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Giant hogweeds (*Heracleum mantegazzianum* and *H. sosnowskyi*) in Ukraine: distribution, ecological and coenotical features

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Abstract

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The paper aims to study the distribution and communities of two giant hogweed species *Heracleum mantegazzianum* and *H. sosnowskyi* in Ukraine. This research was motivated by strong invasive trends, risks for native vegetation and a lack of data on giant hogweeds in Ukraine. We presented phytosociological tables of giant hogweeds communities, maps of their modern distribution in Ukraine, a dendrogram of similarity of the communities, phytoindicative evaluation, and proportions of diagnostic species in the syntaxa. According to our survey and literature data, there are 102 locations of *H. mantegazzianum* and 405 locations of *H. sosnowskyi* throughout most of Ukraine, except for the steppe zone, where the limiting factor is the arid climate. The amplitudes of both studied *Heracleum* species have a significant overlap in the factors of humidity, nitrogen, and salt regime. There are differences between the species in the factors of light, temperature and continentality. The amplitudes of the studied species are the widest for moisture and the narrowest range for soil acidity. Both species favour soils enriched in nitrogen. Based on the phytosociological survey, the species forms two distinct associations *Urtico dioicae-Heracleetum sosnowskyi* and *Urtico dioicae-Heracleetum mantegazzian*i and also occurs with lower abundance in communities belonging to 8 vegetation classes. The obtained data can be used to carry out preventive measures against the further spread of giant hogweeds in new habitats with varying degrees of anthropogenic transformation.

Keywords

giant hogweeds, distribution, phytoindication, phytosociology, Ukraine

Introduction

The expansion of alien species poses a threat to natural ecosystems, causing economic and environmental damage to the environment (Rani et al., 2020, Bradley et al., 2012; Hulme et al., 2018, Cai et al., 2020; Sax and Gaines, 2008). Some of the most aggressive and active invasive species in Europe are representatives of the genus *Heracleum* L.: *Heracleum sosnowskyi* Manden. and *H. mantegazzianum* Sommier & Levier (Pyšek et al., 2007). Due to their size (stem height and large leaves), these species form a group of plants known as “giant hogweeds”.

The genus *Heracleum* comprises 65 species in total (Pimenov and Leonov, 1993), of which 9 species occur in Ukraine: *Heracleum carpaticum* Porcius, *H. ligusticifolium* M. Bieb., *H. sphondylium* subsp. *transsilvanicum* (Schur) Brummitt (*H. palmatum* Baumg.), *H. sibiricum* L., *H. sosnowskyi* Manden., *H. sphondylium* L., *H. villosum* (Hoffm.) Fisch. ex Spreng., *H. mantegazzianum* Sommier & Levier (*H. wilhelmsii* Fisch. & C.A.Mey.) (Fedoronchuk, 2022) and *H. pubescens* (Hoffm.) M.Bieb. (https://powo.science.kew.org/). Communities with the

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participation of giant hogweeds have been recorded in Latvia (Laiviņš & Gavrilova, 2003), Lithuania (Gudžinskas et al., 2015), Poland (Sobisz, 2007), Hungary (Kovács, 2003), Germany (Thiele and Otte, 2006), Czech Republic (Pergl et al., 2012) and other countries. Publications of Ukrainian researchers contain basic information on their distribution in different regions, in particular, mixed forests (Lukash and Zavyalova, 2003; Lukash, 2007; Protopopova et al., 2015; Khomyak et al., 2019; Grygus et al., 2018; Oitsius et al, 2020), broadleaved forests (Mykhalyuk et al., 2017; Korsun, 2022); forest-steppe part (Burda, 2007; Bagatska, 2008; Gubar and Koniakin, 2020, 2021; Koniakin et al., 2023), the Ukrainian Carpathians (Simpson et al., 2011; Vykhor and Prots, 2012; Koynova and Shtoyko, 2015; Didukh et al., 2016; Tokaryuk et al., 2018; Pashkevych, 2018) and Crimea (Naumov et al., 2009).

