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Floristic and Phytocenotic Richness of Urban Protected Natural Areas (Maximov's Dacha, Sevastopol)

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***Abstract* — Phytodiversity of urban specially protected natural areas (SPNA) was studied using the city of Sevastopol (Crimean Peninsula) as a case study with specific focus on the Maximov's Dacha Natural Park (83.9 hectares) (SPNA) situated in the Khomutova ravine on the site of the former estate. The levels of floristic and phytocenotic diversity were assessed using standard methods of floristic and geobotanical descriptions. It appears that the Maximov's Dacha Natural Park has a high level of floristic diversity — 520 species and subspecies from 78 families. The coenotic diversity of the park is formed by associations of forest, steppe, meadow, forest-steppe, shrub, aquatic, and anthropogenically altered communities. The human impact resulted in the formation of habitat diversity promoting floristic diversity of this SPNA.**

Keywords: formation of habitat diversity, biodiversity, protected areas, urban flora, habitat, Sevastopol

I. Introduction

Biodiversity is one of the fundamental properties of wildlife, which is influenced by global and local factors (e.g., the ratio of heat/humidity and the characteristics of the relief and moisture, respectively). Anthropogenic impact has become a powerful factor affecting biodiversity. There exist numerous works on the processes and causes of reduction and loss of biodiversity under the impact of human activities. These studies suggest that urban flora is a combination of natural and anthropogenically altered communities, because the urban environment is the area where introduced species and anthropogenically transformed ecosystems are concentrated. In the urban environment, the structure of the flora changes towards taxonomic simplification — homogenization [1, 2]. Homogenization of the urban flora was reported for cities in Germany [3], Central Europe [4], California [5], etc.

At the same time, anthropogenic activity not only leads to a reduction in biodiversity, but also changes the composition and structure of flora and plant communities — qualitative and quantitative characteristics of biodiversity. For example, human impact, at a certain stage, results in the formation of communities with increased biodiversity compared to the original ones. However, an increase in the number of species occurs mainly due to unintentional introductions by humans. Introductions of species also lead to an increase in absolute biodiversity. Invasive species, especially aggressive ones, significantly change the structure of communities. An example of an invasive species that has spread widely in the European part of Russia is Sosnowski's hogweed. Invasive species at the local level increase the diversity of the flora, mainly due to neophytes [4, 6, 7]. Pasture digression in the initial stages can also be accompanied by enhanced plant diversity due to load-resistant, as a rule, ruderal species. For example, the Crimean yaila, used as pasture for long periods of time, is highly diverse. Some rare species, for example, Boeotia wheat (*Triticum boeoticum*) in the Crimea are often associated with anthropogenically transformed habitats [8].

Environmental management also affects biodiversity in the urban environment. A study of German cities has demonstrated that abandoned urban sites are characterized by a greater diversity than industrial or residential areas. The floristic diversity of deserted urban sites is higher when they are used periodically and are not abandoned over long periods of time. This may be explained by activation of succession processes during periodic deterioration of the vegetation cover and its subsequent restoration [9].

Thus, the areas of long-term development are associated with special communities, fundamentally different from the original ones; such ecosystems may be termed "anthropogenic."

Analysis of the spatial differentiation of flora under the impact of anthropogenic activities allows us to highlight floristic gradients in the urban environment. Urban nuclei — areas in long-term use as urban settlements — are considered to be the most homogeneous. Theses nuclei host species that are best adapted to altered conditions. The role of native species increases when moving away from the city center towards low-rise buildings and city boundaries [1, 10]. One can talk about the ecotone ("fringe") effect on the boundary between urbanized and natural territories [11].

The southwestern part of Crimea is a long-developed territory, where the first cities appeared in the 5th-6th centuries BC. Over a long period of nature management, anthropogenic transformation of forests has occurred. Indigenous oak forests, which have been replaced by agricultural lands and secondary oak-hornbeam forests, have been almost entirely cleared. Steppes have been replaced by farmland. Over the past hundred years, large-scale reforestation works have led to the formation of forest plantations from Crimean pine and Pitsunda pine. Habitats were also changing along with changing economic needs.

