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FLORISTIC STRUCTURE OF SAND COMMUNITIES OF CHERNIHIV POLISSYA

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The purpose of the paper is to determine historical aspects of the research of the flora and vegetation of the region, to describe the floristic structure and composition of the psammophytic communities of Chernihiv Polissya, as well as to analyze the synanthropic fraction of the psammophytic flora and to determine the degree of its anthropogenic transformation. The materials for the article were collected during the field research of Chernihiv Polissya on sandy soil in 2017–2021. According to the results of research, it was found that the psammophytic flora of Chernihiv Polissya includes 282 species of vascular plants belonging to 190 genera and 64 families. Also, seven species of mosses and 15 species of lichens were found. The psammophytic flora of vascular species of Chernihiv Polissya is 21.4% of the flora of Eastern Polissya and 6.3% of the flora of Ukraine. The spreading process of new species are mainly related to climate changes (xerophytization of phytodiversity) and invasions. Poales (19.08% of the total number of species) and Asterales (18.75%) were the most represented orders in the systematic structure. Compositae (18.1%) and Poaceae (12.2%) were dominant families. According to the acquired data on the psammophytic flora of Chernihiv Polissya 132 genera (69.1%) were represented by one species. This indicates a substantial degree of synanthropization in the flora. Perennials (58%) predominate among herbaceous species (91.1%). Mesophytes and xeromesophytes were dominant groups by the attitude to the water regime. Among psammophytes five groups were distinguished and according to the variability of soil moisture the most represented one was the group of hemi-hydrocontrastophiles 133 (47.2%), according to soil acidity (pH) – sub-acidophiles (44%), soil aeration – sub-aerophiles (53.2%), total soil salt content – semi-eutrophes (43.6%), soil carbonate content – hemi-carbonatophobes (46.5%), thermal regime – sub-mesotherms (57.4%), cryoclimatic regime – hemi-cryophytes (46.1%), humidity – sub-aridophytes (37.6%), by the continentality of climate – hemi-continental (50%), lighting conditions – sub-heliophytes (87.6%). The analysis of the synanthropic fraction of the sand flora of Chernihiv Polissya indicated active processes of spreading invasive species within the psammophytic communities of Chernihiv Polissya.

***Key words**: anthropogenic influence, ecological structure, sands, systematic structure, flora.*

Данько Г.В.

ФЛОРИСТИЧНА СТРУКТУРА ПІЩАНИХ УГРУПОВАНЬ ЧЕРНІГІВСЬКОГО ПОЛІССЯ

Мета роботи – визначити історичні аспекти вивчення флори та рослинності регіону, описати флористичну структуру та склад псамофітних угруповань Чернігівського Полісся, а також проаналізувати синантропну фракцію псамофітної флори та визначити ступінь її антропогенної трансформації. Матеріали для статті зібрані під час польових досліджень Чернігівського Полісся на піщаних ґрунтах протягом 2017–2021 років. За результатами досліджень встановлено, що флора пісків Чернігівського Полісся налічує 282 види судинних рослин, які належать до 190 родів та 64 родин. Також виявлено 7 видів мохів та 15 видів лишайників. Флора судинних рослин пісків Чернігівського Полісся становить 21.4% флори Східного Полісся та 6.3% флори України. Процес поширення нових видів в основному

пов'язаний зі змінами клімату (ксерофітизація фіторізноманіття) та інвазіями. У систематичній структурі найбільш представленими порядками були Poales (19.08% від загальної кількості видів) та Asterales (18.75%). Родинами, що переважали, були Compositae (18.1%) та Poaceae (12.2%). Згідно з даними щодо флори пісків Чернігівського Полісся, 132 роди (69.1%) були представлені одним видом. Це свідчить про значний ступінь синантропізації флори. Серед трав'яних рослин (91.1%) переважають багаторічники (58%). За відношенням до водного режиму домінують мезофіти та ксеромезофіти. Серед псамофітів виділено п'ять груп за варіабельністю вологості ґрунту, найбільш представленою була група гемігідроконтрастофілів 133 (47.2%), за кислотністю ґрунту (pH) – субацидофілів (44%), аерацією ґрунту – субаерофілів (53.2%), загальним вмістом солей у ґрунті – семіевтрофів (43.6%), вмістом карбонатів у ґрунті – гемікарбонатофоби (46.5%), термічним режимом – субмезотерми (57.4%), кріокліматичним режимом – гемікріофіти (46.1%), вологістю – субаридофіти (37.6%), за континентальністю клімату – геміконтинентальні види(50%), умовами освітлення – субгеліофіти (87.6%). Аналіз синантропної фракції піщаної флори Чернігівського Полісся свідчить про активні процеси поширення інвазивних видів у межах псамофітних угруповань Чернігівського Полісся.

Ключові слова: *антропогенний вплив, екологічна структура, піски, систематична структура, флора.*

INTRODUCTION

Three stages can be singled out in the history of the study of flora and vegetation of Chernihiv Polissya. During the first stage (until the beginning of the twentieth century), the primary fragmentary study of phytodiversity was carried out for the purpose of further economic use. The first studies of the flora of Chernihiv Polissya were carried out by E.E. Lindeman [10], O.S. Rohovych [32, 33], V.V. Montrezor [23, 24, 25], F.K. Arnold [15]. The first stage was summarized by the works of I.F. Shmalhauzen [38] and Y.K. Pachoskiy [27, 28, 29], which contain references to psammophytic species. The registration of plants of sandy soils in the late nineteenth and early twentieth centuries are known due to N.I. Chikilevskiy [36], Polynov [30] and V.M. Vershkovskiy [18]. At the end of the nineteenth century, geobotanical scientific publications appeared, which was an indicator of the beginning of the second stage of research. The first geobotanical studies were aimed at assessing territories for economic development. D.Y. Afanasiev [16], L.S. Balashov [17], Yu.R. Sheliah-Sosonko [37] studied meadows. S.O. Muliarchuk [26] gave a variant of the sandy vegetation classification. The stage of generalization of floristic and geobotanical data (early 1980 – 2020) can be characterized as a period of comprehensive study of the flora and vegetation of Chernihiv Polissya. The scientific works concerned floristic and geobotanical studies of protected areas [14]. Work of O.V. Lukash [21] summed up results of flora investigations in Eastern Polissya. The list of scientists who studied the flora and vegetation of Chernihiv Polissya is far from completion here and only has to demonstrate that generalizing study of psammophytic flora and vegetation of Chernihiv Polissya was not conducted.

Vegetation of the sands is perhaps the most vulnerable due to habitat disturbance [11]. However, the modification of the habitat, in which sand vegetation historically developed, leads to the habitat loss. Understanding the structure of the sand flora,

knowing the ratio of species according to ecological indicator values and trait values provides additional information about the reaction of vegetation to the established abiotic conditions and human influences. Therefore, the aims of the work are to determine the historical aspects of the flora and vegetation studies of the region, to describe the floristic structure and composition of the psammophyte communities of Chernihiv Polissya, as well as to analyze the synanthropic fraction of the psammophyte flora and to determine the degree of its anthropogenic transformation.