H. sosnowskyi is a Caucasian species, first described in 1936 in Georgia and introduced in the late 1940s (Mandenova, 1944). Its natural range includes mountain forests and subalpine meadows of Eastern Caucasus, South-Eastern Transcaucasia, and South-Eastern Turkey (Jahodova et al., 2007). In the European part of the USSR also Baltic countries and East Germany in the 60s and 70s, the species was intensively cultivated as a silage and fodder crop (Sazyperova, 1984). Subsequently, the cultivation of *H. sosnowskyi* did not become economically important due to the unsuitability of dairy products after consumption by cattle. However, the species began to spread and penetrate natural and anthropogenic coenoses (Mandenova, 1950; Nielsen et al., 2005). Today, in many regions of Ukraine (upper Dniester, southern Zhytomyr region, Kyiv agglomeration), *H. sosnowskyi* is a particular problem, as it occupies large areas (Didukh, 2023). Now, the alien range of Sosnowski's hogweed (*Heracleum sosnowskyi*) recognized as invasive in a number of countries: the Baltic countries, Republic of Belarus, Ukraine, European part of Russia, sporadically occurring Poland, Hungary and Denmark (*Centre for Agriculture*…, 2023).

The natural range of *H. mantegazzianum* covers the western Caucasus and north-eastern Georgia (Nielsen, 2005). It was first introduced in 1817 as a garden plant in Great Britain, after which it actively spread across Europe (Nielsen, 2005; Pyšek et al., 2007). *H. mantegazzianum* was first cultivated in Ukraine as an ornamental plant in Osmolodske Forestry (Ivano-Frankivsk region), and since 1960 in the botanical gardens of Taras Shevchenko University of Kyiv and Uzhhorod University. The first report on the spontaneous spread of *H. mantegazzianum* in the Limnytsia River valley near the village of Osmolod dates back to 1962 (Berko, 1964). In the 1970s, its active spread began to be recorded in Zakarpattia, Prykarpattia, Polissia, and Kyiv's Dnipro region (Protopopova et al., 2002; Protopopova and Shevera, 2005). The Giant hogweed (*Heracleum mantegazzianum*) is recognized as invasive in a number of countries: the USA, Canada, and European countries: Hungary, Slovakia, Germany, Czech Republic, Denmark, Ireland and other countries (*Centre for Agriculture*…, 2023).

The aim of the study is 1) to analyse the current distribution of *H. mantegazzianum* and *H. sosnowskyi* in Ukraine; 2) to investigate the features of communities with *H. mantegazzianum* and *H. sosnowskyi*; 3) to assess ecological variables including differences of communities in which these two species grow.

Materials and methods

The analysis of the current distribution of both *H. mantegazzianum* and *H. sosnowskyi* in Ukraine was based on geobotanical studies, herbarium collections of the M.G. Kholodny Institute of Botany and Chernivtsi National University, literature sources (Lukash and Zavyalova, 2003; Burda, 2007; Lukash, 2007; Bagatska, 2008; Naumov et al, 2009; Vykhor and Prots, 2012; Tokaryuk et al., 2012; Protopopova et al., 2015; Didukh et al., 2016; Mykhalyuk et al., 2017; Grygus et al., 2018; Pashkevych, 2018; Tokaryuk et al., 2018; Khomyak et al., 2019; Oitsius et al., 2020; Gubar and Koniakin, 2020, 2021; Dubyna et al, 2021; Lyubinska and Matvieiev, 2021; Korsun, 2022; Koniakin et al., 2022, 2023; *Records of alien...*, 2023) and internet resources – UkrBIN (https://ukrbin.com), INaturalist (https://www.inaturalist.org). Data on findings are summarised in Supplementary Table S1 in a unified manner, with an indication of region and habitat (if available), and were used to create distribution maps for Ukraine.

The geobotanical survey was carried out using the route method with the conventional vegetation plot technique (Braun-Blanquet, 1964; Mirkin et al., 2001). The total number of relevés (plots) is 123. The time range covers the period from 2019 to 2021. The projected coverage of species is indicated according to the scale of B.M. Mirkin (2001). For comparison, our relevés from Ukraine are supplemented with data from other regions based on literature sources and are included in Supplementary Table S2. Taxonomic names of species are unified according to the Euro+Med PlantBase resource (https://europlusmed.org).

Vegetation classification was based on the Braun-Blanquet approach (1964). Differential species were identified based on their fidelity (Barkman, 1989; Chytry et al., 2002; Willner, 2006; Kusbach et al., 2012). Species fidelities were assessed by the Ochiai coefficient (Ochiai, 1957; Chytry et al., 2002; De Caceres et al., 2008). The final distribution of relevés between syntaxa was improved by the criterion of species dominance, which is of particular importance in the classification of anthropogenic vegetation due to the lack of characteristic species.

