Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2021, 11(1), 218-233, doi: 10.15421/2021_34

ORIGINAL ARTICLE *UDC 502.172(477.43-751.3):911.373*

The current state of flora in the National Nature Park "Podilski Tovtry" (Ukraine)

L.G. Lyubinska [1], O.V. Mudrak[2*], D.V. Andrusiak[3], G.V. Mudrak[4], T.V. Dushanova[1]

[1] *Kamianets-Podilskyi Ivan Ohiienko National University, 61 Ohiienko St, Kamianets-Podilskyi, 32300, Ukraine*

[2] *Public Higher Educational Establishment "Vinnytsia Academy of Continuing Education", 13 Hrushevskyi St, Vinnytsia, 21050, Ukraine*

[3] *Institute of Agroecology and Environmental Management NAAS of Ukraine, 2 Metrolohichna St, Kyiv, 03143, Ukraine*

[4] *Vinnytsia National Agrarian University, 3 Soniachna St, Vinnytsia, 21008, Ukraine*

**Corresponding author E-mail: ov_mudrak@ukr.net*

Received: 10.01.2021. Accepted 16.02.2021

The article considers the current state of the flora of the National Nature Park (NNP) "Podilski Tovtry", one of the largest in Ukraine, occupying 261,316 hectares, where about 72% are anthropogenic landscapes, which significantly affected the transformation of its flora. The article provided the park's characteristics from physical-geographical, geomorphological, geobotanical, and floristic zoning. It describes the species composition of flora, its biomorphological, ecological, ecotopic, and ecocoenotic features. The park's systematic structure has been established, its biomorphological and chorological analysis, and the flora's ecological structure concerning the water regime of soils, light regime have been carried out. The influence of edaphic factors and phytoenvironment that lead to the formation of the corresponding ecocenomorphs has been clarified. The degree of anthropogenic transformation of flora according to different indices is determined. The autphytososological index of flora was calculated, and its sosological analysis was performed.

Keywords: biodiversity, flora, anthropogenic transformation, sozology, National Nature Park "Podilski Tovtry".

Introduction

Conservation of biodiversity (BR) is one of the most important world community tasks to achieve sustainable development. It is essential for all spheres of human activity (economic, social, environmental), determining society's culture, spirituality, and mentality. The scope of society has approached the limits of stability and resilience of natural ecosystems. As a biological species, humans must realize that its survival depends on the survival of other plants and animals and preserving the fullness of the gene pool in ecosystems. The solution to the conservation of BR at the biosphere originates from local and regional nature reserve networks, a kind of "framework" for maintaining natural systems' ecological balance. BR, which was formed during the long biological evolution, is the most important natural resource (it is 35% of all human needs), and its full preservation is possible only by bequeathing reference sites, which mainly represent the existing richness of flora and fauna and landscape complexes of any region (Mudrak, Mudrak, 2013, 2020).

One of the most important objects for the protection, preservation, and reproduction of BR on the territory of Ukraine is the National Nature Park "Podilsky Tovtry".

The main landscape complexes common in the park are Tovtrov hills, ridge-hilly, karstic, composed of reef limestones with gray forest soils, and carbonate chernozems with hornbeam oaks. Here there are forest hills, dissected by black valleys and chernozems podzolic with island oak oaks and high Dniester terraces, dissected by valleys cut into Paleozoic deposits with gray and dark gray forest soils, deep chernozems with hornbeam groves, which belong to the deciduous forests of the plains of Ukraine (Marinich, Shishchenko, 2005).

The diversity of landscapes contributes to the formation of the unique flora of NNP. The systematic structure of the flora is determined by Tolmachev A.I. (1974), as inherent in each flora distribution of species between systematic categories of higher rank, which is its most important structural and functional feature. It reflects the patterns of adaptation of species to the maximum use of a particular region's ecotopic wealth. It is a quantitative characteristic of the taxa that makes up the flora, thus reflecting one aspect of its organization and its differentiation. Of particular interest is the possibility of comparative analysis of the flora of different areas through indicators of their systematic structures and identifying the place of the studied flora in the

system of adjacent regional and elementary flora (Kamelin, 1973; Tolmachev, 1974, 1986; Shelyag-Sosonko, Didukh, 1987; Yurtsev, Kamelin., 1991).
The most critical quantitative indicator of any flora is floristic richness, which is determined by the number of species, genera, and families. The leading indicators of the systematic structure are the ratio between different groups of vascular plants, which are expressed as a percentage of the total number of species, genera, and families; distribution of species between different taxa – types, families, and genera; quantitative composition of leading families; the ratio between the number of species in different families. The obtained quantitative indicators and their comparison with those of other regional flora reveal specific botanical and geographical patterns of flora (Tolmachev, 1986). The percentage of endemics can judge the degree of individuality of flora, and the analysis of endemism gives an idea of the features and ways of origin of flora (Jena, 2009; Zaverukha, 1985; Kleopov, 1990). The originality of the flora and the degree of its originality is revealed by the analysis of phylogenetic, chorological, coenoecological features of endemics, which are absolute indicators of its difference from other flora. Accounting for the quantitative and qualitative composition of endemics is important in floristic zoning and provides valuable factual material to address florogenesis, floristic zoning, and the development of plant protection issues (Tolmachev, 1974; Jena, 2009).
The modern NPP "Podilski Tovtry" territory is actively studied since the 19th-20th centuries. We have studied well-known scientific works (Andrzejowski, 1862; Rogovich, 1869; Besser, 1882; Montrezor, 1886; Krutskevych, 1937; Makowiecki, 1939; Grin, 1973; Kovalchuk, 1981).

Material and Methods

The research was based on the authors' field research during 1991-2020 on the NPP "Podilski Tovtry" territory. The research methods included stationery, semi-stationary, and detailed-route.
Administrative location. The park's territory is part of Kamyanets-Podilsky, Chemerovetsky, and Horodok districts of the Khmelnytsky region (Fig. 1) (Mudrak, 2012).
Various anthropogenic landscapes occupy an area – 261316 hectares (12.5% of the Khmelnytsky region territory), about 72%. 4453.1 ha (1.7% of the total area) were transferred to the permanent use of the NNP, the rest of the territory – 256862.9 ha was included in the park's total area without withdrawal from other users. It is one of the largest in Europe.
General characteristics. This area's decoration is Tovtrov ridge, which has no analogs in Europe and is unique. It has about 200 tons and is rich in karst forms. There are occasional caves (for example, "Atlantis" and "Malyshka-Kiyanka" near the village of Zavallya, Karmelyukova cave in the village of Pryvorottya), but small karst forms dominate the karst: cracks, furrows, cells, funnels, crates, which form on the main ridge of the Tovtrov massif is sometimes a real karst field. Weathered and blurred limestone outcrops form exotic rocks of various shapes – columns, pillars, giant "mushrooms," or chaotic accumulations of boulders and boulders. The geological monuments of nature attract both scientists and travelers: Kitaygorod outcrop – the world-famous reference section of the Silurian sediments and Smotrytsky canyon – a picturesque work of nature, the vertical walls of which reflect the history of the Silurian. Two sites – "Bakotskaya Bay" (1590 ha) and "Smotrych River Lowland" (1480 ha) – are WBU of international importance and play an essential role in preserving the Dniester river basin as a habitat for waterfowl.
The park includes 142 objects of the nature reserve fund (NRF), but its protected area is formed by landscape reserves of national importance "Knyazhpilsky", with an area of 821 hectares (established in 1983) and "Owl Yar", with an area of 827 hectares (created in 1978). In the southern peripheral zone of the park, there are two more botanical reserves of national importance "Nyzhni Patryntsi", with an area of 80 hectares (established in 1996) and "Heron" (177 hectares, created in 1989) (Mudrak O.V., 2012), which are key areas of the ecological network park. According to the physical and geographical zoning of the territory of Ukraine, the park belongs to the Transnistrian-East-Podilsky forest-steppe of the Dniester-Dnieper forest-steppe region of the Forest-steppe zone of the Eastern European plain landscape country (Marinich, Shishchenko, 2005).
According to the geomorphological zoning of the territory of Ukraine, NPP "Podilski Tovtry" belongs to the Podil structural-denudation upland, which is part of the Volyn-Podilsk region of formation-denudation uplands and formation-accumulative elevated plains, which is part of the Eastern European polygenic plain of Ukraine and Moldova (Marinich, Shishchenko, 2005). NNP combines two valuable geological formations of international level – Tovtrov ridge and geological outcrops of different ages of the canyons of the Dniester River's left tributaries and its left bank.
According to the climatic zoning of the territory of Ukraine, the northern part of the park belongs to the 6th climatic region of the Western Forest-Steppe climatic zone. The humidity is 1.9-2.4, and the number of days per year with an average daily temperature above 15 °C is 110-120, and from 5 up to 15 °C – 105-110. The southern part of the park belongs to the 7th climatic region of the Central Forest-Steppe climatic zone, where the humidity is 1.7-1.9, and the number of days per year with an average daily temperature above 15 °C is 105-115, and from 5 to 15 °C – 90-100. According to the hydrological zoning of the territory of Ukraine, NPP "Podilski Tovtry" belongs to the Volyn subregion of the acceptable water content of the Western region of the acceptable water content of the zone of the acceptable water content of the plain part of Ukraine. According to the soil-geographical zoning of the territory of Ukraine, the park belongs to the forest-steppe zone of podzolic, leached, and typical chernozems of the Central forest-steppe and steppe region of the Subboreal Belt (Marinich, Shishchenko, 2005).
According to the geobotanical zoning of the territory of Ukraine, one part of the park belongs to the Pokutsko-Medoborsky district of beech, hornbeam-oak and oak forests, real and steppe meadows and meadow steppes European deciduous forest region, and the other – to the Central Podolsk district of hornbeam-oak and oak forests and dry meadows of the Ukrainian forest-steppe subprovince of the Eastern European forest-steppe province of oak forests, steppe meadows and meadow steppes of the Forest-steppe region (Didukh, Shelyag-Sosonko, 2003).