MATERIALS AND METHODOLOGY

The materials for the article were collected during the field research on sands of Chernihiv Polissya in 2017–2021. The field study of the vegetation was carried out by generally accepted geobotanical methods. Plots of 4–100 m² [3] were selected for surveys on alluvial riverbanks, boreal terraces and sand areas affected by anthropogenic impact throughout the research region in order to obtain a holistic view of the phytodiversity of sands. Relevés were carried out during all vegetative seasons. The systematic structure was analyzed both for the vascular plants and for mosses and lichens. The list of vascular plants, as well as their systematic structure, were agreed with the Euro+Med PlantBase nomenclature for vascular plants [5]. The following family treatments have been provided to Euro+Med PlantBase by POWO (Plants of the World Online) [13] (according to POWO, the *Poales* order includes *Cyperaceae* and *Juncaceae* families). The Second checklist of Bryophytes of Ukraine was used to harmonize the nomenclature of bryophytes [2]. The nomenclature of lichens was checked in according to the Index Fungorum [6] and the Checklist of lichens and lichenicolous fungi of Ukraine [9].

For ecological and biomorphological analysis, we used only vascular plant species, because ecological scales for non-vascular plants and lichens are poorly developed. However, cryptogamic species are important in the analysis of the vegetation, as they affect the composition of the sand plant community and are able to be a key component in the determining of syntaxonomic ranks.

Biomorphological analysis of the flora was carried out according to I.H. Serebriakov's classification of the plant life forms [34].

An analysis of the ecological structure of the sand flora of Chernihiv Polissya was carried out in according to the ecological scales of Ya.P. Didukh [4], such as eco-groups by the relation of plant species to various soil parameters (variability of damping, soil aeration, soil acidity, total salt regime, carbonate content in soil, nitrogen content in soil) and to climate parameters (thermal climate, continentality of climate, humidity, cryo-climate, and light).

The distribution of sand flora in relation to the water regime was carried out according to V.V. Protopopova [31]. Ecological values for species which were absent in literature sources [31] were evaluated by the author, considering peculiarities of species ecology.

RESULTS AND DISCUSSION

Systematic structure

During the field work, 304 species of vascular plants, mosses and lichenized fungi belonging to 30 orders, 64 families and 191 genera in the flora of the sands of Chernihiv Polissya were found. As for vascular plants, the list of species contains 282 of them, which is 21.4% of the Eastern Polissya flora according to the most comprehensive summary of vascular plants [21] and 5.6% of the Ukrainian flora [19]. According to the species classification, *Poales* became the most represented order, consisting of 58 species (19.08% of the total number of species). *Asterales* had 57 species (18.75%), *Caryophyllales* – 40 (13.2%), and the rest of orders were represented in a much smaller number of species: *Lamiales* – 23 species (7.57%), *Fabales* – 17 species (5.59%), *Rosales* – 14 species (4.61%), etc. (Fig. 1). Lichens were an important component of the sandy phytodiversity indicated by the number of species within the *Lecanorales* order, namely 13 species (4.28%). Detailed information on the plant and lichenized fungi order spectrum of the sands of Chernihiv Polissya could be found on the figure 1.

As for the plant families' distribution, the *Compositae* (*Asteraceae*) family with 55 species (18.1%) and the *Poacea* family with 37 species (12.2%) dominated. The *Caryophyllaceae* family was ranked third in terms of the number of species with 19 of them (6.25%). The number of the *Fabaceae* family representatives was smaller – 17 species (5.59%). The fifth place was occupied by the *Rosaceae* family, as 12 species (3.95%) were found. More detailed distribution of species by families and genera is shown in figure 3. The *Poaceae* family assumes a primary role in the establishment of psammophytic phytocoenoses. Species of this family are more abundant in sandy communities. At the same time, the significant representation of the *Compositae* (*Asteraceae*) family can be explained by the significant participation of weeds and alien species [1].

The species distribution by genera reflects the internal structure of the flora and its specificity. According to the obtained data of Chernihiv Polissya sand flora, 132 genera (69.1%) were represented by only 1 species, 36 genera (18.8%) had 2 species each, 13 genera (6.8%) had 3 species. More numerous were genera: *Silene* – 5 species in its composition (1.64%), *Artemisia*, *Rumex* and *Trifolium* – 6 species each (1.97%), *Carex* – 7 species (2.3%), *Juncus* – 8 species (2.63%) and *Cladonia* – 11 species, which is 3.62% of the total number of species.