The phytosociological analysis of communities with *Heracleum* species was carried out by the ratio of the number of diagnostic species of different vegetation classes. The species-to-classes classification was based on the EuroVegChecklist (Mucina et al., 2016). The proportions of species were calculated based on their occurrence and converted to percentages. We determined the predominant vegetation classes by the number of species, which form the floristic core of the communities. The proportions of species of different vegetation classes were also used to compare our communities with similar ones from other

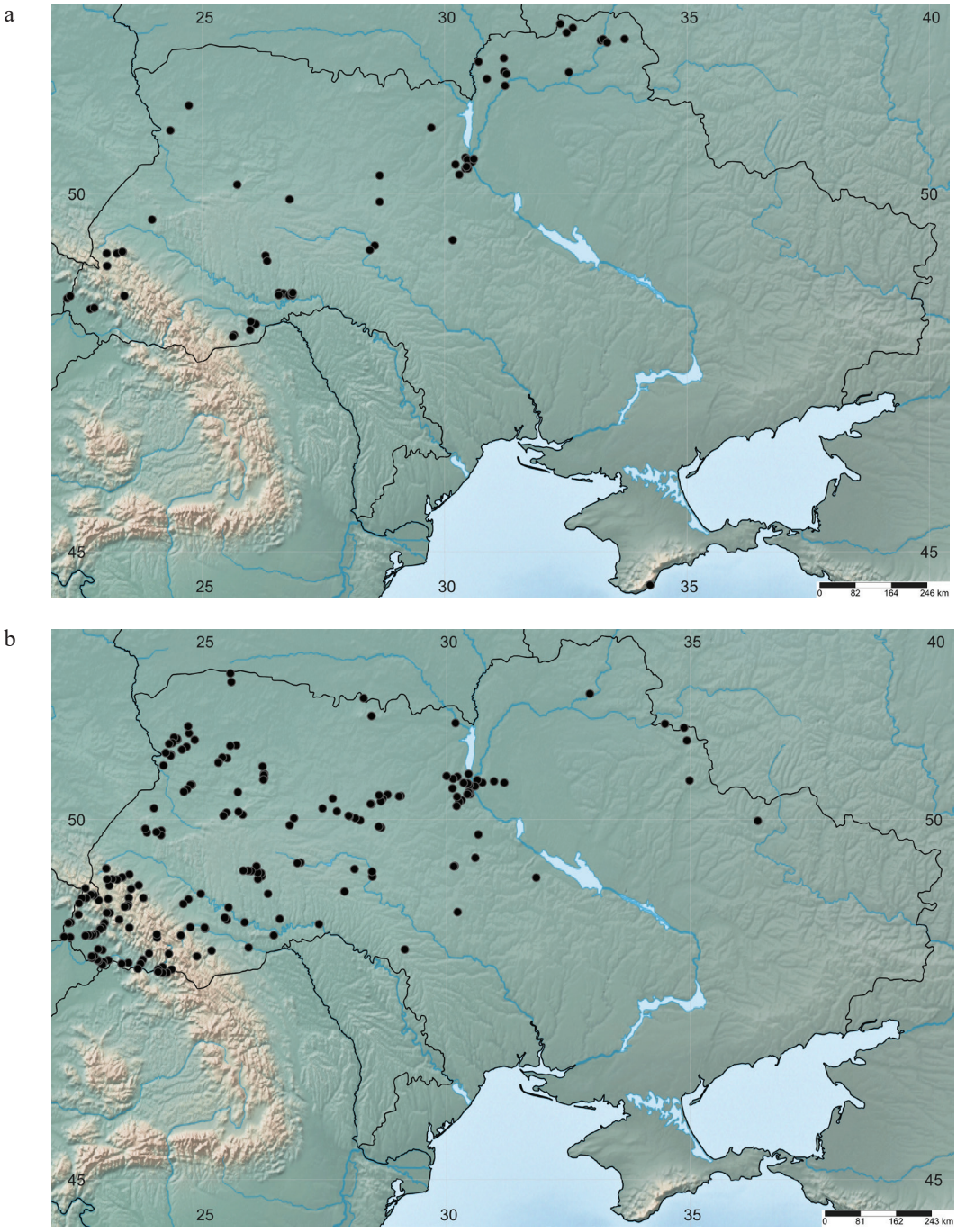

Fig. 1. Distribution map of *Heracleum mantegazzianum* (Fig. 1a) and *H. sosnowskyi* (Fig. 1b) in Ukraine. Source of data with links to resources are presented in Supplementary Table S1.

regions. The nomenclatural types of *Urtico dioicae-Heracleetum sosnowskyi* (Panasenko et al., 2014) and *Urtico dioicae-Heracleetum mantegazzianii* (Klauck, 1988) associations were taken as standards for comparison (Supplementary Table S3, S4).