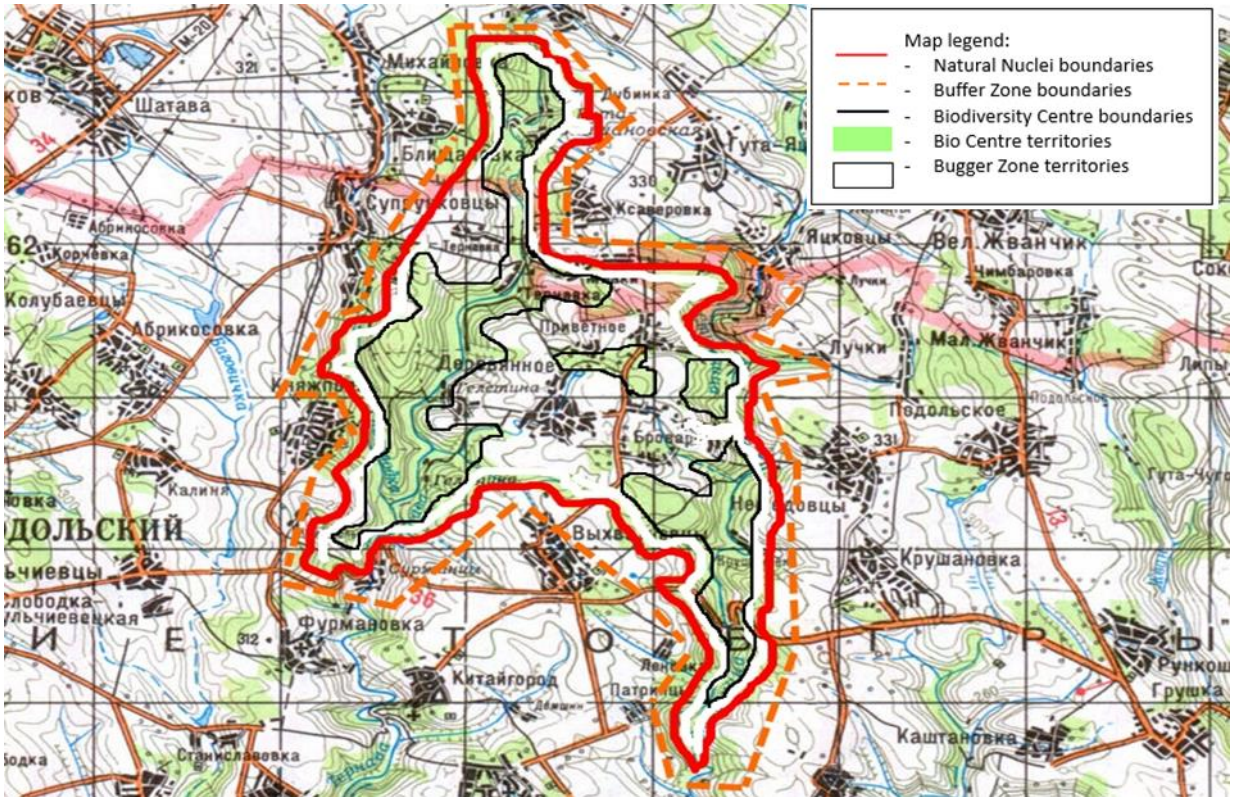

Fig. 1. **Topographical map of NPP "Podilski Tovtry"**

Forest phytocenoses represent the vegetation of the park with participation *Fagus sylvatica*, *Quercus robur*, *Fraxinus excelsior* and other; steppe – with *Carex humilis*, *Stipa pennata*, *Seslerieta heufleranae*, *Amygdalus nana* and other; calcepetrophytic phytocenoses, where common *Astragalus monspessulanus*, *Allium podolicum*, *Asplenium ruta-muraria*, *Asplenium trichomanes* and other; coastal water – with *Phragmites australis*, *Carex acuta*, *Typha latifolia*, and other; water – with *Lemna minor*, *Nuphar lutea* and other.

According to the floristic zoning, the territory of the NNP belongs to the Rostok-Podolsk district of the Lublin-Volyn-Podolsk subprovince of the Central European province of the European region of the North Palearctic subkingdom of the Holarctic kingdom (Zaverukha, 1985).

The study of the species composition of flora, its biomorphological, ecological, ecotopic, ecocoenotic features was carried out during expeditions, using classical methods and literature data for biomorphological analysis of the K. Raunkiaer scale (Raunkiaer, 1934) and the system of life forms of V.M. Golubev (1962). The establishment of floroecocenotypes was performed based on V.V. Novosad (1992) and Ya.P. Didukh (2000). Chorological analysis was performed using Meusel et al. (1965), with additions B.V. Zaverukhy (1985) for regional-geographical groups.

The floristic description was made from literature sources, long-term research, and materials of herbariums KW, KWHA, KXM, LWKS, PTR and PDH. Personal herbarium collections are about 3200 specimens stored in the herbarium of NPP "Podilski Tovtry", in the national herbarium of the Institute of Botany of NASU. The names of higher vascular plants are given according to "Vascular plants of Ukraine. A nomenclatural checklist" (Mosyakin, Fedoronchuk, 1999).

The degree of anthropogenic transformation was determined using accepted indices introduced by B. Jackowiak (Jackowiak, 1990).

The flora synanthropization index (IS) indicates the percentage of synanthropic species out of the total number of species:

$$IS = \frac{Ap+An}{Sp+An} \times \div 100\%$$

where Ap – apophytes, An – anthropophytes, Sp – spontanophytes, Arch – archaeophytes, Ken – kenophytes, Diaf – diaphytes.

Flora apophytization index (I_{AP}) is calculated as the percentage of apophytes from the total number of flora species:

$$I_{AP} = \frac{Ap}{Sp+\ An} \times 100\%$$

Spontanophyte apophytization index (I_{APS}) indicates the percentage of apophytes in the aboriginal element of the flora, equal to the percentage of apophytes to spontaneous:

$$I_{APS} = \frac{Ap}{Sp} \times 100\%$$

The index of anthropophytization of flora (I_{AN}) indicates the percentage of adventive species in general in the urban flora:

$$I_{AN} = \frac{Ap}{Sp+\ An} \times 100\%$$

The Flora Archaeophytization Index (IArch) indicates the percentage of archaeophytes in general in the urban flora:

$$IArch = \frac{Arch}{Sp+An} \times 100\%$$

The flora kenophytization index (IKen) indicates the percentage of kenophytes as a whole in the urban flora:

$$IKen = \frac{Ken}{Sp+An} \times 100\%$$

Flora Modernization Index (IM) indicates the percentage of kenophytes in the adventive element of the urban flora:

$$IM = \frac{Ken}{An} \times 100\%$$

The hemerobic index (RIH) is calculated based on the ratio of the sum of euhemerobes (β-EH and α-EH) and polyhemerobes (PH) to the sum of oligohemerobes (OH) and mesohemerobes (MH):

$$RIH = \frac{\beta-EH+\alpha-EH+PH}{OH+MH}$$

RIH values range from + 1 (the territory is occupied exclusively by poly- and euhemerobes) to – 1 (the territory is occupied exclusively by meso- and oligohemerobes) (Jackowiak, 1998).

The autphytososological index is calculated according to the formula $API = \frac{\sum CoxK}{N}$, where Co is the indicator of sozological assessment (in points), K is the coefficient of phytosozological value, N is the number of signs.

Data processing was performed by Statistica 6.0 software.

Results

Species diversity of the flora of NPP "Podilsky Tovtry" is 1525, of which *Equisetophyta* – 5, *Polypodiophyta* – 15, *Pinophyta* – 6, *Magnoliophyta* – 1499. The vast majority of species of NPP *Magnoliophyta* (97.6%), and the class *Liliopsida* accounts for 16.9% (191 species) and *Magnoliopsida* – 80.7% (909 species), i.e., they are related as 1:4.8. This ratio is higher than in Central Europe (1:2.9) but is very close to the ancient Mediterranean flora (Zaverukha, 1985; Tolmachev, 1974, 1986).

Indicators of systematic diversity include floristic proportions and the average number of species in the genus, family, and the average number of genera in the family. These indicators illustrate the degree of species and genus diversity in different departments of vascular plants. For NPP "Podilski Tovtry" the total floristic proportion is 1:4.2:10.2, which brings it closer to similar proportions of florid areas. The average number of family species is 10.2, and in the genus (genus coefficient) – 2.4.

The spectrum of NNP "Podilski Tovtry" families (Table 1) has a much lower position of the Brassicaceae family than the flora of Voronyak, Opillya, Maly Polissya, and Volyn-Podillya. The next distinctive feature is the more significant xerothermicity of the region's total flora and higher overall synanthropization (Mirkin, Naumova, 2001; Protopopova, 1991; Protopopova et al., 2002). However, the flora of the NNP is similar to the Khotyn Upland, which is explained by the xerothermism and high synanthropy (Table 1).

The genus Carex's high location indicates a closeness to the boreal flora, but genera such as Trifolium and Allium are close to the Mediterranean type. There are 677 species of aboriginal species and 848 species of synanthropy flora in the flora of the NNP "Podilski Tovtry". The synanthropic fraction is divided into apophytic and adventive fractions. Among synanthropic species, 513 are the apophytes species and 335 adventive species. The vegetation cover of NPP "Podilski Tovtry" reflects the ecological features of the territory. Ecological characteristics of species such as climamorphs, hygromorphs, heliomorphs, and thermomorphs indicate the plant's relationship with the environment, with the ecotope. According to Raunkier's life forms (Raunkiaer, 1934) in the flora of NNP "Podilski Tovtry", as can be seen from Fig. 1, dominated by hemicryptophytes (35%), almost at the same level geophytes (24%) and therophytes (22%).

Table 1. **Comparison of the dominant plant families of NPP "Podilski Tovtry"**

No	NPP "Podilsky Tovtry"		Khotyn Upland		Volyn-Podillya		"Medobory" Nature Reserve	
	Family name	species	Family name	species	Family name	species	Family name	species
1	*Asteraceae*	130	*Asteraceae*	129	*Asteraceae*	242	*Asteraceae*	111
2	*Rosaceae*	83	*Poaceae*	96	*Poaceae*	142	*Poaceae*	73
3	*Poacea*	78	*Rosaceae*	68	*Rosaceae*	141	*Fabacea*	53
4	*Lamiaceae*	68	*Fabaceae*	64	*Brassicaceae*	98	*Rosaceae*	52
5	*Fabaceae*	65	*Brassicaceae*	59	*Cyperaceae*	89	*Lamiaceae*	52
6	*Ranunculacea*	49	*Lamiaceae*	57	*Lamiaceae*	87	*Brassicaceae*	46
7	*Scrophulariaceae*	49	*Scrophulariaceae*	46	*Fabacea*	86	*Ranunculaceae*	39
8	*Apiaceae*	47	*Ranunculaceae*	39	*Scrophulariaceae*	78	*Caryophyllaceae*	37
9	*Caryophyllaceae*	44	*Cyperaceae*	39	*Caryophyllaceae*	74	*Scrophulariaceae*	35
10	*Brassicaceae*	43	*Apiaceae*	37	*Ranunculaceae*	69	*Cyperaceae*	33

The flora of the NNP "Podilski Tovtry" has a Central European character and corresponds to the forest-steppe zone's flora. Biomorphological analysis indicates that the flora of the NNP is a typical Holarctic with herbaceous plant domination. In particular annuals, monocarpic species present mainly a group of adventive species, which indicates the transformation of flora.