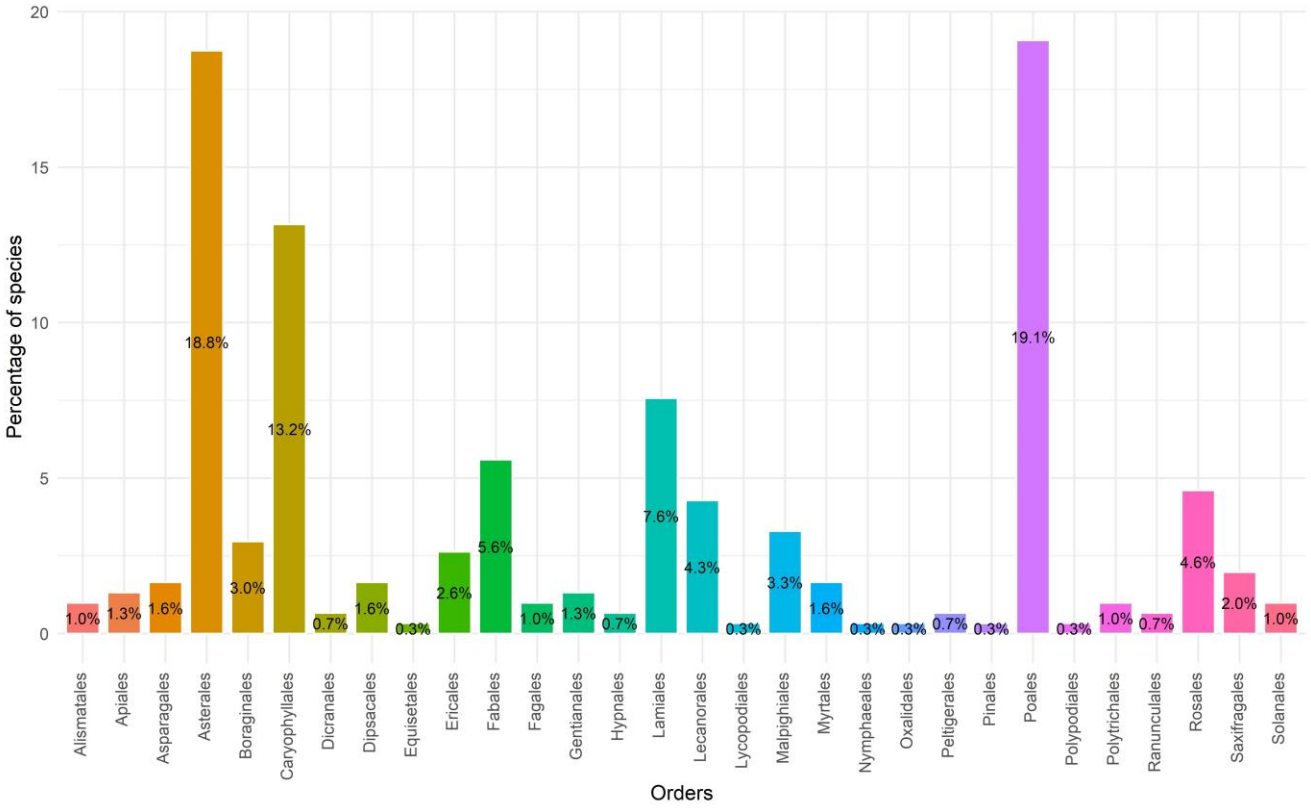

Fig. 1. Distribution of psammophytic plant species orders of Chernihiv Polissya

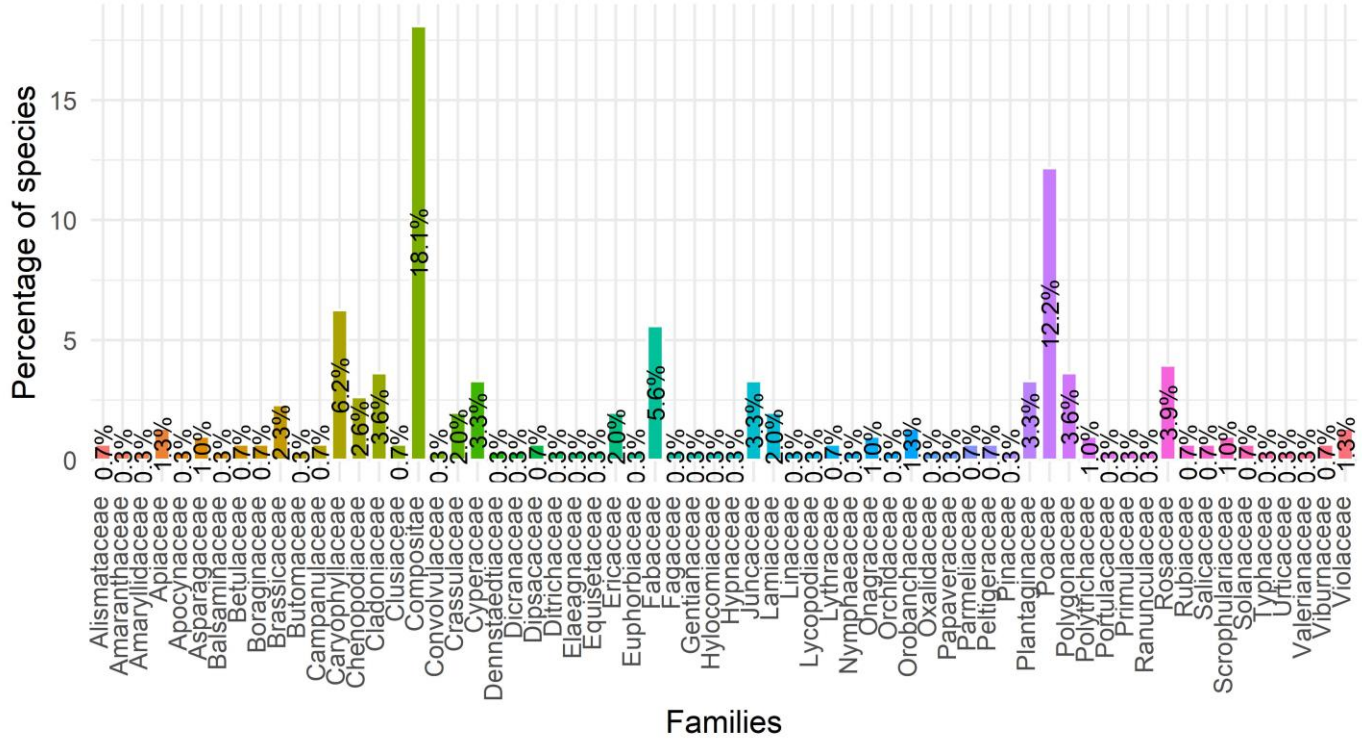

Fig. 2. Distribution of psammophytic plant species families of Chernihiv Polissya

The flora of Chernihiv Polissya sands is dominated by species that grow on overmoistened alluvial sands, such as the *Juncus* and *Carex* species, or by xerophyte species, such as representatives of the genera *Cladonia, Artemisia*, etc.

To more fully reveal the place of the analyzed flora in the system of its own kind comparative analysis with other sandy soils flora was conducted. For analysis, a flora of NNP Biloberezhzhia Sviatoslava [22] was chosen because in this case, we can analyze resemblance and differences caused not only by soil condition but also by geographical location.

The article did not support us with data on cryptogam species, so we also decided not to consider them. The first difference between analyzed floras is a difference in species quantity, as the flora of NPP Biloberezhzhia Sviatoslava is richer: 595 species versus 282 – in Chernihiv Polissya. It can be explained as a general tendency to the growth of biodiversity toward warmer regions. As for plant families' distribution, here we can see that the main role is played by edaphic (not climatic) conditions, as families with a large number of species are almost the same in those two floras (table). It was hard to explore results in more detail because family concepts differed (for example *Veronicaceae* is a part of *Plantaginaceae* in POWO [13], while it was treated as an independent plant family in the cited article [22], where any data were absent about other species of *Plantaginacea* family).

Table

Family distribution comparison between sand soil floras of Chernihiv Polissya and NNP Biloberezhzhia Sviatoslava

		Chernihiv Polissya			NNP Biloberezhzhia Sviatoslava		
	Family	Number of species	Percentage	Place	Number of species	Percentage	Place
1	*Compositae*	55	19.50355	1	83	13.94958	1
2	*Poaceae*	37	13.12057	2	65	10.92437	2
3	*Caryophyllaceae*	19	6.737589	3	28	4.705882	5-6
4	*Fabaceae*	17	6.028369	4	37	6.218487	3
5	*Rosaceae*	12	4.255319	5	17	2.857143	9
7	*Polygonaceae*	11	3.900709	6	19	3.193277	8
8	*Cyperaceae*	10	3.546099	7-9	27	4.537815	7
9	*Juncaceae*	10	3.546099	7-9	10	1.680672	13-15
10	*Plantaginaceae*	10	3.546099	7-9	10*	1.680672*	13-15*
11	*Chenopodiaceae*	8	2.836879	10	30	5.042017	4
12	*Brassicaceae*	7	2.48227	11	28	4.705882	5-6