The ecological assessment of *H. mantegazzianum* and *H. sosnowskyi* was carried out based on the complete floristic composition of the communities where these species occur, using the phytoindication method (Ramenskii, 1956; Ellenberg, 1988; Didukh and Plyuta, 1994). The ecological scales of Ya.P. Didukh adapted for the Ukrainian flora were used as a basis (Didukh, 2011). Weighted average scores were calculated taking into account the projected coverage of species. For comparability of values between factors with different scores, they were rescaled to a single 100-point scale (Goncharenko, 2017).

Differences in ecological parameters in the two *Heracleum* species were detected using the nonparametric Mann-Whitney U-test (Mann and Whitney, 1947). To quantify the differences in floristic composition, hierarchical cluster analysis was applied, taking into account the occurrence of species and based on the Bray-Curtis distance matrix (Bray and Curtis, 1957). Grouping was

performed using the flexible-beta algorithm with a value of β = –0.25 (Lance and Williams, 1967). All quantitative calculations were performed in R environment (R Core Team, 2020).

Results and discussion

Distribution in Ukraine

Based on the analysis of herbarium collections, literature, internet resources, and our observations, 102 localities of *Heracleum mantegazzianum* and 405 localities of *H. sosnowskyi* are known in Ukraine (Fig. 1).

The expansion of giant hogweeds in Ukraine was firstly recorded in the western regions of Ukraine (Berko, 1964; Mandenova, 1950; Vykhor and Prots; 2012). Currently, most of the giant hogweed occurrences are located in the Ukrainian Carpathians, zone of mixed and deciduous forests, and the forest-steppe region (mainly in the western and northern parts) (Fig. 1).

Spontaneous spread of the species is observed in anthropogenic and semi-anthropogenic, mesophytic, nitrogen-enriched habitats, including abandoned gardens, near buildings, fences, along watercourses, forest edges and clearings (Fig. 2).

Fig. 2. Expansion of giant hogweeds in different habitats in Ukraine. 2a – *H. sosnowskyi* in the floodplain of the Southern Bug River (Vinnitsa); 2b – *H. sosnowskyi* on an abandoned farm (Zhytomyr); 2c – *H. sosnowskyi* in abandoned vegetable gardens (Hlevakha, Kyiv region); 2d – *H. sosnowskyi* on the floodplain meadows of the Hnylyi Tikych River (Kyiv region); 2e – *H. mantegazzianum* near buildings (Khotiv village, Kyiv region); 2f – *H. sosnowskyi* in the floodplain of the Uzh River (Uzhhorod). Photos by S. Koniakin.

Table 1. Characteristic table of the *Urtico dioicae-Heracleetum sosnowskyi* association

Relevé numbers	1	2	3	4	5	6	7	8	9	10	Mean of projective cover (%)	Constancy (%)
Number of species	20	20	12	19	22	37	15	13	26	23		
Cover of trees	–	30	35	15	10	5	40	5	10	30		
Cover of shrubs	10	10	5	–	–	20	25	20	15	–		
Cover of herbs	45	60	90	75	80	85	60	65	75	65		
Phytoindicational variables												
Hd, moisture	48.8	47.3	53.6	51.7	48.5	42.6	53.8	50.3	50.5	46.0		
Rc, soil acidity	58.8	58.5	61.1	60.1	59.3	60.8	62.9	58.0	57.6	57.6		
Nt, nitrogen	76.4	70.3	74.1	70.5	57.9	70.8	75.5	72.4	66.8	69.3		
Lc, light regime	53.1	53.5	53.3	59.5	59.6	62.2	52.3	58.8	61.6	57.4		
Tm, temperature	55.4	54.0	53.0	55.6	53.4	59.4	53.3	54.8	54.6	56.4		
Kn, continuity	36.9	36.3	33.4	35.8	34.8	41.8	35.7	37.4	39.3	36.2		
D.s. ass. *Urtico-dioicae - Heracleetum sosnowskyi*												
Heracleum sosnowskyi	4	5	4	4	4	4	4	4	4	4	66	100
Urtica dioica	5	2	2	3	1	3	2	2	2	4	30	100
D.s. Cl. *Galio-Urticetea*												
Galium aparine	1	4	1	2		2				3	22	60
Solidago canadensis	+	+						2	2	2	9	50
Glechoma hederacea	+		1		2		1			+	5	50
Geum urbanum	1	3					2			+	14	40
Alliaria petiolata	+					2				+	6	30
D.s. Cl. *Robinietea*												
Acer negundo	+	+	+	+	+	+		1	+	2	3	90
Parthenocissus inserta	2			1		1		1			6	40
Ballota nigra						3	1			+	14	30
D.s. Cl. *Artemisietea vulgaris*												
Artemisia vulgaris	+			1		1	+	1	1	+	3	70
Arctium tomentosum	+					+	+	+	+		2	50
D.s. Cl. *Molinio-Arrenatheretea*												
Elytrigia repens	+	1		+		3		2	2	+	10	70
Dactylis glomerata		+	+	1	2		+		2	2	7	70
Other species												
Rubus caesius							2	1	1		6	30
Taraxacum sect. *Taraxacum*	+	2			+	+				1	4	50
Salix alba			2	+			2				9	30
Fraxinus excelsior	+	1					+				2	30
Poa nemoralis	+	1								+	2	30
Juglans regia					1			+	+		2	30
Erigeron annuus		1							+	+	2	30