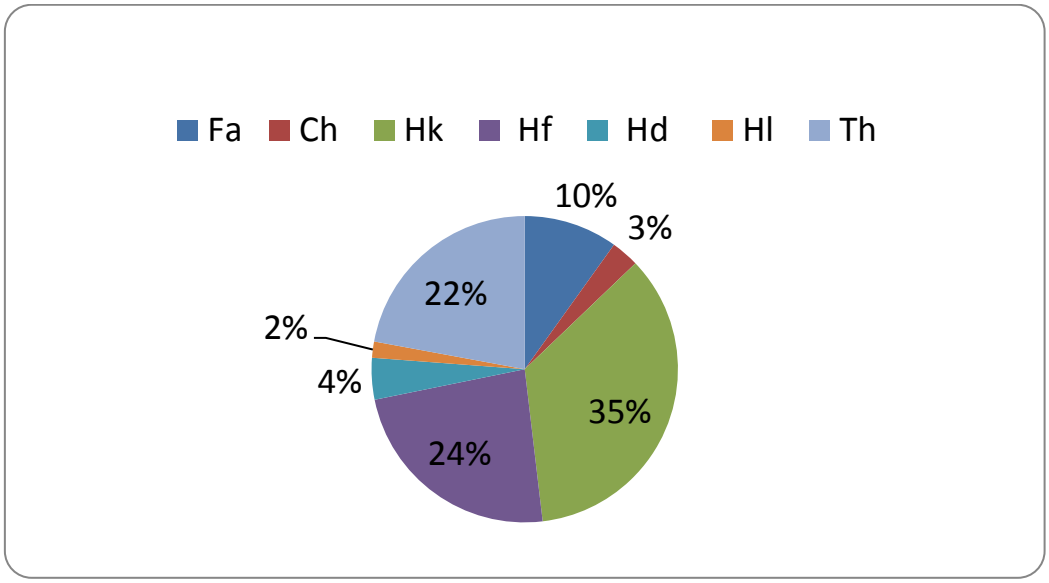

Fig. 1. **Life forms of NPP flora.** (Fa – phanerophytes, Ch – hamephytes, Hk – hemicryptophytes, Hf – geophytes, Hd – hydrophytes, Hl – helophytes, Th – therophytes)

Concerning moisture, xeromesophytes and mesophytes are predominant (33% and 32%, respectively), mesoxerophytes account for 13%, and the remaining groups of hygromorphs are represented 3-5% of species (Figs. 2, 3). Such indicators highlight the landscape features of the study area, the richness of ecotopes.

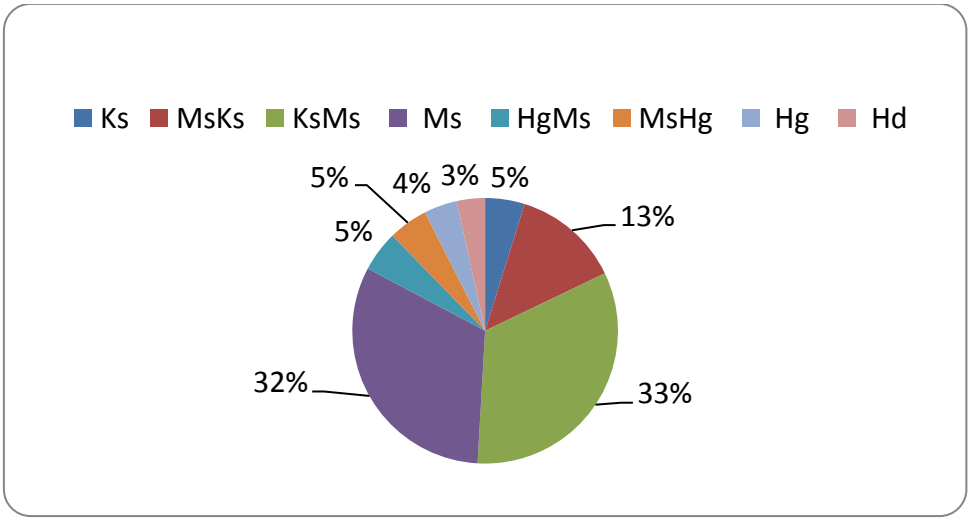

Fig. 2. **Hygromorphs of NPP flora.** (Ks – xerophytes, MsKs – mesoxerophyte, KsMs – xeromesophytes, Ms – mesophytes, HgMs – hygromesophytes, MsHg – mesohygrophytes, Hg – hygrophytes, Hd – hydrophytes)

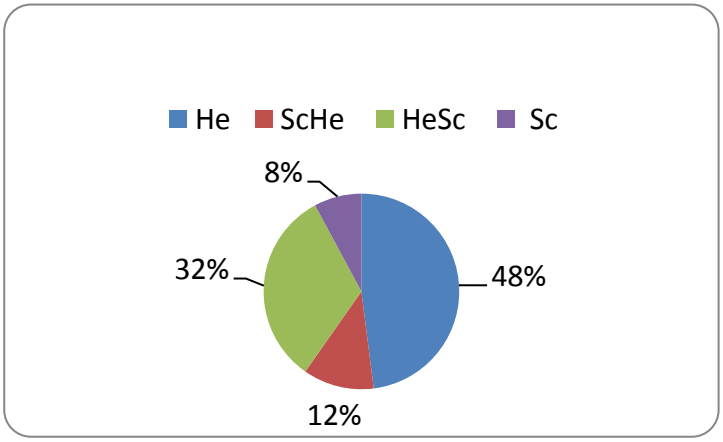

Fig. 3. **Heliomorphs of NPP flora.** (He – heliophyte, ScHe – sciogeliophyte, HeSc – heliosciophyte, Sc – sciophyte)

Among heliomorphs there are heliophytes and sciogeliophytes, which is fully explained by ecotopes' peculiarities. The influence of edaphic factors and phytoenvironment leads to the formation of appropriate ecocenomorphs. The presence of groups that mainly gravitate to rocky ecotopes is due to the NNP "Podilski Tovtry" specifics. The predominant are silicants, silvopetrophants, manganese, synanthropophants, to a lesser extent proto-stepants and stepants. Ecological features of the flora of NPP "Podilski

Tovtry" correspond to the peculiarities of geomorphology, orography, and the research area's landscape structure. The flora's geographical structure is an indicator of its formation's genesis directions and reveals the originality, the degree of similarity of the studied flora with the flora of the surrounding areas (Litvinov, 1902; Zaverukha, 1985).

The flora of NNP "Podilski Tovtry" is characterized by species that grow in several latitudinal zones, and only a small number of them can represent one zone. Latitudinal areal types are of the following types: meridional-temperature - (265 species; 23.6%), meridional-boreal (203; 18.0%), submeridional-temperature (194; 17.2%) and submeridional-boreal (133; 11.8%), temperature-boreal (10; 0.9%), meridional (6; 0.5%) sub-tempered (28), submeridional (15; 1.5%), tempered (6). Such data confirm the moderate nature of the flora of the park. A small number of multizonal species (103; 9.2%) indicate the flora's regional specificity.

Longitudinal types of habitats are various. The predominant species are with Euro-Asian (Euro-Asian, Euro-West Asian) (631; 41.3%) and European (568; 37.2%) habitat types. Other types of habitats are represented as follows: Euro-Siberian (Euro-West Siberian and Euro-Siberian) (98; 6.4%), circumpolar (198; 12.9%), multiregional (14; 0.9%). Cosmopolitans are a small group (17; 1.15%). This flora distribution confirms the marginal geobotanical location of the NNP and the influence of the adventive factor. The flora of the park and Podillya, in general, is a striking example of heterogeneous flora.

The peculiar nature of the flora is manifested through species on the border of their range (Tolmachev, 1974; Zaverukha, 1985; Jena, 2009). The park seven species have a northern limit of distribution, in particular *Crocus heuffelianus, Staphyllea pinnata*, *Astragalus monspessulanus, Fritillaria montana*, and on the western border nine species (*Ephedra distachia, Centaurea orientalis etc.),* 15 species grow here on the eastern border *(Fagus sylvatica, Crataegus pentagyna, Phyllitis scolopendrium, Helleborus purpurascens* etc*).* The flora of the park also includes species with a broken range (disjunctive-area). Among this group, which includes 43 species, are known *Allium obliquum, Fritillaria montana, Allium strictum, Salvia cremenecensis.* They also confirm the florogenesis phenomena.

An absolute indicator of the originality of the flora is the presence of endemic species in its composition. The criterion of endemicity is the confinement of this species' entire range to a particular area (Shelyag-Sosonko et al., 1982; Tolmachev, 1986; Jena, 2009). Thus, endemism – is a geographical concept.

The establishment of systematic and geographical connections of endemics is of the highest importance in analyzing endemism. The endemic species' position in the genus system allows determining its genetic connections and possible origin, which, together with the data of chorology, makes it possible to identify common features of the studied flora and flora of other areas to suggest ways and conditions of florogenesis (Tolmachev, 1974). Issues of endemism in the territory included in the NNP were considered in the works of W. Gajewski, (1931), G.O. Kuznetsov (1963), G.S. Kukovytsi (1970), I.I. Moroz (1970), Yu.R. Shelyag-Sosonko et al. (1982). More detailed data are in the article by Yu.R. Shelyag-Sosonko and Ya.P. Didukh (Didukh, 2000; Didukh, Shelyag-Sosonko, 2003), in which the list of endemic species of Podillya is given when substantiating the eastern border of the Central European floristic province. B.V. Zaverukha paid significant attention to endemism in Volyn-Podillya (1985) territory, considered theoretical problems, and described the main endemic species singled out true endemics and subendemics, taking into account the peculiarities of the area. In particular, true endemics are species distributed within the region, and subendemics cover neighboring floristic areas. For Volyn-Podillya, B.V. Zaverukha (1985) identified 88 species of endemic elements, V.V. Novosad and L.I. Krytska (2009) lists 74 species of endemics and subendemics for Middle Transnistria (Zaverukha, 1985; Novosad, Kritska, Lyubinska, 2009).