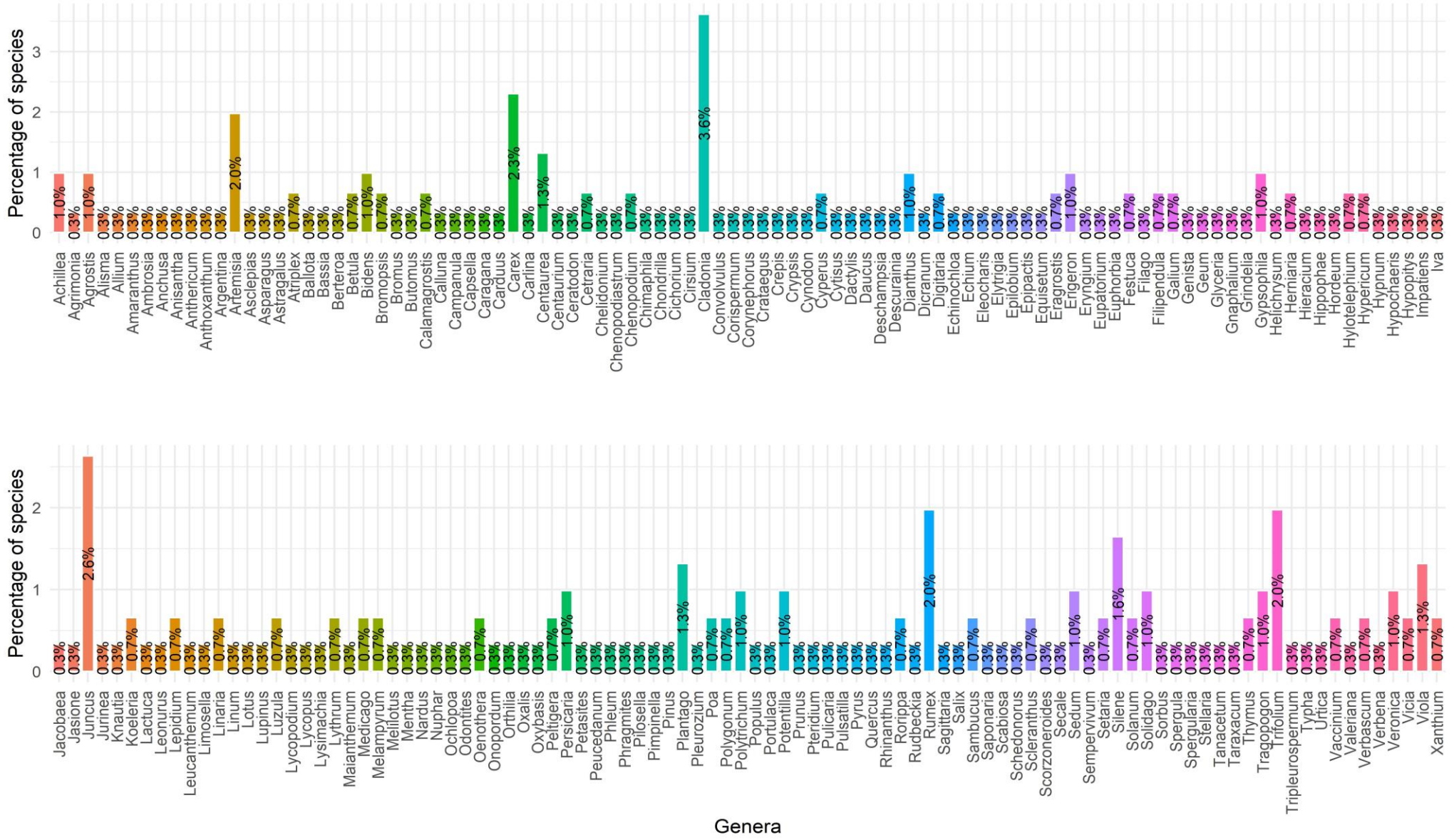

Fig. 3. Distribution of psammophytic plant species genera of Chernihiv Polissya

Biomorphological structure

Trees in the sand flora of the study area were represented by seven species (*Pinus sylvestris*, *Betula pendula*, *Betula pubescens*, *Quercus robur*, *Pyrus communis*, *Sorbus aucuparia*, *Populus tremula*). Also, eight species of shrubs (*Hippophae rhamnoides*, *Cytisus ruthenicus*, *Prunus fruticosa*, *Crataegus meyeri*, *Salix daphnoides* subsp. *acutifolia*, *Sambucus nigra*, *S. racemosa*, and *Caragana arborescens*), as well as six species of tall half-shrubs (*Calluna vulgaris*, *Vaccinium myrtillus*, *V. vitis-idaea*, *Genista tinctoria*, *Artemisia abrotanum*, and *Thymus pulegioides*), and four species of dwarf half-shrubs (*Thymus serpyllum*, *Chimaphila umbellata*, *Orthilia secunda*, and *Solanum dulcamara*) were found. The vast majority of species (257 species, 91.1%) were herbaceous plants.

Perennial plants, in particular representatives of the *Carex*, *Calamagrostis*, *Koeleria*, and *Corynephorus* genera, with their total amount of 149 species (58%) predominate among herbaceous species. The proportion of annuals, biennials and of a separate group of species with a life span of 1–2 years was 71 species (27.63%), 22 species (8.56%) and 15 species (5.84%), respectively (Fig. 4).

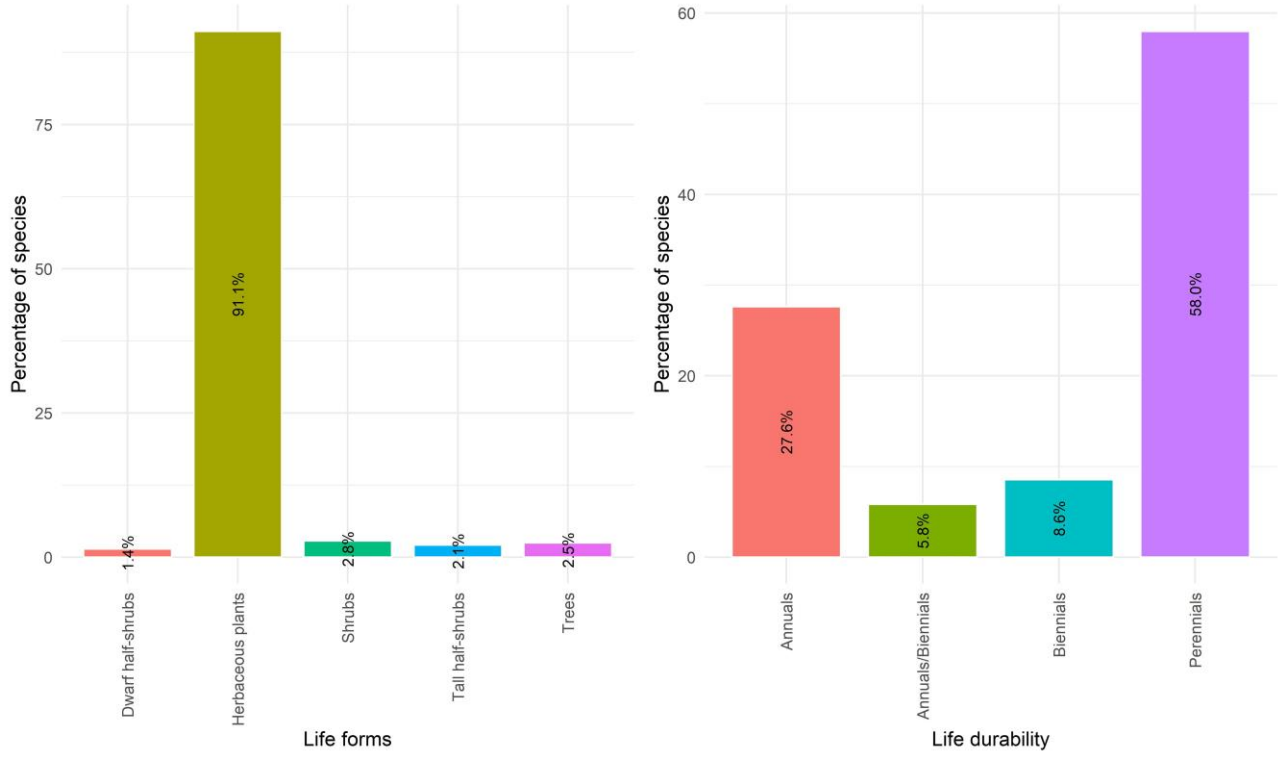

Fig. 4. Distribution of psammophyte species based on ecological and morphological characteristics (on the left) and herbaceous species categorized by their life span (on the right), according to Serebriakov [34]