Rare species (in less than two relevés): *Acer platanoides* 10 (2); *A. pseudoplatanus* 1 (+); *Aegopodium podagraria* 3 (2); *Alnus glutinosa* 7 (2); *Alopecurus pratensis* 5 (+); *Ambrosia artemisiifolia* 6 (+); *Anchusa officinalis* 6 (+); *Anisantha tectorum* 6 (+); *Arctium lappa* 9 (1); *Argentina anserina* 9 (1); *Arrhenatherum elatius* 4 (2), 10 (3); *Atriplex tatarica* 6 (2); *Bidens frondosa* 4 (+); *Bunias orientalis* 6 (+); *Calystegia sepium* 4 (+); *Carex acuta* 5 (2); *C. hirta* 9 (1); *C. spicata* 5 (+); *Cerastium fontanum vulgare* 8 (+); *Chaerophyllum aromaticum* 3 (+); *C. temulum* 10 (1); *Chelidonium majus* 1 (3), 6 (2); *Cicerbita muralis* 10 (+); *Cirsium arvense* 8 (+), 9 (1); *Convolvulus arvensis* 4 (+); *Cornus sanguinea* 2 (+), 3 (+); *Daucus carota* 9 (+); *Deschampsia cespitosa* 9 (1); *Equisetum arvense* 5 (+), 9 (+); *Erigeron canadensis* 2 (+); *Euphorbia* sp. 9 (+); *E. virgata* 6 (+); *Geranium pratense* 5 (+), 9 (+); *Heracleum sphondylium sibiricum* 9 (+); *Hordeum murinu*m 6 (+); *Humulus lupulus* 3 (1), 6 (+); *Impatiens parviflora* 1 (1); *Lactuca serriola* 6 (1), 10 (1); *Lolium perenne* 6 (+); *Lysimachia nummularia* 10 (+); *Lythrum salicaria* 9 (+); *Malus pumila* 2 (2); *Myosotis sparsiflora* 1 (+), 2 (2); *Myosoton aquaticum* 1 (+), 2 (+); *Oenothera biennis* 4 (+); *Pastinaca sativa* 5 (1); *Phragmites australis* 4 (1), 9 (+); *Plantago lanceolata* 5 (+); *P. major* 10 (+); *Poa angustifolia* 5 (1), 10 (2); *P. compressa* 6 (+); *P. pratensis* 2 (1); *P. trivialis 3* (3), 4 (2); *Polygonum aviculare* 6 (+); *Prunus cerasifera* 5 (+); *Pyrus communis* 2 (1); *Raphanus raphanistrum* 6 (+); *Rumex confertus* 6 (+); *R. crispus* 5 (+); *R. obtusifolius* 6 (+); *Salix caprea* 7 (+); *S. cine-*

Table 1. Continued

rea 8 (+), 9 (+); *S.* sp. 6 (+); *S. triandra* 4 (+); *Saponaria officinalis* 6 (1); *Schedonorus arundinaceus* 9 (+); *S. pratensis* 5 (3); *Solidago gigantea* 4 (+), 6 (+); *Sonchus asper* 5 (1); *S. oleraceus* 6 (+); *Symphyotrichum novi-belgii* 9 (+); *Tanacetum vulgare* 6 (+); *Torilis japonica* 6 (1), 7 (+); *Tragopogon dubius* 6 (+); *Trifolium medium* 4 (+), 6 (+); *Ulmus glabra* 6 (+), 7 (+); *U. laevis* 5 (+); *U. pumila* 6 (1); *Veronica chamaedrys* 2 (1), 5 (+); *Vicia sepium* 5 (1).