The floristic and phytocenotic richness was assessed in the territory of the Maximov's Dacha Natural Park SPNA (83.9 ha) used as a case study. The park is located in the urban area of Sevastopol in the Khomutova ravine. The SPNA was established in 2015 on the site of the former estate of Major A.A. Maximov (early 20th century). The history of nature management in this area goes back to antiquity — the modern territory of the park was part of the Tauric Chersonese Chora. The foundation of the ancient manor has been preserved. At the beginning of the 20th century, the Crimean building stone was mined on the Khomutova ravine slopes and thereafter, the slopes of the quarry were terraced for vineyards and ornamental plantations — *Celtis australis, Gleditsia triacanthos, Robínia pseudoacácia*, etc. In the central part of the Khomutova ravine, A.A. Maximov created a manor with an artificial water supply system, ponds, and small architectural forms. An important factor influencing the flora was the massive introduction of alien plants (they were brought from all over the world to create a unique park). In the Soviet period, the territory of Maximov's Dacha was transferred to a leshoz, (i.e., a forest management enterprise) whose employees established forest belts and other plantations (*Cotinus coggygria, Juglans regia,* etc.) in the post-war period. Thus, the territory of the SPNA is a combination of natural and anthropogenic environment with a variety of habitats.

II. Materials and Methods (Model)

The Maximov's Dacha Natural Park is located in the southwestern part of Russia, on the Crimean Peninsula.

To study the flora and vegetation of the territory of the Maximov's Dacha Natural Park, a field description of flora and vegetation was carried out from late April to September 2019. Plant identification reference guides were used to determine species composition. Some floristic information related to the park was published earlier [12, 13]. The taxa nomenclature is given in accordance with the report "Natural flora of the Crimean Peninsula" [14].

Based on the collected data, a geobotanical map of the territory of the Maximov's Dacha Natural Park was compiled. To study of plant communities, standard geobotanical descriptions were carried out on 20 sample plots where their floral and phytocenotic structure were determined. Sample plots were established in different types of forest communities — oak-hornbeam, oak, oak-scumpia, pistachio, polydominant (an array of alien species), and pine (forest plantation). Also, to identify and clarify the boundaries of plant communities' habitats, an orthophotograph obtained in the fall of 2018 by photogrammetry from an unmanned aerial vehicle (UAV) Phantom4 was used.

The geobotanical map was compiled based on the typological principle and utilized the ecological-phytocenotic classification of vegetation. Groups of associations and types of vegetation were identified. The main types of vegetation included forest and woodland, forest-steppe, steppe and meadow, and aquatic and man-made communities.

III. Results and Discussion

According to geobotanical zoning, the studied territory is located in the foothill zone of forb steppes, shibliak thickets, forest-steppe, and oak forests in the Piedmont Crimean region of the Crimean Novorossiysk sub-province of the Euxin Province of the Mediterranean Region [15, 16]. The zonal type of vegetation is feather-grass steppes and oak forest-steppe. The climate of the region is temperate coastal with Mediterranean features. The annual precipitation is 420 mm; the average annual air temperature is 12.1 degrees.

The vegetation of the Maximov's Dacha Natural Park is a combination of artificial monodominant tree plantations of various compositions, areas of mixed plantings of alien tree species, preserved zonal steppes with shrub clumps, and transformed communities of weed species on altered substrates.

Forests of Maximov's Dacha have elements of both natural and anthropogenic origin. There, several types of forest plant communities can be distinguished — pistachio woodlands on the eastern slope of the ravine; oak-hornbeam communities with dogwood, Christ's thorn, etc. on the western slope of the ravine in its lower part; pine forests (forest plantations) on the western side of the ravine in its upper part; mixed stands of ornamental trees on the bottom and on the slopes (as groves) of the ravine; and hornbeam-scumpia forests on the western plateau (forest plantations).

Grass communities cover the watersheds and the near-watershed areas of the eastern slope and include oak forest-steppe on the watersheds, feather-grass petrophytic steppes on the slopes and watersheds, mixed-grass communities on the bottom of the ravine; transformed (weed-ruderal) communities; and common laburnum (plantings) forest-steppe.

Aquatic communities of spring-fed man-made reservoirs represent a class of its own.

Thus, it is apparent that Maximov's Dacha has a variety of habitats, which largely determines floristic diversity, including that in the urban environments [17].