In stable plant communities, annual and biennial species are mostly absent [7]. A significant percentage (27.6 %) of annuals may indicate anthropogenic pressure. Also, such ratios could be explained by the life strategies of plant species of alluvial and anthropogenically transformed sands, as they are mostly explerents and R-

selected annual herbs [12]. The predominance of perennials in the sand flora can be explained by the fact that they fix the sand, especially pine terraces. Perennial species of sands are mainly stress-tolerators and competitors, forming more stable communities during the successional development of vegetation.

Ecological structure

Water, temperature, light conditions, the amount of mineral substances and anthropogenic influence are the main factors affecting the vital activity of plants. Next ecological groups were distinguished among the sand plant species of Chernihiv Polissya according to the water regime [31]: xerophytes (species of arid soil conditions), mesophytes (species of medium soil humidity), hyhrophytes (growing under condition of permanently or temporarily moist soil), hydrophytes (submerged or attached to the bottom of a reservoir), and intermediate groups, such as xeromesophytes, mesoxerophytes, mesohyhrophytes, hyhromesophytes, hydrohyhrophytes. The flora is dominated by mesophytes (36.9%), xeromesophytes (25.2%) and hyhromesophytes (9.9%). Hydrophytes are the least represented (1.1%). The distribution in general can be considered typical for the temperate climate of Chernihiv Polissya. The proportion of xerophytes (on pine sands) and hyhrophytes (on alluvial sands) is somewhat higher, which obviously reflects the peculiarities of the ecological conditions for the growth of psammophyte species (Fig. 5).

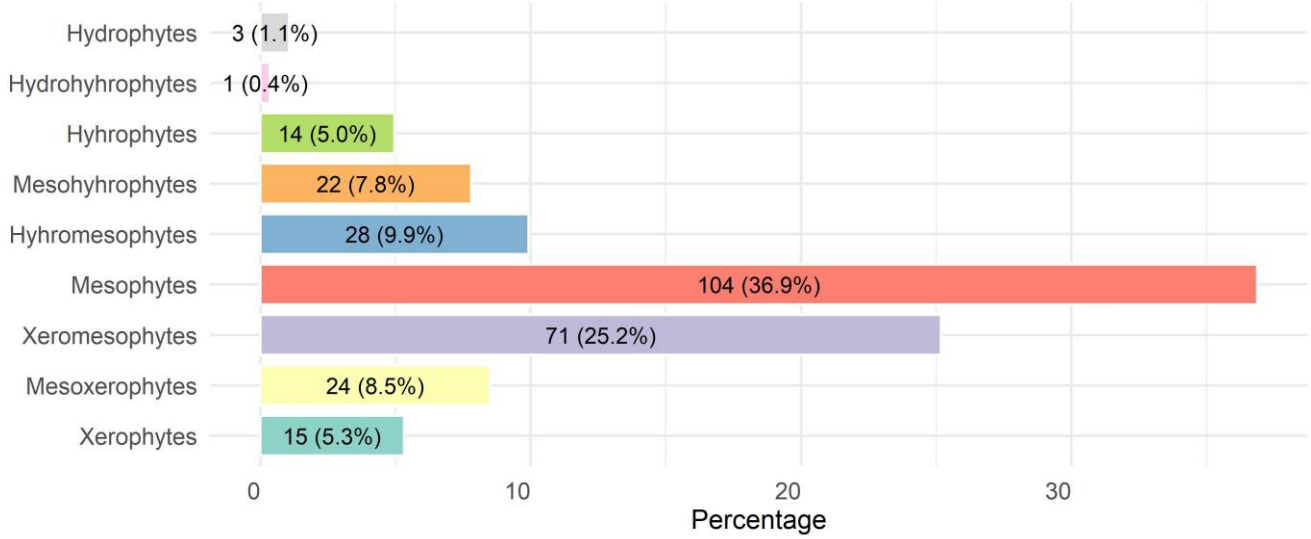

Fig. 5. Distribution of psammophytic species according to soil water regime, according to Protopopova [31]

Among psammophytes five groups were distinguished according to the variability of soil moisture (Fig.6). There was only the one representative of the hyper-hydrocontrastophiles – *Coryspermum hyssopifolium*, which grows in extremely irregular wetting. The most represented was the group of hemi-hydrocontrastophiles – 133 species (47.2%). These results explain that species on sandy soil mostly adapted to dry habitats with irregular moisture level.

According to soil acidity (pH), the 5 categories were found among the species (Fig. 6). Sub-acidophiles (44%) prevailed. This distribution shows that the flora of Chernihiv Polissya sands was dominated by species growing on slightly acidic (pH = 5.5–6.5) soils of pine forests and meadows. With such a composition, we cannot help but notice a certain shift in the balance towards acidophilic species, which is obviously explained by the predominance of the acidic reaction of sandy soils.

According to soil aeration, psammophytic species of Chernihiv Polissya were divided into 5 groups (Fig. 6). Among mega-aerophobes only *Typha laxmannii*, *Persicaria lapathifolia*, *Nuphar lutea*, *Phragmites australis*, *Limosella aquatica* were noted. The presence of these species can be explained by the fact that they occur on alluvial sands during periods of drought and low water levels in rivers. However, the most numerous group occurred to be sub-aerophiles, which contained 150 species (53.2%). This distribution can be interpreted by the preference of species for the sand substrate. The majority of plants are adapted to highly aerated habitats – sand terraces, and also, to the conditions of slight and moderate wetting of soil layer by the precipitations and melted waters on alluvial riverbanks.

According to the total soil salt content, 6 groups were identified (Fig. 6). Glycotrophes were the least numerous, and consisted of 3 species (*Juncus gerardii*, *Xanthium strumarium*, *Crypsis alopecuroides*). Semi-eutrophes contained 123 species (43.6%). The predominance of semi-eutrophes was due to the presence of podzolic processes in the study area, as well as specific physical-geographical and climatic conditions (precipitation quantity). However, it is noteworthy that the species composition of sands of Chernihiv Polissya lacks species adapted to extreme conditions within the salinity regime.

According to soil carbonate content (Fig. 6), the species were divided into 5 groups. Hemi-carbonatophobes were appointed 46.5% of species. According to soil nitrogen content (Fig. 6), hemi-nitrophiles (47.2%) were the most numerous group of sand flora. Shifts to the hemi-carbonatophobes as well as to the sub-anitrophiles and hemi-nitrophiles prevailing could be easily explained by obvious peculiarities of the sandy soil environment, poor in organic matter and inorganic nitrogen content.