Location and other metadata of relevés with the occurrence of *H. sosnowskyi*

Relevé 1. 18.05.2022. Koniakin S.M., Gubar L.M. m. Kyiv, Holosiivskyi district (50.362320N 30.4711197E). Roadside, under the garages.

Relevé 2. 19.05.2022. Koniakin S.M., Gubar L.M. m. Kyiv, National Complex "Expocenter of Ukraine" (50.375727N 30.473385E). Fruit perennial plantations.

Relevé 3. 2.06.2022. Koniakin S.M., Gubar L.M. m. Kyiv, Syretskyi Hai – a park-monument of landscape art of national importance (50.485159N 30.438754E). The coastal and aquatic phytocoenosis of Syretskyi Stream.

Relevé 4. 6.06.2022. Koniakin S.M., Gubar L.M. m. Zhytomyr (50.2833235N 28.681820E). The coastal strip of the Kroshenko River, the roadside of Malynska Street.

Relevé 5. 6.06.2022. Koniakin S.M., Gubar L.M. m. Zhytomyr (50.284791N 28.660675E). Meadow phytocoenosis, floodplain of the Kroshenka River.

Relevé 6. 14.07.2022. Koniakin S.M., Gubar L.M. Glevakha village, Fastiv district, Kyiv region (50.257232N 30.307301E). Ruderal site, 8 m from the railway.

Relevé 7. 23.07.2022. Koniakin S.M., Gubar L.M. Stavyshche village, Bila Tserkva district, Kyiv region (49.377683N 30.144181E). The floodplain of the Hnylyi Tikych River.

Relevé 8. 31.08.2022. Koniakin S.M. m. Rivne (50.612184N 26.232722E). Ruderal cenosis under the railway embankment.

Relevé 9. 31.08.2022. Koniakin S.M. m. Rivne (50.607546N 26.232935E). Meadow cenosis under the railway embankment.

Relevé 10. 22.06.2021. Koniakin S.M., Gubar L.M. m. Kyiv, National Complex "Expocenter of Ukraine" (50.607546N 26.232935E). Ruderal coenosis on abandoned administrative buildings, wasteland.

The main factors contributing to the species distribution are the humid climate in most of Ukraine, as well as the dense river network along which the species spreads, and the presence of favourable shaded anthropogenic habitats, especially in the northern regions.

Syntaxonomical scheme and main communities

Both representatives of the genus *Heracleum* are species with a wide ecological range. We divide the communities in which they occur into two types. The first type is where *Heracleum* species are main dominants and the second type is where these species occur with a lower projective coverage. The first type includes two associations within the class *Galio-Urticetea*. The syntaxonomic scheme and characteristics of the associations are presented below.

Class ***Galio-Urticetea*** **Passarge ex Kopecký 1969**

Ord. *Circaeo lutetianae-Stachyetalia sylvaticae* Passarge 1967

All. *Aegopodion podagrariae* Tüxen 1967

Ass. *Urtico dioicae-Heracleetum sosnowskyi* Panasenko et al. 2014

Ass. *Urtico dioicae-Heracleetum mantegazzianii* Klauck 1988.

In the European vegetation survey, the class *Galio-Urticetea* is included in the class *Epilobietea angustifolii*, but it is noted that this interpretation is controversial (Mucina et al., 2016). We believe that the class *Galio-Urticete*a is independent. In Ukraine, the class *Galio-Urticetea* is also recognised as an independent unit (Dubyna et al., 2019).

The association *Urtico dioicae-Heracleetum sosnowskyi* Panasenko et al. 2014 (Table 1). Diagnostic species: *Heracleum sosnowskyi* (dom.), *Urtica dioica* (dom.).