Table 2. **Endemic plant species of NPP "Podilski Tovtry".**

Families	Number of endemic genera	Total species
Ranunculaceae	3	3
Caryophyllaceae	7	9
Brassicaceae	3	3
Malvaceae	1	1
Euphorbiaceae	1	5
Rosaceae	3	14
Fabaceae	1	3
Linaceae	1	2
Apiaceae	3	3
Rubiaceae	2	5
Boraginaceae	2	4
Lamiaceae	4	10
Asteraceae	3	5
Alliaceae	1	3
Poaceae	1	1
Araceae	1	1
Total:	38	70

As the area of NNP "Podilski Tovtry" is insignificant, we have not identified narrow endemics for this area, but it is worth noting the presence of narrow endemics characteristic of Podillya. As indicated by A.V. Jena (2009), narrow endemics deserve absolute priority in the study and conservation of phytodiversity: they are not just rare or original forms, but the insurance potential of heredity and continuity of evolutionary changes in flora (Jena, 2009).

As a result of the analysis of the flora of NPP, there is 4.5% (70 species) of endemic elements. The distribution of all endemic and subendemic species by families is shown in Table 2, while the main number belongs to the families Rosaceae, Lamiaceae, Caryophyllaceae, and five species families Euphorbiaceae, Rubiaceae, Asteraceae.

Three species contain the families *Ranunculaceae*, *Brassicaceae*, *Fabaceae*, *Apiaceae*, *Alliaceae*. Among the 40 genera that contain endemic species, the largest are *Rosa* L. (10 species), *Thymus* L. (5), *Euphorbia* L. (5), *Galium* L. (4), three species are part of the genera *Chamaecytisus Link*, *Salvia* L. and *Allium* L., two each – *Gypsophila* L., *Dianthus* L., *Crataegus* L., *Linum* L., *Jurinea Cass*., *Anchusa* L., *Onosma* L., *Spiraea* L., one – 21 families each.

Herbaceous polycarpics, summer-winter-green and summer-green plants, hemicryptophytes, taproot, non-rosette, and semi-rosette plants with caudexes, which coincides with the biomorphological features of the region's flora, predominate among the endemics. Among ecocenomorphs, petrophants and steppes predominate. Since the park is located on the border of two geobotanical areas, the presence of so many endemic elements of Podillya indicates the florogenesis processes in this region and the flora's originality.

One of the indicators of the antiquity of the flora is the presence of relict species. The first data on this group within the park are given in J. Pachosky (1910). The general analysis of relict species of deciduous forests was given by Yu.D. Kleopov (1990), and the whole territory of Ukraine Klokov (1963). B.V. Zaverukha (1985) summarized Volyn-Podillya. 64 relict species grow in the NNP, including *Carex humllis*, *Euonimus nana*, *Euphorbia volhynica*, *Schivereskia podolica*, *Laser trilobum* and others. It should be noted that the vast majority of them occur in rare habitats.

Thus, the NNP "Podilski Tovtry" flora is characterized by rich species diversity and the presence of endemic and subendemic species, relics, species with a disjunctive range, or the border of the range.

The first lists of rare species for the territory of NPP "Podilski Tovtry" are given in the first volume of the Chronicle of Nature of NPP and transferred to create a list of potentially protected species of the Khmelnytsky region. Principles and criteria have been developed to include plants in regional lists. The generally accepted principle of species protection is the existence of higher conservation status: international (interstate) (World Red List (IUCN), European Red List, Annex I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Berne Convention) and national book of Ukraine (1996) (Mosyakin, 1999; Didukh, 2009; IUCN, 2011; Lubinska, Yuglichek, 2017). The criteria correspond to those adopted in the Red Book of Ukraine. In particular, there are endemic species, on the border of the range, disjunctive-areal (with a broken range); species whose habitats are intensively destroyed due to the use of subsoil; relict; species that form rare groups, which are listed in the Green Book of Ukraine; species that have low biological potential, low number of individuals; species that are intensively used by the population (ornamental, medicinal, fodder, etc.); rare species that were listed for this area, but at the present stage the information is not enough to establish their status.

The lists of species in need of protection on Podilsky Tovtry National Park territory are updated continuously, caused by the update of information and changes in the Red Book of Ukraine. The critical point is to confirm the location or growth of species that are known from herbarium collections or literary sources. We have established a list of species included in the Red Book of Ukraine (2009) (Mosyakin S.L., 1999; Didukh Ya.P., 2009) with 77 species, 46 genera, 22 families, three classes, and two divisions.

Sozological lists of international importance include 38 species (IUCN) – 4, the European list – 5, Annex 2 of the Berne Convention – 6 species, ICTS – 27 (Table 3). The share of rare species listed in the CCU in the flora of NPP "Podilski Tovtry" is 5.0%, in the flora of Ukraine – 1, 4% (although the parking area occupies only 0.42% of the territory of Ukraine). More species are listed in the Red Book of Ukraine in the Podilski Tovtry National Park compared to the adjacent protected sites.

We used autphytososological assessment for rare species, which was introduced and improved in Ukraine by S.M. Stoyko (1983). It is based on characteristics that indicate botanical-geographical and phytohistorical significance, reveal the species' uniqueness for Central Europe and Ukraine, geobotanical provinces and districts of Ukraine, and taxonomic originality, IUCN rarity category, number of localities, ability to generative and reproduction. Accordingly, the obtained number of points is distributed among the classes (1-API 4-6.9; II-API 7.0-8.9; III-API 9.0-10.90; IV-API 11.0-12.9; V-API 13-15.2); as can be seen from Table 3, the highest indices (13-15) have species that are relics or endemics and are known from one or more habitats. The lowest indices (4-6) were given to species whose growth sites have not been confirmed, and they have not been found in the park. This group includes species from the family *Orchidaceae*.

The location is not confirmed for 15 species and in other places of growth they are not detected (Anacamptis morio, Anacamptis palustris, Anacamptis pyramidalis Asplenium adiantum-niqrum, Carlina cirsioides, Dactylorhiza fuchsii, Dactylorhiza maculata, Dracocephalum austriacum, Gymnadenlos, Gymnadenia Neotinea ustulata, Orchis mascula, Orchis militaris, Orchis signifera).

Rare species that are included in the CCU grow mainly in forest habitats (55.9%), in grassland habitats – 24.7%, in rocky – 13%, wetlands and shrubs – 2.6%, and aquatic – 1.2%.

Table 4 lists the species that are not listed in the Red Book of Ukraine and need protection within the NPP "Podilski Tovtry" and Khmelnytsky region. We included 93 species from 39 families and 4 classes (Lubinska, Yuglichek, 2017).

Table 3. **Autphytososological indices of rare species of NPP "Podilski Tovtry"**

	Name of the species	AF1 NPP	European list	IUCN	Annex II Bernese Convention	CITES
1.	*Aconitum besserianum* Andrz.	14.6				
2.	*Aconitum pseudanthora* Blocki ex Pacz.	9.1				
3.	*Adonis vernalis* L.	6.1				
4.	*Allium obliquum* L.	11.2				
5.	*Allium pervestitum* Klok.	13.1		+		
6.	*Allium sphaeropodum* Klok.	13.8				
7.	*Allium strictum* Schrad.	12.7				
8.	*Allium ursinum* L.	7.5				
9.	*Anacamptis coriophora* (L.) (R.M. Bateman, Pridgeon et M.W. Chase	5.7				+
10.	*Anacamptis morio* (L.) R.M. Bateman, Pridgeon et M.W. Chase	9.4				+
11.	*Anacamptis palustris* (Jacq.) R.M. Bateman, Pridgeon et M.W. Chase	7.4				+
12.	*Anacamptis pyramidalis* (L.) Rich.	5.7				+
13.	*Asplenium adiantum-nigrum* L.	7.1				+
14.	*Astragalus monspessulanus* L.	9.4				
15.	*Astragalus ponticus* Pall.	10.2				
16.	*Atropa belladonna* L.	7.7				
17.	*Carex alba* Scop.)	10.3				
18.	*Carlina cirsioides* Klok.	12.5	+			
19.	*Cephalanthera damasonium* (Mill.) Druce	6.8				+
20.	*Cephalanthera longifolia* (L.) Fritsch	8.8				+
21.	*Cephalanthera rubra* (L.) Rich.	8.8				+
22.	*Chamaecytisus albus* (Hacq.) Rothm.	11.4				
23.	*Chamaecytisus blockianus* (Pawl.) Klaskova	12.0	+	+		
24.	*Chamaecytisus paczoskii* (V.Krecz.) Klaskova	11.0		+		
25.	*Chamaecytisus podolicus* (Blocki) Klaskova	14.2	+	+		
26.	*Corallorhiza trifida* Chatel.	10.5				
27.	*Crocus heuffelianus* Herb.	9.5				
28.	*Cypripedium calceolus* L.	9.3			+	+
29.	*Dactylorhiza fuchsii* (Druce) Soo	3.7				+
30.	*Dactylorhiza incarnata* (L.) Soo	4.2				+
31.	*Dactylorhiza maculata* (L.) Soo	4.2				+
32.	*Dactylorhiza majalis* (Reichenb.) P.F.Hunt et Summerhayes	5.7				+
33.	*Dictamnus albus* L.	10.0				
34.	*Dracocephalum austriacum* L.	6.0			+	
35.	*Epipactis atrorubens* (Hoffrn. et Bernh.) Schult	7.7				+
36.	*Epipactis helleborine* (L.) Crantz	7.2				+
37.	*Epipactis palustris* (L.) Crantz	8.1				+
38.	*Epipactis purpurata* Smith	8.9				+
39.	*Euonymus nana* Bieb.	10.5				
40.	*Euphorbia volhynica* Bess, ex Szaf., Kulcz. et Pawl.	14.7				
41.	*Fritillaria montana* Hoppe	11.5			+	
42.	*Galanthus nivalis* L.	6.8				
43.	*Gladiolus imbricatus* L.	9.5				
44.	*Gymnadenia conopsea* (L.) R.Br.	4.2				+
45.	*Gypsophila thyraica* Krasnova	14.7				
46.	*Iris sibirica* L.	9.7				
47.	*Lathyrus laevigatus* (Waldst. et Kit.	12.8				
48.	*Lathyrus venetus* (Mill.) Wohlf.	10.5				
49.	*Lilium martagon* L.	8.0				
50.	*Linum basarabicum* (Savul. et Rayss) Klokov ex Juz.	14.3				
51.	*Listera ovata* (L.) R.Br.	8.0				+
52.	*Lunaria rediviva* L.	9.8				
53.	*Malaxis monophyllos* (L.) Sw.	8.2				+
54.	*Neottia nidus-avis* (L.) Rich.	9.1				+