Four groups were identified according to the species thermal regime (Fig. 7). Sub-mesotherms (57.4%) were the most represented group, and could be treated as typical for the minimal (42 kcal/cm) value indicators of the northeastern plain part of Ukraine [4].

According to cryoclimatic regime (Fig. 7), species were classified into 4 groups. The widest groups of hemi-cryophytes (46.1%) and sub-cryophytes (42.2%) could be treated as a response to a usual winter cryo-regime of the territory – -14 – +2°C.

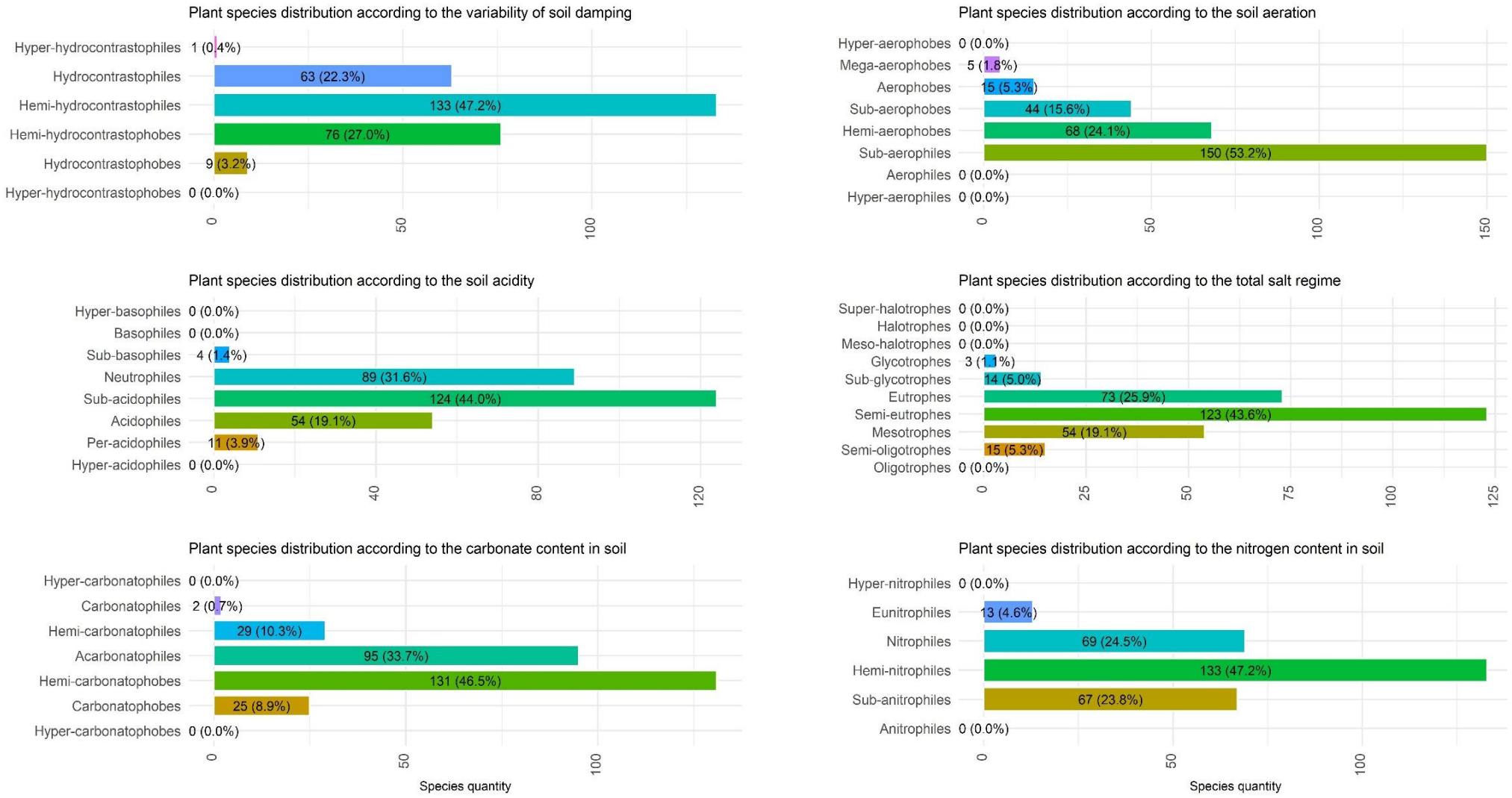

Fig. 6. Distribution of psammophytic species according to edaphotope variables, proposed by Ya.P. Didukh [4]