In Ukraine, the communities are most common in the zone of mixed and deciduous forests, forest-steppe (mainly in the western and northern) parts. The association is formed in semi-natural nitrogen-enriched habitats, as well as along watercourses and forest edges under mesophytic conditions. The herbage is tall and dense with a projected cover of 75–100%, on average 66%. The species *Acer negundo* (0.2–0.1), *Salix alba* (0.3–0.4), *Fraxinus excelsior* (0.4) grow in the tree layer. The undergrowth of trees is 1.5–2.5 m high, and it is formed by *A. negundo*, *F. excelsior, Juglans regia*. The liana *Parthenocissus inserta* is very characteristic. The shrub layer is dominated by *Rubus caesius*. The first sublayer (2 to 4.5 m) is formed by tall shoots of *H. sosnowskyi*; the second (1.0–1.7 m) is dominated by *Urtica dioica*, *Solidago canadensis, Artemisia vulgaris*, the third sublayer (up to 0.5 m) by *Glechoma hederacea*, *Geum urbanum* and others. The number of species varies from 12 to 37, with an average of 20. The total number of species in the combined list is 101. The position *H. sosnowskyi* is stable in the communities, and juvenile and immature individuals were observed.

The association *Urtico dioicae-Heracleetum mantegazziani* Klauck 1988 (Table 2). Diagnostic species: *Heracleum mantegazzianum* (dom.), *Urtica dioica* (dom.).

The association was described for the first time in Germany and is typical for many European countries (Chytry, 2009). In Ukraine, its communities are most common in the Carpathian region, Zhytomyr Polissya, and the western and central parts of the forest-steppe zone of Ukraine. The communities are confined to nitrogen-enriched marginal shaded anthropogenic habitats, mesophytic forest edges, watercourses, abandoned gardens, estates, weedy meadows, streams and river valleys.

The total projective coverage is 55–100%, with

Table 2. Characteristic table of the *Urtico dioicae-Heracleetum mantegazziani* association

Relevé numbers	1	2	3	4	5	6	7	8	9	10	Mean of projective cover (%)	Constancy (%)
Number of species	14	19	24	13	21	39	32	16	13	11		
Cover of trees	–	25	30	10	–	10	–	–	–	–		
Cover of shrubs	25	10	15	–	10	–	–	–	–	–		
Cover of herbs	65	45	55	80	75	45	90	100	100	100		
Phytoindicational variables												
Hd, moisture	48.5	47.7	59.3	47.9	40.8	43.6	41.6	44.1	47.3	45.2		
Rc, soil acidity	57.4	59.8	59.7	60.7	62.1	59.6	57.2	54.0	56.2	56.0		
Nt, nitrogen	77.9	69.3	68.6	66.7	73.2	69.2	64.3	68.9	69.7	61.3		
Lc, light regime	58.4	63.0	60.9	67.4	73.0	62.2	67.8	65.8	63.1	67.4		
Tm, temperature	61.5	61.1	58.1	58.1	66.3	61.3	57.6	55.8	54.1	52.3		
Kn, continuity	37.3	41.7	40.8	48.7	51.8	41.6	42.7	40.9	38.0	35.2		
D.s. ass. *Urtico-dioicae-Heracleetum mantegazziani*												
Heracleum mantegazzianum	2	4	3	3	3	4	5	5	5	2	53	100
Urtica dioica	2	1	1	1		3	+	2			11	70
D.s. Cl. *Galio-Urticetea*												
Erigeron annuus		3		1	+	+	2	+			10	60
Galium aparine	3					+			2		18	30
Geum urbanum			+			+	+				2	30
Humulus lupulus	+	2	2		1						8	40
D.s. Cl. *Robinietea*												
Acer negundo	2		1	+	+						5	40
Parthenocissus inserta	1	3				3					26	30
D.s. Cl. *Artemisietea vulgaris*												
Arctium lappa			+			1	1				3	30
Lactuca serriola				+		1	+				2	30
D.s. Cl. *Molinio-Arrenatheretea*												
Elytrigia repens	+	1		2	+	1	+	2			5	70
Dactylis glomerata							1	2	3	2	17	40
Other species												
Agrostis capillaris							+	3		2	18	30
Plantago lanceolata							+	1		1	3	30
Glechoma hederacea						+	+		1		2	30