55.	*Neotinea ustulata* (L.) R.M. Bateman, Pridgeon et M.W. Chase	7.4				+
56.	*Orchis mascula* (L.) L.	7.4				+
57.	*Orchis militaris* L.	5.3				+
58.	*Orchis signifera* Vest	7.7				+
59.	*Platanthera bifolia* (L.) Rich.	7.1				+
60.	*Platanthera chlorantha* (Cust.) Reichenb.	7.1				+
61.	*Pulsatilla grandis* Wend.	10.3			+	
62.	*Pulsatilla patens* (L.) Mill.	9.6			+	
63.	*Pulsatilla pratensis* (L.) Mill.	11.2				
64.	*Rhamnus tinctoria* Waldst. Et Kit.	7.8				
65.	*Rosa czackiana* Besser	14.0				
66.	*Salvia cremenecensis* Bess.	15.1	+			
67.	*Schivereckia podolica* (Bess.) Andrz. ex DC.	14.0	+	+	+	
68.	*Scopolia carniolica* Jacq.	9.1				
69.	*Scutellaria verna* Bess.	11.9				
70.	*Sorbus torminalis* (L.) Crantz	9.0				
71.	*Staphylea pinnata* L.	9.1				
72.	*Stipa capillata* L.	8.2				
73.	*Stipa pennata* L.	8.3				
74.	*Stipa lessingiana Trin.en Rupr.*	9.8				
75.	*Stipa pulcherrima* C.Koch	8.3				
76.	*Thalictrum foetidum* L.	9.9				
77.	*Viola alba* Bess.	11.3				

Table 4. **List of species in need of protection within NPP "Podilski Tovtry" and Khmelnytsky region**

No	Name of the species	NPP "Podilski Tovtry"	Khmelnytsky region
1	*Aconitum eulophum* Reichenb.	+	
2	*Aconitum moldavicum* Hacq.	+	
3	*Aconitum variegatum* L.	+	
4	*Actaea spicata* L.	+	
5	*Allium podolicum* (Aschers. et Graebn.) Blocki ex Racib.	+	
6	*Allium sphaerocephalon* L.	+	
7	*Allisum medium* Iljinskaja	+	
8	*Amygdalus nana* L.	+	
9	*Anchusa pseudoochroleuca* Des.-Schost.	+	
10	*Anemone sylvestris* L.	+	
11	*Antenaria dioica* (L.) Gaertn.	+	
12	*Arum besseranum* Schott.	+	
13	*Astragalus albidus* Waldst. et Kit.	+	
14	*Astragalus austriacus* Jacq.	+	
15	*Blechnum spicant* L.	+	
16	*Campanula persicifolia* L.	+	
17	*Carex atherodes* Spreng.		+
18	*Carex brevicollis* DC.	+	
19	*Carex hordeistichos* Vill.		+
20	*Carex limosa L.*		+
21	*Carex lasiocarpa* Ehrh.	+	
22	*Centaurea marschalliana* Spreng.	+	
23	*Centaurea orientalis* L.	+	
24	*Centaurium erythraea* Rafn.	+	
25	*Cerasus fruticosa* Pall.	+	
26	*Chamerion dodonaei* (Vill.) Holub	+	
27	*Cicuta virosa* L.	+	
28	*Cleistogenes serotina* (L.) Keng	+	
29	*Coronilla coronata* L.	+	
30	*Crataegus lipskyi* Klok.	+	
31	*Cymicifuga europaea* Schipcz.	+	
32	*Daphne mezereum* L.	+	
33	*Dentaria glandulosa* Waldst. et Kit.	+	
34	*Dianthus andzejowskianus* (Zapal.) Kulcz.	+	
35	*Ephedra distachya* L.	+	

36	*Equisetum telmateia* Ehrh.	+	
37	*Euphorbia angulata* Jacq.		+
38	*Euphorbia lingulata* Jacq.		+
39	*Euphorbia tyraica* Klok. et Artemcz.	+	
40	*Galium tyraicum* Klok.	+	
41	*Genista germanica* L.	+	
42	*Gentiana pneumonanthe* L.		+
43	*Gnaphalium uliginosum* L.		+
44	*Hackelia deflexa* (Wahlenb.) Opiz.	+	
45	*Hedera helix* L.	+	
46	*Helleborus purpurascens* Waldst. et Kit.	+	
47	*Hordelymus europaeus* (L.) Harz.	+	
48	*Hyacintella leucopaea* (C. Koch) Schur.	+	
49	*Inula helenium* L.	+	
50	*Iris graminea* L.	+	
51	*Iris hungarica* Waldst. et Kit.	+	
52	*Lappula semicincta* (Stev.) M.Pop. ex Dobrocz.	+	
53	*Laser trilobum* (L.) Borkh.	+	
54	*Lemna gibba* L.	+	
55	*Leopoldia tenuiflora* (Tausch) Heldr.	+	
56	*Linum linearifolium* (Lindem.) Jav.	+	
57	*Melittis sarmatica* Klok.	+	
58	*Mercurialis ovata* Sternb. et Hoppe	+	
59	*Minuartia thyraica* Klok.	+	
60	*Nymphaea alba* L.		+
61	*Nymphaea candida* J. et C. Presl		+
62	*Onosma macrochaeta* Klok. et Dobrocz.	+	
63	*Oxytropis pilosa* (L.) DC.	+	
64	*Pedicularis kaufmannii* Pinzg.	+	
65	*Pillosella shultesii* (F.Schultz) F.Schultz et Sch.Bip		+
66	*Phyllitis scolopendrium* (L.) Newm.	+	
67	*Polygala sibirica* L.	+	
68	*Polypodium vulgare* L.	+	
69	*Polypodium interjectum* Shivas		+
70	*Polystichum braunii* (Spenn) Fee	+	
71	*Potentilla alba* L.	+	
72	*Poterium sanguisorba* L.	+	
73	*Primula veris* L.	+	
74	*Primula elatior* (L.) Hill.	+	
75	*Pulmonaria mollis* Wulf. ex Hornem	+	
76	*Ptarmica vulgaris DC.*	+	
77	*Pyrola rotundifolia* L.		+
78	*Ranunculus zapalowiczii* Pacz., *R. lingua* L.	+	
79	*Rosa livescens* Bess.	+	
80	*Rosa nitidula* Bess.	+	
81	*Salvia austriaca* Jacq.	+	
82	*Salvia betonicaefolia* Etl	+	
83	*Scorzonera purpurea* L.	+	
84	*Senecio nemorensis* L.	+	
85	*Sesleria heufleriana* Schur	+	
86	*Spiraea pikoviensis* Besser		
87	*Teucrium pannonicum* A.Kerner	+	
88	*Trifolium ochroleucum* Huds.	+	
89	*Trifolium pannonicum* Jacq.	+	
90	*Trollius europaeus* L.		+
91	*Veratrum lobelianum* Bernh.		+
92	*Veronica montana* L.	+	
93	*Vinca minor* L.	+	

In the list of species in need of protection on the territory of the NNP, in addition to 77 Red Book, 27 relics (*Arum besseranum Ephedra distachya*, *Polygala sibirica*), 12 endemics (*Anchusa pseudoochroleuca*, *Minuartia thyraica*, *Euphorbia tyraica*), species on the border of the range – 12 (*Centaurea orientalis, Helleborus purpurascens, Sesleria heuflerana*) and 14 species with broken range (*Amygdalus nana, Centaurea marschalliana*).

Rare species that are included in the CCU grow mainly in forest habitats (55.9%), in grassland habitats – 24.7%, in rocky – 13%, wetlands and shrubs – k 2.6% and aquatic – 1.2%. In the regional list, 39.8 species are distributed in forest habitats, 23.7% – in rocky, 20.3% in the grass, 7.5% in wetlands, 4.3% in aquatic and shrub habitats.
The vast majority of rare species grow in rare habitats (Table 5) (Lubinska L.G., 2013).

Table 5. **Rare habitats NPP "Podilski Tovtry"**

№ rare	habitat name	typical representatives
3160	Natural dystrophic lakes and ponds	*Nymphaea alba*; *Nymphaea candida*
40A0*	Subcontinental Peri-Pannonian	*Amygdalus nana*; *Dracocephalum austriacum*; *Dictamnus albus*
6110*	Rocky carbonate or basophilic grass groups *Alysso-Sedion albi*	*Schivereckia podolica*; *Polypodium vulgare*
6190	Pannonian rock herbal groups (*Stipo-Festucetalia pallentis*)	*Schivereckia podolica; Minuartia thyraica; Sesleria heuflerana*
6210*	Semi-natural meadow steppes, steppe meadows and shrubs on limestone substrates (*Festuco-Brometalia*) (habitat important for orchids)	*Adonis vernalis*; *Chamaecytisus albus; Cerasus fruticose; Polygala sibirica; Scorzonera purpurea; Stipa pulcherrima; Stipa capillata*
6240*	Sub-Pannonian meadow steppes and steppe meadows are common	*Adonis vernalis; Anemone sylvestris; Campanula persicifolia; Centaurea marschalliana; Hyacintella leucopaea; Iris hungarica; Scorzonera purpurea; Stipa pennata; Linum basarabicum*
6250*	Pannonian meadow steppes and steppe meadows in the less	*Scorzonera purpurea*; *Cerasus fruticosa , Salvia cremenecensis*
6430*	Hydrophilic coastal high-grass phytocenoses of plains and from the montana to the alpine highlands	*Trifolium ochroleucum, Trifolium pannonicum*
8160*	Centraleuropean carbonate screes of the foothills and the montana belt	*Allium obliquum, Allium pervestitum,Allium sphaeropodum, Allium strictum, Astragalus monspessulanus*, *Gypsophila thyraica*, *Scutellaria verna, Allium podolicum, Teucrium pannonicum*
8210	Carbonate rocky slopes with chasmophytic vegetation are noted	*Astragalus monspessulanus, Allium obliquum, Teucrium pannonicum*
9130	Beech forests *Asperulo-Fagetum*	*Allium ursinum, Neottia nidus-avis Cephalanthera damasonium, Dentaria glandulosa*
9170	Oak-hornbeam forests *Galio-Carpinetum*	*Lilium martagon, Crocus heuffelianus, Cypripedium calceolus, Listera ovata, Scopolia carniolica, Euonymus nana, Aconitum besserianum, Cephalanthera damasonium*
9180*	Forests *Tilio-Acerion* found on slopes, screes and in gorges	*Lunaria rediviva, Phyllitis scolopendrium*
91Y0	Dacian oak-hornbeam forests	*Sorbus torminalis*, *Daphne mezereum*, *Carex brevicollis, Allium ursinum*, *Epipactis helleborine, Epipactis purpurata*
91G0	Pannonian forests with *Quercus petraea and Carpinus betulus*	*Carex brevicollis, Staphylea pinnata, Hedera helix*