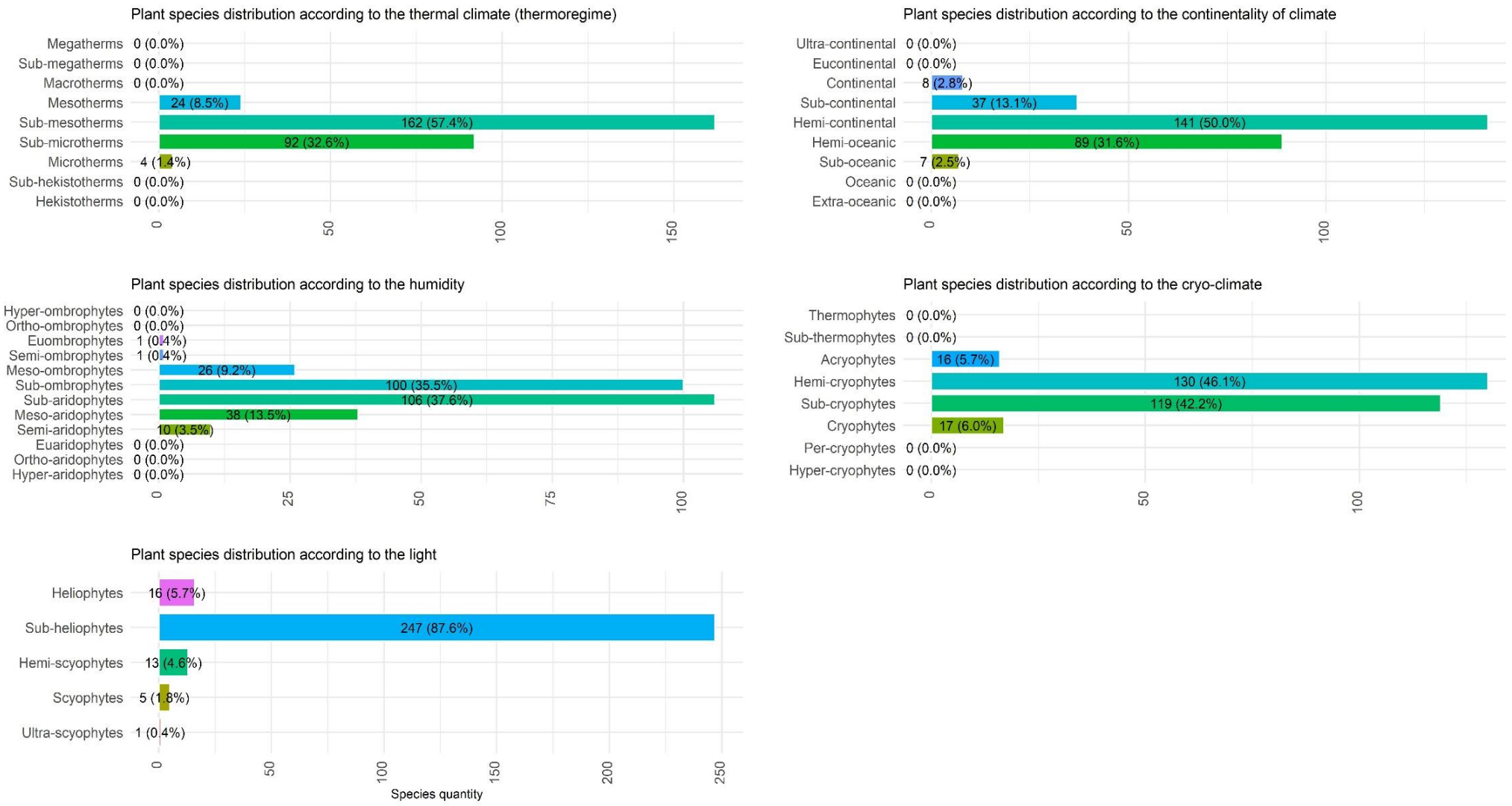

Fig. 7. Distribution of psammophytic species according to climatope variables, proposed by Ya.P. Didukh [4]

In relationship to humidity (Fig. 7), species were divided into euombrophytes and semi-ombrophytes – 1 species each (*Stellaria media* and *Hypericum maculatum*, respectively), semi-arydophytes – 10 species (3.5%), meso-ombrophytes – 26 species (9.2%), meso-arydophytes – 38 species (13.5%). The most widespread groups occurred to be sub-ombrophytes – 100 species (35.5%) and sub-aridophytes – 106 species (37.6%). Also, the following groups by the continentality of climate were present: sub-oceanic – 7 species (2.5%), continental – 8 species (2.8%), sub-continental – 37 species (13.1%), hemi-oceanic – 89 species (31.6%) and hemi-continental – 141 species (50%). The bigger volume of the hemi-continental species group, while the climate of the research territory is supposed to be sub-continental [4], could be explained by species of alluvial communities' variety whose growth conditions are usually damper. At the same time, the range of humidity (aridity) of Chernihiv Polissya sand species showed a rather typical picture as for the most part of Ukraine.

According to the lighting conditions (Fig. 7), four groups were identified. Sub-heliophytes, with 247 species (87.6%), dominated among them. Such a distribution was observed due to peculiarities of sand communities – the presence of only herb layer (which led to good sun exposure) and a sparse plant coverage.

Therefore, the species spectrum of psammophyte flora of Chernihiv Polissya could be treated as typical for the temperate latitudes of Europe with an average sub-continental climate. The peculiarities of the ecology of psammophytes were indicated by the shift of the spectrum towards sun-loving, eutrophic/mesotrophic, sub-acidophilic, and acidophilic species.

Analysis of the synanthropic fraction of flora of sands

The sands of Chernihiv Polissya are a dynamic and unstable substrate. They can be a favorable environment for intrusion and further distribution of synanthropic aboriginal and adventive species. The degree of anthropogenic transformation of the psammophyte flora was assessed using the flora index system (Fig. 8) of B. Jackowiak [8].

The overall degree of anthropogenic transformation of the flora was characterized by the Index of synantropization (IS, the proportion of synanthropes in the total number of species). A value of the index (47.9%) indicated anthropogenic pressure and a significant transformation of flora.

The Index of apophytization (IAp, which was calculated as a share of apophytes in the total number of species) was 26.6%, and the Index of aboriginal flora apophytization (IAps, equaled to the percentage ratio of apophytes to aboriginal species) was 33.8%.

Index of anthropophytization (Ian, 21.3%), determining the proportion of adventitious species in the flora as a whole, characterized the role of invasive adventive plants in the synanthropization of the flora.

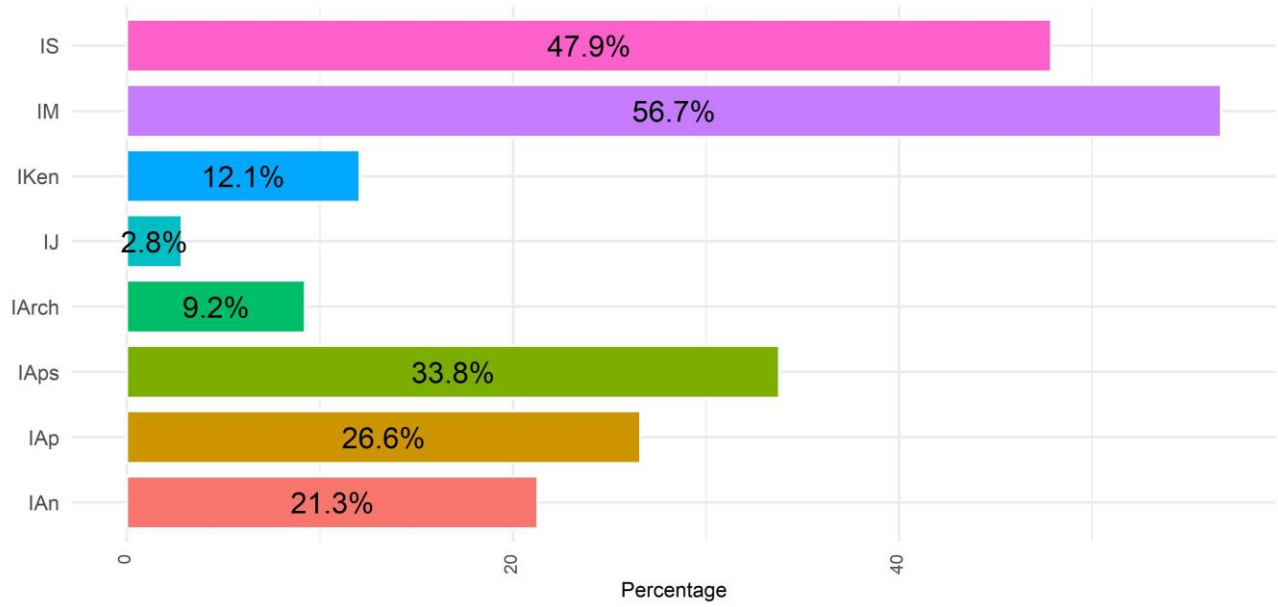

Fig. 8. Indices of flora synanthropization according to B. Jackowiak
IS – Index of synantropization, IM – Index of modernization, IKen – Index of kenophytization, IJ – Index of instability, IArch – Index of archeophytization, IAps – Index of aboriginal plants apophytization, IAp – Index of apophytization, IAn – Index of anthropophytization

The Index of archaeophytization (IArch, 9.2%) indicated the participation of species with a high degree of naturalization, which had been introduced to Ukraine before the 15th century. The Index of kenophytization (IKen, 12.1%) reflected the proportion of kenophytes in the total number of species, which could show the intensity of invasions in the period from the 15th to the 20th century. The obtained results indicate moderate to significate transformation of the sand flora of the region, according to Fitsailo & Pashkevych [35]. The percentage share of plant families with a small number of species (1-3) accounting for 70.2%, as well as plant genera consisting of 1-3 species share of 95.1%, can also be treated as strong evidence for a significant degree of flora synanthropization [31].