As a result, we have identified 520 taxa at the species and subspecies levels, which belong to 286 genera, 78 families, five classes, and three divisions of higher vascular plants. The spectrum of the ten most species-rich families includes 281 species (58.6% of the species composition of the flora) belonging to 172 genera (60.1% of the total number of genera). Families *Asteraceae*, *Poaceae*, and *Fabaceae* are most abundant, as in the flora of the Crimean peninsula in general [2], [20]; these families account for 31.1% of the park's flora (30% of the Crimean flora). This fact suggests the taxonomic position of the park's flora — *Fabaceae*-type (southern, mediterranean-southwest-asian). The Brassicaceae family holds the next position in terms of importance both in the park's flora and in the Crimean flora. This fact indicates that the taxonomic spectrum of the park's flora belongs to the *Brassicaceae* subtype and is a reflection of the synantropization of the flora, since a significant number of species of the *Brassicaceae* family are ephemera and weeds growing in disturbed ecotopes. By the number of species, the leading positions belong to by the genera *Euphorbia*, *Galium*, *Medicago*, *Carex*, and *Alyssum*.

The Maximov's Dacha Natural Park has a high number of rare species — 38 species of plants are listed in the Red Book of the Russian Federation and Sevastopol, as well as the European Red List and the Red List of the International Union for Conservation of Nature (Fig. 1-3; Table I).

Fig. 1. Habitat of *Orchis purpurea*.

Fig. 2. *Himantoglossum comperianum*.

TABLE I. PROTECTED SPECIES OF THE MAXIMOV'S DACHA NATURAL PARK [18, 19]

№	**Species**	**environmental list** [a, b]			
		S RB	***R RB***	***E RL***	***RL IUCN***
1	*Hippocrepis ciliata*	3			
2	*Satureja taurica*	3			
3	*Verbascum marschallianum*	3			
4	*Beta maritima*	3			LC
5	*Scilla bifolia*	2		LC	
6	*Crocus angustifolius*	2			
7	*Crocus pallasii*	3	2		
8	*Centaurea caprina*	2			
9	*Juniperus deltoides*	2			
10	*Taxus baccata*	3	2		LC
11	*Pistacia mutica*	2	3		NT
12	*Pinus nigra* subsp. *pallasiana*	4	1		LC
13	*Pinus brutia* var. *pityusa*	2	2		VU
14	*Iris pumila*	4	3		
15	*Iris pseudacorus*	2			LC
16	*Bellevalia speciosa*	4	2		
17	*Paeonia daurica*	2			
18	*Stipa pontica*	2			
19	*Stipa lessingiana*	2			LC
20	*Stipa capillata*	2			
21	*Stipa pulcherrima*	2	3		VU
22	*Stipa lithophila*	2			
23	*Scabiosa praemontana*	2			
24	*Avena barbata*	3		LC	
25	*Avena clauda*	2		LC	
26	*Paronychia capitata*	2	2		
27	*Triticum boeoticum*	2			
28	*Galanthus plicatus*	2	2		LC
29	*Himantoglossum comperianum*	2		EN	
30	*Anacamptis morio ssp. caucasica*	3	3	NT	
31	*Anacamptis pyramidalis*	3	3	LC	
32	*Cephalanthera damasonium*	3	3	LC	
33	*Epipactis helleborine*	3		LC	
34	*Orchis purpurea*	3	3	LC	
35	*Orchis simia*	2	3	LC	
36	*Himantoglossum caprinum*	2	1	NT	
37	*Sternbergia colchiciflora*	2	1	LC	
38	*Rumia crithmifolia*	3			

a. S RB - Sevastopol Red Book, R RB - Russian Red Book, E RL European Red List, RL IUCN - Red List of the International Union for Conservation of Nature

[b.] EN – Endangered, VU - Vulnerable, NT - Near Threatened, LC - Least Concern

Fig. 3. *Cephalanthera damasonium*.

Thus, it is obvious that *Pinus brutia* var. *pityusa*, *Stipa pulcherrima* (Vulnerable), and *Pistacia mutica* (Near Threatened) have the highest-priority protection status.

IV. Conclusion

Field observations conducted in the territory of the SPNA "Maximov's Dacha Natural Park" have identified more than 520 species of vascular plants, i.e., 30% of the urban flora and 20% of the flora of the Crimean peninsula are concentrated on 1% of the city's area, which allows us to consider Maximov's Dacha to be a biodiversity hotspot.

The vegetation cover of the SPNA includes a complex combination of forest, steppe, forest-steppe, shrubby meadow, and aquatic communities of natural and anthropogenic origin. Floristic diversity is associated with a variety of habitats, including anthropogenic ones.

The Maximov's Dacha Natural Park has 38 plant species listed in the regional Red Book; out of this number, 17 and 21 species are in the national and international Red Lists, respectively.

Thus, there is an apparent positive anthropogenic impact on floristic and phytocenotic diversity, even in conditions of urbanization.

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