As can be seen from the results obtained in the group of regionally rare species are also dominated by forest species but in second place species of rocky habitats. Thus, 47.1% of sozophytes of all levels grow in forest habitats, 22.4% – in grassland habitats, 18.8% – rocky habitats, 5.2% – wetlands, 3.6% – shrubs, 2.9% – aquatic habitats. A significant number of regionally rare species in forest habitats are associated with high anthropogenic pressures, mainly deforestation and the replacement of hornbeam-oak and beech forests to introduce atypical coniferous species change the habitat. Species of rock and grass habitats are disappearing or changing populations' viability due to the destruction of ecotopes during limestone excavation, construction, afforestation, burning by grass.
We believe that species such as *Allisum medium*, *Anchusa pseudoochroleuca, Iris hungarica, Minuartia thyraica, Ranunculus zapalowiczi, Rosa livescens, R. Nitidula* should be included in the next fourth edition of the Red Book of Ukraine. Thus, rare species of NPP "Podilski Tovtry" are witnesses of anthropogenic impact on habitats. Therefore, it is first necessary to pay attention to the state and habitats (habitats) and trends in their state when protecting species. Floristic diversity in NPP "Podilski Tovtry" is in constant dynamics caused by various factors. Natural dynamics depend on the processes associated with climate change, hydrochemical status, and hydration of the territory. However, the vast majority of dynamic changes occur under the influence of anthropogenic factors. An indicator of such transformations is the synanthropization of flora. This problem has received considerable attention in recent decades and is devoted to research and publications of scientists of many scientists worldwide (IUCN,2011) and Ukraine (Burda R.I., 1991, 2007; Zhizhin N.P., Kagalo O.O., 1989, Lyubinska L., 2009). As indicated by V.V. Protopova (1991), V.V. Protopova, S.L. Mosyakin, M.V. Shevera (2002), synanthropization of flora is a trend of all flora because the anthropogenic factor is most conducive to this process.

Environmental facilities are no exception, as they are organized in areas that are under anthropogenic pressure. The territory of NPP "Podilski Tovtry", as mentioned earlier, is significantly developed. In the flora of NNP, autochthonous and allochthonous species are represented almost equally. Adventive species deserve careful analysis, as the dynamics of adventive species diversity indicate invasion and biohazard. In Fig. 4, we list the ten leading families of adventive species, and apparently, the families *Asteraceae* (13.7%) and *Brassicaceae* (11.35%) are predominant. In the park's flora, these families occupy the first (8.5%) and tenth (2.8%) place in terms of species saturation, respectively, and change the family spectrum due to adventive species.

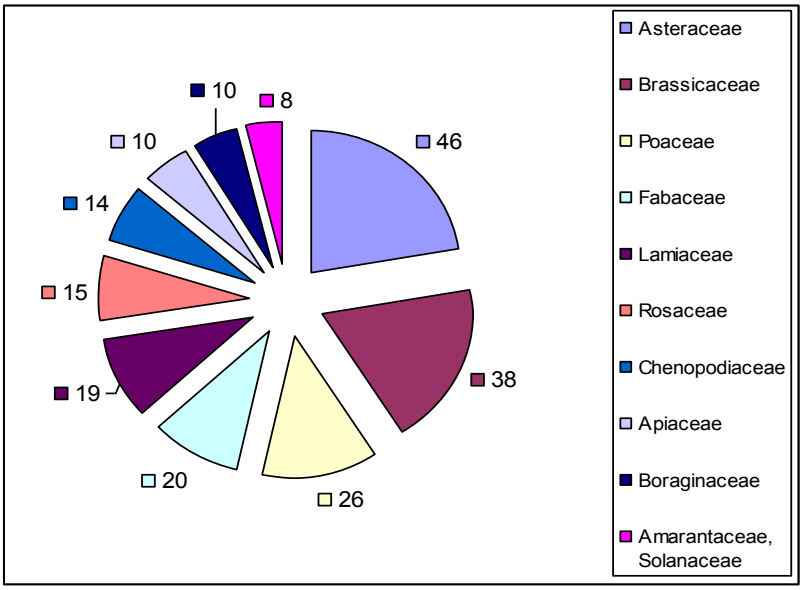

Fig. 4. **Dominant families with adventive plants** (number of species in absolute numbers)

The ten leading adventive families make up 61.4% of the group. In third place are species from the family *Poaceae*. Hygroecomorphs of adventive species (Fig. 5) are represented mainly by xeromesophytes, mesophytes, mesoxerophytes, which is explained by favorable climatic conditions and soil moisture.

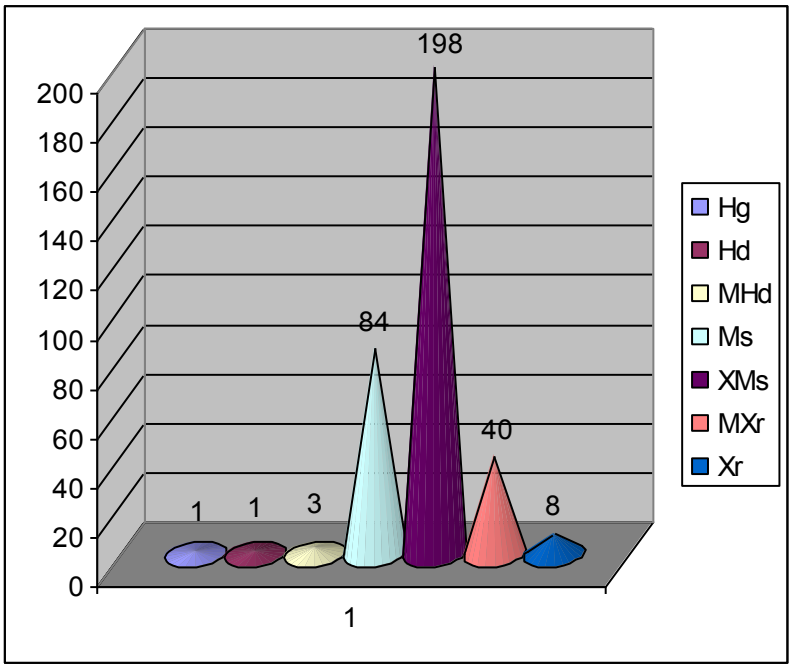

Fig. 5. **Hygromorphs of adventive species**

Among the life forms of adventive species (Fig. 6), the therophytes and hemicryptophytes predominate. High seed productivity and competitiveness provide rapid renewal and the ability to survive in the phytoenvironment.

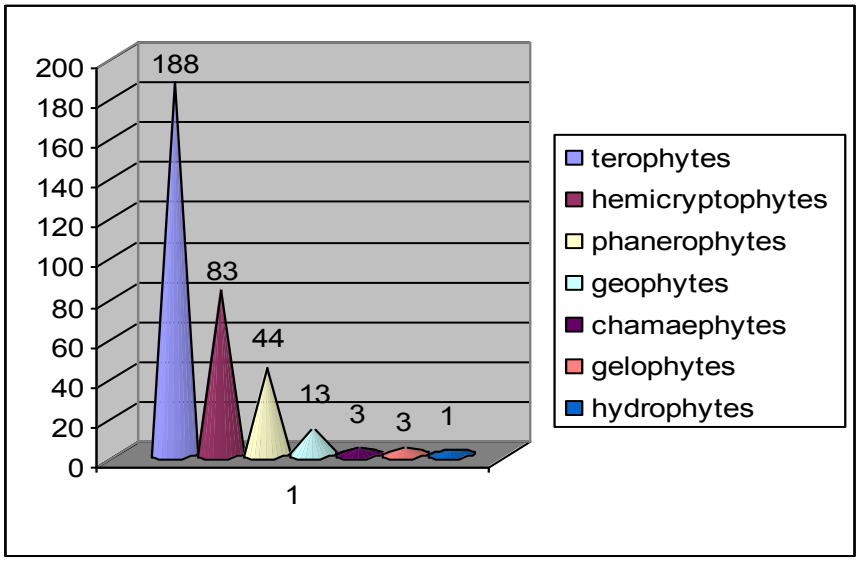

Fig. 6. **Raunkier life forms**

Adventive species of NPP "Podilski Tovty" by origin are mainly kenophytes (213), archeophytes include 112 species. According to the degree of naturalization (Fig. 7), the distribution indicates a significant predominance of epecophytes (Epo – 57%), species that live only in anthropogenic floristic complexes. Species naturalized in natural habitats agriophytes (Agr) are 5%, wild cultured species (Ergaz) – 8%, plants kept in this flora for a short time ephemerophytes (Efm) – 16%, species naturalized in semi-natural colonophytes – (Col) – 14%.