The index of flora modernization (IM, 56.7%) showed a high part of kenophytes in the adventive element of sand flora, and the Index of instability (IJ, 2.8%) revealed that the share of diaphytes was small enough which allows claiming a good naturalization status of kenophytes.

Comparing the synanthropization coefficients of the sandy soil flora of Chernihiv Polissya with the flora of protected areas (in the example of the Shatsky National Park [35]), it was found that such indices as the index of modernization (56.7% and 41%), anthropophytization (21.3% and 15.4%), and kenophytization (12.1% and 6.3%) are larger on sands, which indicates the significant vulnerability of sandy biotopes to invasions. The very close indices of archaeophytization (9.2% and 9.1%) and apophytization (26.6% and 28.1%) indicate the joint processes of floras' formation/development.

135 species out of 282 species (47.9%) of vascular plants of psammophytic flora of Chernihiv Polissya occurred to be synanthropic. Among synanthropes, 75

species (which made 55.6% of the total number) were apophytes (Fig. 9), and 60 species (44.4%) were adventive. The general index of adventitious flora (15.7%) confirmed the vulnerability of psammophytic communities to invasions.

The apophytic fraction of the synanthropic flora was divided into:

- hemiapophytes, that was, species that were equally adapted to both natural and anthropogenic biotopes (such as, for example, *Carex leporina*, *Bidens tripartitus*, *Tanacetum vulgare*) – 34 species overall, or 12.1% of the total number of species;

- evapophytes, or species preferring anthropogenic ecotopes (such as *Elytrigia repens*, *Artemisia vulgaris*, *Stellaria media*, *Chenopodium album*) – 23 species, or 8.2%;

- eventapophytes, or occasional apophytes (such as *Eryngium planum*, *Chondrilla juncea*, *Hypericum perforatum*) – 18 species, or 6.4%.

Next groups were distinguished among the adventitious species of sand flora of the research area (Fig. 9):

- By the time of settlement: archaeophytes, or plant species that appeared in the local flora before the year 1492, such as *Artemisia absinthium*, *Lactuca serriola*, *Capsella bursa-pastoris* (26 species, 9.2% of the total number of species); kenophytes, or species introduced after the 15th century, such as *Amaranthus retroflexus*, *Bidens frondosus*, *Erigeron canadensis*, *Solidago canadensis*, *Ambrosia artemisiifolia*, etc. (34 species, 12.1%).

- According to the degree of naturalization: epecophytes, or species naturalized in anthropogenic ecotopes: *Amaranthus retroflexus*, *Asclepias syriaca*, *Grindelia squarrosa*, etc. (52 species, or 18.4% of the total number of species); agrophytes, or species naturalized in natural and semi-natural communities: *Lupinus polyphyllus*, *Erigeron annuus*, *Artemisia abrotanum*, etc. (8 species, 2.8%).

- A group of ergasiophytes, i.e. species introduced deliberately, which had 8 species, or 2.8%. These are *Hippophae rhamnoides*, *Vicia sativa*, *Artemisia abrotanum*, *Saponaria officinalis*, *Lupinus polyphyllus*, *Caragana arborescens*, *Rudbeckia hirta*, *Solidago gigantea*. Apparently, other species, or xenophytes, were introduced to the territory of Chernihiv Polissya undeliberately.

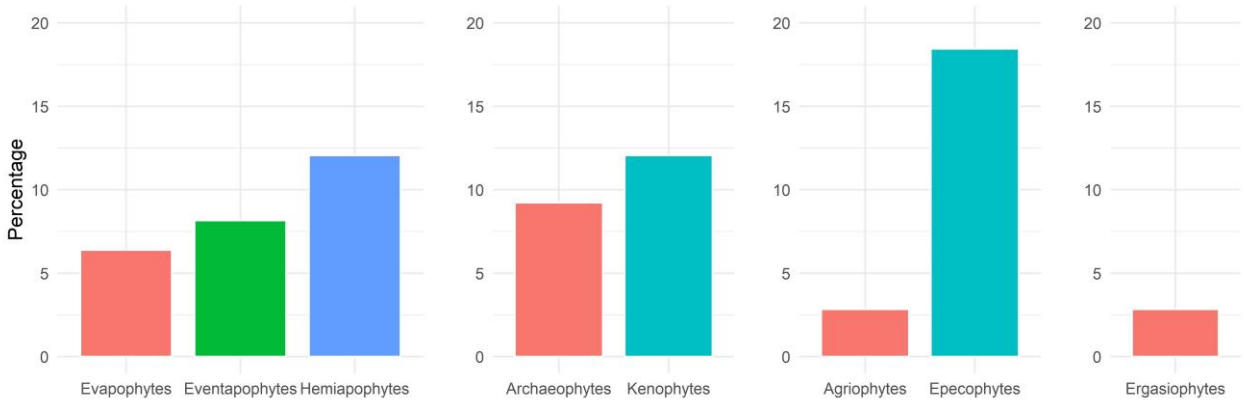

Fig. 9. Distribution of synanthropic plant species of Chernihiv Polissya

CONCLUSIONS

According to the results of research, it was found that the flora of Chernihiv Polissya sands includes 282 species of vascular plants belonging to 190 genera and 64 families. Also, 7 species of mosses and 15 species of lichens were found. The flora of vascular species of Chernihiv Polissya sands is 21.4% of the flora of Eastern Polissya and 6.3% of the flora of Ukraine. The process of new species spreading are mainly related to climate changes (xerophytization of phytodiversity) and invasions. *Poales* (19.08% of the total number of species) and *Asterales* (18.75%) were the most represented orders in systematic structure. *Compositae* (18.1%) and *Poaceae* (12.2%) were dominant families. According to the acquired data on the flora of Chernihiv Polissya sands, 132 genera (69.1%) were represented by one species. This indicates a substantial degree of synanthropization in the flora. Perennials (58%) predominate among herbaceous species (91.1%).

Mesophytes and xeromesophytes were dominant groups by the attitude to the water regime. Among psammophytes 5 groups were distinguished according to the variability of soil moisture the most represented was the group of hemi-hydrocontrastophiles 133 (47.2%), according to soil acidity (pH) – sub-acidophiles (44%), soil aeration – sub-aerophiles (53.2%), total soil salt content – semi-eutrophes (43.6%), soil carbonate content – hemi-carbonatophobes (46.5%), thermal regime – sub-mesotherms (57.4%), cryoclimatic regime – hemi-cryophytes (46.1%), humidity – sub-aridophytes (37.6%), by the continentality of climate – hemi-continental (50%), lighting conditions – sub-heliophytes (87.6%).

The analysis of the synanthropic fraction of the sand flora of Chernihiv Polissya indicated active processes of spreading invasive species within the psammophyte communities of Chernihiv Polissya.

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