp	45	45
12	*Carex melanostachya* Bieb.	Sp	Sp	50	50
13	*Carex michelii* Host.	Sp	Sp	65	65
14	*Carex tomentosa* L.	Sp	Sp	65	40
15	**Centaurea czerkessica* Dobrocz. & Kotov.	Sol	Sol	10	10
16	*Cynodon dactylon* (L.) Pers.	Sp	Sp	45	45
17	*Delphinium consolida* L.	Sol	--	10	0
18	*Digitaria sanguinalis* (L.) Scop.	Sp	Sp	65	70
19	*Echinochloa crus-gall* (L.) P. Beauv.	Sp	Sp	71	70
20	*Elytrigia repens* (L.) Nevski	Sp	Sp	62	63
21	*Euphorbia sp.*	Sol	--	12	0
22	*Festuca rupicola* Heuff.	Cop[2]	Sp	80	79
23	*Festuca valesiaca* Gaudin	Sp	Sp	30	32
24	*Filipendula vulgaris* Moench.	Sp	Sp	30	30
25	*Geranium sanguineum* L.	Sol	Sol	10	10
26	*Iris notha* Bieb.	Sol	Sol	10	7
27	*Koeleria macrantha* (Ledeb.) Schult.	Sp	Sp	60	64
28	*Medica gofalcata* L.	Sp	Sp	70	70

No.	Species	Abundance according to Drude		Occurrence % (n = 15)	
		2014	2016	2014	2016
29	*Muscari muscarimi* Medikus	Sp	Sp	10	15
30	**Paeonia biebersteiniana* Rup.	-	Sol	0	10
31	**Paeonia tenuifolia* L.	Sp	Sp	60	62
32	*Phleum pratense* L.	Cop[2]	Sp	78	78
33	*Poa pratensis* L.	Sp	Sp	70	65
34	*Ranunculus carpaticus* Herbich.	Sol	Sol	10	10
35	**Salvia nutans* L.	Sol	Sp	10	10
36	*Salvia verticillata* L.	Sol	Sol	12	12
37	*Setaria verticillata* (L.) P. Beauv.	Sp	Sp	55	50
38	*Stipa lessingiana*Trin. &Rupr.	Cop[2]	Sp	70	70
39	*Stipa pennata* L.	Cop[2]	Sp	70	70
40	*Thymus marschallianus* Willd.	Sp	Sp	15	15
41	*Trifolium repens* L.	Sp	Sp	23	28
42	*Vicia cracca* L.	Sp	Sp	65	60
43	*Vinca herbacea*Waldst. &Kit.	Sp	Sp	10	10

Symbols: * -- a rear species of Stavropol region.

The populations of *carex michelii*, *c. tomentosa* are fully-fledged, developing dynamically. *C. humilis*. is sometimes found on the slopes. The diameter of its bed sometimes reaches 15 cm. while the height reaches 45 cm. The projective cover is decreasing by 50--70 % when climbing the mountain. There is a decline in the population of peony and a rise in cereal plants -- *(tragus racemosus* (L.) All., *tomentosa. digitaria ischaemum* (Schreb.) H.L. Muhl., *digitaria pectiniformis* (Henrard) Tzvelev, *hierochloe repens* (Host) P. Beauv.). The plots with 30--40 % of projective cover are marked with the height of grass reaching 50 cm, the population of *c. humilis* is growing and accounts for: g -- 3 specimens/m^2, im -- 6 specimens/m^2, j -- 8 specimens/m^2. Sometimes there are *paeonia tenuifolia* and *carex micheli, c.*

The projective cover on the slopes of mount Piket is 30--50 %. The height of grass is reducing to 40--50 cm and the number of peonies is decreasing while the numerical and species composition of *tragus racemosus* (L.) All., *digitaria ischaemum* (Schreb.) is increasing. H.L. Muhl., *digitaria pectiniformis* (Henrard) Tzvelev, *hierochloe repens* (Host) P. Beauv.), *astragalus demetrii* Kharadze., *eremurus spectabilis* M. Bieb. There is a decrease in the number of *carex michelii* Host., *carex tomentosa* L. However, the amount of *c. humilis* per one square meter is increasing: g -- 8, im -- 5, j -- 15.

Figure 3: Fine-leaved peony in Semistozhki area.

4. Conclusion

The growing locations and the inclusion of species in plant associations of floral variety in Stavropol region were determined during this study. Several found species can be treated as rare due to their limited occurrence in the territory of Stavropol region. The area of Semistozhki is marked by the presence of *paeonia tenuifolia* L., which is a tertiary relict, and *paeonia biebersteiniana* Rupr., which is subendimic for Stavropol region. Rare species (3^{rd} category of conservation status) with a low population that are not threatened by the grave danger of extinction are decreasing in number as a result of changes in the existence conditions or destruction of habitat. *Carex hordeistichos* Vill. and *c. otrubae* Podp. species in the area are small in number. Their populations in the area are inadequate with young, vegetative and strong specimens lacking. The limiting factors are represented by human activities (fires, pasturing). The monitoring will continue. To preserve the species of peony with a big number of pink petals several specimens were brought to the botanical garden. Currently, they are being studied.

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