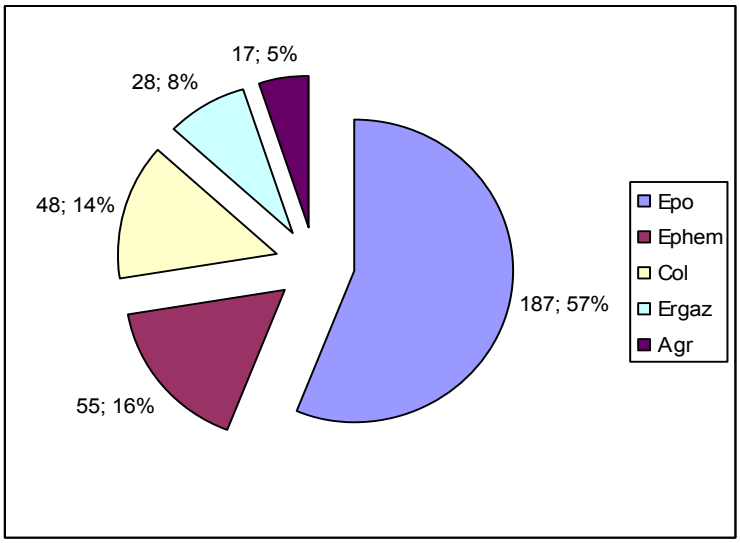

Fig. 7. **Distribution of adventive species by naturalization level**

Predominantly, by geographical origin, there are species with Mediterranean and Mediterranean-Iranian-Turanian origin, much less with Iranian-Turanian and Asian origin.

The degree of transformation of flora, which indicates groups' participation concerning anthropogenic pressure, is determined by several indices (IUCN, 2011). Indices are calculated using the number of plant species grouped according to a similar response rate to a particular anthropogenic factor. The formulas for calculating the indices are given in the second section. The results of data processing are as follows: synanthropization index (IS) is 50.6%, spontaneousity apophytization index, I Aps – 75.7%, flora apophytization index IAn – 28.5%, archeophytization index IArch – 9.4%, kenophytization index IKen – 18.7%, the index of flora modernization – IM – 66.5% 18.7%. The ratio of the allochthonous group of species of synanthropic flora to adventive is an essential indicator of synanthropization. For Ukraine, it is 1.3: 1 (Protopova V.V., 1991), and for NPP "Podilsky Tovtry" respectively 1.5: 1, which indicates the predominance of apophytes present stage. However, there are processes of dynamics of adventive species. An example of this is the discovery for the first time in 2007 of such a species as *Centaurea iberica.*

Invasive species cause changes in vegetation. The appearance of invasive species in natural and anthropogenic landscapes in significant quantities is also alarming. Transformer species can change habitats. We found mass reproduction of *Ailanthus altissima* in steppe, meadow-steppe, and calcepetrophytic phytocenoses within the Smotrytsya canyon, Chinatown slopes. This species aggressively occupies places of growth of autochthonous flora, and under its canopy, the synanthropic floristic complex is formed. On the Smotrych River slopes, a peculiar biotope is formed with a predominance of invasive tree species. Another species of *Reinoutria japonica* was found in the forest of the Surzhenets ravine. The probability of its entry from the settlement,

which is located at the top of the stream. This species has spread in hornbeam-oak forest and reaches up to 3.2 m, covering an area of up to 200 m^2. Along with it, typical and rare species disappear as they become uncompetitive.

The expansion of *Pinus sylvestris* is indicative; it has entered the generative stage, captures meadow-steppe and steppe phytocenoses, and settles on fallows. Typical and rare grassland habitats undergo significant changes and are gradually disappearing. Important indicators of flora are its anthropotolerance and resistance to urbanization and the conditions of landscaping – hemerobia. As a result of the research, it was found that the flora of the park is dominated by anthropophobic species that are not adapted to anthropogenic influences (Fig. 8).

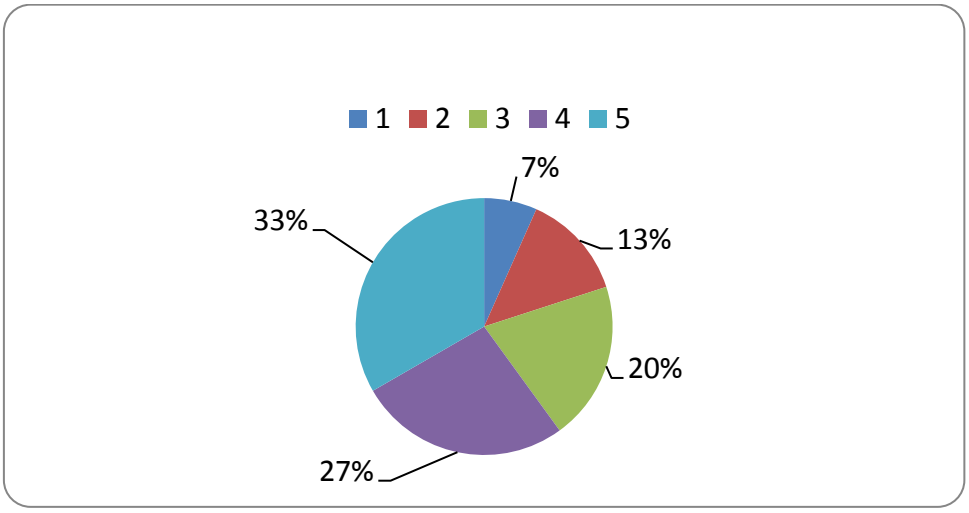

Fig. 8. **Distribution of species by anthropotolerance.** 1 – anthropophytes, 2 – evapophytes, 3 – hemiapophytes, 4 – eventoapophytes, 5 – anthropophobes

The flora of NPP "Podilsky Tovtry" is dominated by urbanophobes and eurbanophobes (902 and 35 species, respectively). The group of urban neutrals is 434 species, eurbanophiles number 17 species. Such indicators indicate the transformation of semi-natural habitats and the presence of a numerical group of anthropogenic habitats. One of the characteristics of flora is its relation to the transformation of habitats. Oligohemerobes (878) and mesohemerobes (279) predominate in the NPP flora (Fig. 9).

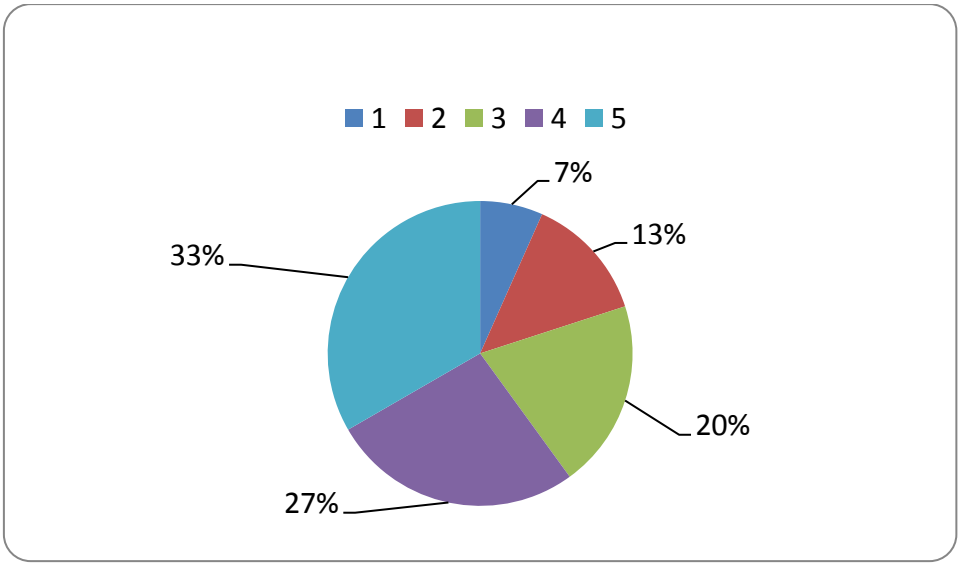

Fig. 9. **Distribution of species by resistance to hemerobic conditions.** 1 – ahemerobes, 2 – oligohemerobes, 3 – mesohemerobes, 4 – (α, β) euhemerobes, 5 – polyhemerobes

The ahemerobe species of the parking flora is *Batrachium aquatile*; oligohemerobes are *Allium oleraceum, Galantus nivalis, Maianthemum bifolium, Butomus umbelatus, Poligonatum verticillatum, Nymphaea alba, Carpinus betulus,* and *Dipsacus sylvestria*; mesohemerobes species are *Allium podolicum, Achilea pannonica, Hypericum perforatum, Swida sanguinea, Hepatica nobilis, Potentilla reptan*; euhemerobi – *Scrophullaria nodosa, Impaties glandulifera,* and *Ipomea purpurea*; polyhemerobes speices are *Phalacraloma annua*, *Arctium lappa, Berteroa incana, Iva xantifolia,* and *Descurania sophia.* The indicator of hemerobicity is generalizing and indicates the processes of synanthropization of flora. In NNP, it is 0.3 and indicates a significant level of synanthropization.

Synanthropization of the flora of Podilsky Tovtry National Park and the dynamics of invasive species require active research and management, as such changes can lead to the loss of typical natural flora and vegetation (Konishchuk et al., 2020).

Conclusions

Analysis of flora showed significant species diversity. The flora of the park has 1525 species. For NPP "Podilski Tovtry," the total floristic proportion is 1: 4.2: 10.2, making it closer to similar proportions of florid arid territories. In the flora of NPP aboriginal species, there are 677 species and 848 species of synanthropy flora. The average number of species per family is 10.2, and in the genus (genus coefficient – 2.4). Among synanthropic species, the apophytes (513) and adventive (335) species predominate. Sozological analysis revealed that the Red Book of Ukraine (2009) includes 77 species, 46 genera, 22 families, three classes, and two divisions. Thirty-eight species are included in the sozological lists of international importance (IUCN – 4, European list – 5, Annex 2 of the Bern Convention – 6 species, ICTS – 27), the share of rare species listed in the CCU in the flora of NPP "Podilski Tovtry" is 5.0%, in the flora of Ukraine – 1.4% (although the area of the park occupies only 0.42% of the territory of Ukraine).

References

Andrzejowski, A. (1862). Enumeratio plantarum in gubernio Podolico et locis adjacentibus crescentium. Universitetskie Izvestiya (Kiev), 7, 94-142 (in Latin).

Besser, W. (1882). Enumeration plantarum hucusque in Volhynia, Podolia, gub. Kioviensi, Bessarabia cis Thyraica et circa Odessam collectarum simul cum observationibus in rimitias Florae Galicia Austriacae. Vilnae (in Austrian).

Burda, R.I. (1991). Anthropogenic transformation of flora. Kyiv. Naukova dumka (in Ukraine).

Burda, R.I. (2007). Resistance of the nature reserve fund to phytoinvasions. *Industrial botany,* 7, 11-21 (in Ukraine).

Convention on Biological Diversity: Public Awareness and Participation. (1997). Kyiv: Stylos (in Ukrainian).

Convention on the Conservation of European Wildlife and Natural Habitats. Available from: http://zakon1.rada.gov.ua/laws/show/995_032/print1247741934069335/ (in Ukrainian).

Didukh, Ya.P. (2000). Ecoflora of Ukraine. The general part. Lycopodiophyta. Equisetophyta. Polypodiophyta. Pinophyta. Kyiv. Phytosocial center, 1, 283 (in Ukraine).

Didukh, Ya.P., Shelyag-Sosonko, Y.R. (2003). Geobotanical zoning of Ukraine and adjacent territories. *Ukrainian Botanical Journal,* 60(1), 6-17 (in Ukraine).

Dobrochaeva, D.N., Kotov, M.I. (1987). Keys to higher plants of Ukraine. Kyiv: Naukova Dumka (in Ukrainian).

Gajewski, W. (1931). Szczątki flory pierwotnej w jarze Dniestru. Ochrona przyrody, 11, 10–40. (in Polish).

Golubev, V.N. (1962). Fundamentals of biomorphology of herbaceous plants of the Central forest-steppe. Part I. Biomorphology of underground organs. Proceedings of the Central Chernozem State Reserve, 7. Voronezh: Voronezh University Press (in Russian).

Grin, F.O. (1973). Vegetation of limestone outcrops. In the book: Vegetation of the USSR. Steppes, stony outcrops, sands. Kyiv: Naukova Dumka (in Ukraine).

IUCN. 2011. IUCN red list of threatened species. Threats classification scheme (Version 3.0). International Union for Conservation of Nature and Natural Resources. Available from: http://www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme-ver3/ .

Jackowiak, B. (1990). Antropogeniczne przemiany flory roslin naczyniowych Poznania. Poznan: Wyd–wo Un–tu im. A. Mickiewicza (in Polish).

Jena, A.V. (2009). The phenomenon of floristic endemism and its manifestations in the Crimea. Thesis of Doctoral Dissertation. Institute of Botany M.G. Kholodny NAS of Ukraine (in Ukrainian).

Kamelin, R.V. (1973). Florogenetic analysis of the natural flora of mountainous Central Asia. Leningrad: Nauka (in Russian).

Kleopov, Y.D. (1990). Analysis of the flora of deciduous forests of the European part of the USSR. Kyiv: Naukova Dumka (in Ukrainian).

Klokov, M.V. (1981). Psammophilic floristic complexes on the territory of the Ukrainian SSR. (Experience of analysis of psammophyton). News of the taxonomy of higher and lower plants. Kyiv: Naukova Dumka (in Ukrainian).

Konishchuk, V.V., Solomakha, I.V., Mudrak, O.V., Mudrak, H.V., Khodyn, O.B. (2020). Ecological impact of phytoinvasions in Ukraine. *Ukrainian Journal of Ecology*, 10(3), 69-75 DOI: 10.15421/2020_135 (in Ukrainian).

Kovalchuk, S.I. (1981). Flora and vegetation of Transnistria of Khmelnytsky region as a part of Podolsk natural park. Proceed. Int. Sc. Conf. "Productive forces and nature of Khmelnytsky region. Kamyanets-Podilsky (in Ukrainian).

Krutskevych, M.M. (1937). Additions to the flora of Kamianets-Podilskyi. Journal of the Institute of Botany of the USSR Academy of Sciences, 11, 137-140 (in Ukrainian).

Kukovytsia, G.S. (1970). Rare, endemic and relict species of Podolsk Transnistria. Nature protection and rational use of natural resources. Kyiv. Naukova Dumka (in Ukrainian).

Kuznetsova, G.O. (1963). Flora and vegetation of Middle Transnistria. Materials for the study of natural resources of Podillya. Ternopil-Kremenets (in Ukrainian).

Litvinov, D.I. (1902). On the relict nature of the flora of the stony slopes of European Russia. Proceedings of the Botanical Museum of the Academy of Sciences, 1, 76-109 (in Russian).

Lubinska, L.G. (2013). Anthropogenic transformation of vegetation of NPP "Podilski Tovtry": protection and reproduction. Thesis of Doctoral Dissertation. Kyiv (in Ukrainian).

Lubinska, L.G., Yuglichek L.S. (2017). Flora of Khmelnytsky region. Tutorial. Khmelnytsky, Polygraphist (in Ukrainian).

Lyubinska, L. (2009). Alien plants of the Podilski Tovtry National Nature park (Ukraine). Biodiversity Reseach & Conservation, 3, 123-131. (in Ukrainian).

Makowiecki, S. (1939). Spis roslin poludniowa–zachodniej czesci Podola Zazbrucza–askiego. Spraw. Kon. Fizjogr, 72, 269–326 (in Polish).
Marinich, O.M., Shishchenko, P.G. (2005). Physical geography of Ukraine: textbook. Kyiv. Znannya (in Ukrainian).
Meusel, H., Jager, E., Weinert, E. (1965). Vergleichende Chorologie der Zentrale–europaischen Flora. Jena : Fischer. Bd. I. (in German).
Mirkin, B.M., Naumova, L.G. (2001). Vegetation adventitization: invasive species and invasiveness of communities. Uspekhi Soveremennoy Biologii, 121(6), 550-562 (in Russian).
Montrezor, V.V. (1886). Obozrenie rastenii, vkhodiashchikh v sostav flory gubernii Kievskoi, Podolskoi, Volynskoi, Chernigovskoi i Poltavskoi [Survey of plants that are part of the flora of the provinces of Kiev, Podolsk, Volyn, Chernihiv and Poltava]. Zapisky Kievskogo Obshchestva Estestvoispytatelei (in Russian).
Moroz, I.I. (1970). Rare plants of the Tovtry ridge of Podillya and their protection. Nature protection and rational use of natural resources. Kyiv: Naukova Dumka (in Ukrainian).
Mosyakin, S.L. (1999). Plants of Ukraine in the world Red List. *Ukrainian Botanical Journal,* 56(1), 79–88 (in Ukrainian).
Mosyakin, S.L., Fedoronchuk, M.M. (1999). Vascular plants of Ukraine. A nomenclatural checklist. Kyiv: M.G. Kholodny Institute of Botany (in Ukrainian).
Mudrak, O.V. (2012). Balanced development of the Podillya ecological network: state, problems, prospects. Monograph. Vinnytsia: "SPD Hlavatka R.V." (in Ukrainian).
Mudrak, O.V., Mudrak, G.V. (2013). Features of biodiversity conservation in Podillya: theory and practice. Monograph. Vinnytsia: Nilan Ltd. (in Ukrainian).
Mudrak, O.V., Mudrak, G.V. (2020). Protected areas. Kherson: OLDI-PLUS (in Ukrainian).
National Atlas of Ukraine. Goal. (2008). Rudenko, L.G. (Ed.). Kyiv: DNVP "Cartography" (in Ukrainian).
Novosad, V.V., Kritska, L.I., Lyubinska, L.G. (2009). Phytobiota of the Podilsky Tovtry National Nature Park. Vascular plants. Kyiv: Fiton (in Ukrainian).
Pachosky, I.K. (1910). The main features of the development of the flora of southwestern Russia. Izvestiaya of Novorossyskogo Obshchestva Naturalistov. Kherson, 34, 430 (in Ukrainian).
Protopopova, V.V. (1991). Synanthropic flora of Ukraine and ways of its development. Kyiv: Naukova Dumka (in Ukrainian).
Protopopova, V.V., Mosyakin, S.L., Shevera M.V. (2002). Phytoinvasions in Ukraine as a threat to biodiversity: current status and challenges for the future. NAS of Ukraine. Botanical Institute named M.G. Kholodnyi (in Ukrainian).
Rabotnov, V.A. (1992). Phytocenology. Moscow: Publishing House of Moscow State University (in Russian).
Raunkiaer, C. (1934). Life forms of plants and statistical plant geography. New York; London.
Red Book of Ukraine. Flora. (2009). Kyiv: Globalconsulting (in Ukrainian).
Reserved pearls of Khmelnytsky region (2008). For order. T.L. Andrienko. Kamyanets-Podilsky: In the private enterprise Moshinsky V.S. (in Ukrainian).
Rogovich, A.S. (1869). Obozrenie sosudistykh i polusosudistykh rastenii, vkhodiashchikh v sostav flory gubernii Kievskoi, Chernigovskoi i Poltavskoi. Estestvennaia istoriia gubernii Kievskogo okruga. Botanika. Kyiv, 3. 1-147 (in Russian).
Shelyag-Sosonko, Yu.R., Didukh, Ya.P. (1987). A systematic approach to the study of flora: Theoretical and methodological problems of comparative floristry. Leningrad: Nauka (in Russian).
Shelyag-Sosonko, Yu.R., Osychnyuk, V.V., Andrienko, T.L. (1982). Geography of the vegetation cover of Ukraine. Kyiv: Naukova Dumka (in Ukrainian).
Stoyko, S.M. (1983). Problems of phytososology and paths and trends. *Ukrainian Botanical Journal,* 50, 6-14 (in Ukrainian).
Tolmachev, A.I. (1974). Introduction to plant geography. Leningrad: Publishing house of Leningrad State University (in Russian).
Tolmachev, A.I. (1986). Methods of comparative floristics and problems of florogenesis Novosibirsk: Nauka (in Russian).
Yurtsev, B.A., Kamelin, R.V. (1991). Basic concepts and terms of floristry. Perm: Publishing house Perm. University (in Russian).
Zaverukha, B.V. (1985). Flora Volino-Podilla and genesis. Kyiv: Naukova Dumka (in Ukrainian).
Zhizhin, N.P., Kagalo, O.O. (1989). Features of the process of synanthropization of the flora of protected areas. Problems of studying the synanthropic flora of the USSR. Part 2. (in Russian).

Citation:
Lyubinska, L.G., Mudrak, O.V., Andrusiak, D.V., Mudrak, G.V., Dushanova, T.V. (2021). The current state of flora in the National Nature Park "Podilski Tovtry" (Ukraine). *Ukrainian Journal of Ecology, 11* (1), 218-233.