Rare species (in less than two relevés): *Acer platanoides* 6 (+); *A. pseudoplatanus* 6 (+); *Achillea millefolium* 7 (+), 9 (1); *Aegopodium podagraria* 1 (+), 9 (2); *Agrimonia eupatoria* 7 (+); *Alliaria petiolata* 5 (+), 6 (+); *Alnus glutinosa* 3 (2); *Amaranthus retroflexus* 5 (+); *Ambrosia artemisiifolia* 5 (1); *Anthriscus sylvestris* 8 (1), 9 (2); *Arctium tomentosum* 2 (+); *Arrhenatherum elatius* 6 (2); *Artemisia absinthium* 7 (+); *A. vulgaris* 4 (1); *Atriplex sagittata* 5 (1); *A. tatarica* 6 (+); *Ballota nigra* 6 (+), 7 (+); *Bidens frondosa* 3 (1); *Bromopsis inermis* 4 (4); *Calamagrostis epigejos* 4 (+); *Carduus acanthoides* 2 (+); *Carex hirta* 6 (1); *Carum carvi* 7 (+); *Chaerophyllum aromaticum* 3 (+), 9 (2); *Chelidonium majus* 1 (2), 6 (2); *Chenopodium album* 5 (2), 6 (1); *C. album* 5 (1); *Cirsium arvense* 4 (+), 7 (+); *Convolvulus arvensis* 6 (+); *Cornus sanguinea* 3 (+), 7 (+); *Crepis biennis* 10 (+); *Echinochloa crus-galli* 5 (+); *Echinocystis lobata* 3 (+); *Equisetum arvense* 2 (+), 10 (1); *E. palustre* 3 (+); *E. pratense* 7 (+); *Erigeron canadensis* 7 (+); *Eupatorium cannabinum* 3 (1); *Fallopia convolvulus* 6 (2); *Filipendula vulgaris* 3 (+); *Fraxinus excelsior* 2 (3), 6 (+); *Geranium sibiricum* 3 (+), 6 (+); *Helianthus annuus* 5 (+); *H. tuberosus* 5 (+); *Heracleum sphondylium sibiricum* 6 (+); *Impatiens glandulifera* 1 (+); *I. parviflora* 3 (+); *Iva xanthiifolia* 5 (4); *Juglans regia* 2 (+); *Lamium album* 6 (+), 8 (3); *L. maculatum* 7 (+); *L. purpureum* 6 (+); *Lapsana communis* 6 (1); *Leonurus cardiaca* 8 (2); *L. quinquelobatus* 1 (+); *Lupinus polyphyllus* 2 (+); *Lycopus europaeus* 3 (1); *Medicago sativa* 7 (+); *Melilotus albus* 8 (1); *Mentha longifolia* 9 (+); *Morus nigra* 6 (+); *Myosoton aquaticum* 6 (+); *Oenothera biennis* 2 (1); *Oxalis stricta* 2 (1), 6 (+); *Pastinaca sativa* 6 (+); *Phlomis tuberosa* 6 (+); *Phragmites australis* 3 (2), 4 (+); *Poa pratensis* 9 (2), 10 (2); *P. trivialis* 1 (1); *Polygonum aviculare* 5 (+), 6 (+); *Potentilla argentea* 7 (+); *Prunus armeniaca* 5 (+); *P. cerasifera* 6 (+); *P. cerasus* 2 (+); *Ranunculus acris* 9 (2); *R. polyanthemos* 8 (1); *R. repens* 1 (+), 8 (1); *R.* sp. 6 (+); *Rosa rugosa* 2 (+); *Rubus caesius* 2 (1), 3 (1); *R. idaeus* 7 (+); *Rumex confertus* 7 (+); *R. crispus* 8 (1), 9 (1); *R. obtusifolius* 10 (2); *Salix alba* 3 (+), 4 (+); *S. cinerea* 4 (+); *S. daphnoides* 3 (1); *Sambucus nigra* 3 (1); *Schedonorus arundinaceus* 8 (2); *Scirpus sylvaticus* 3 (3); *Senecio viscosus* 7 (+); *Setaria verticillata* 6 (+); *S. viridis* 5 (1); *Solanum nigrum* 5 (+); *Solidago canadensis* 5 (+), 7 (1); *S. gigantea* 2 (2); *Sonchus asper* 6 (+); *Taraxacum* sect. *Taraxacum* sect. 6 (1), 7 (+); *Thladiantha dubia* 1 (2); *Tilia cordata* 2 (+); *Torilis arvensis* 7 (1); *T. japonica* 3 (+), 6 (+); *Trifolium pratense* 8 (1), 10 (2); *T. repens* 5 (+), 10 (3); *Tripleurospermum inodorum* 7 (+); *Tussilago farfara* 10 (3); *Veronica chamaedrys* 7 (+); *Vicia cracca* 9 (2); *Viola tricolor* 7 (+).

Table 2. Continued

Location and other metadata of relevés with the occurrence of *H. mantegazzianum*

Relevé 1. 6.06.2022. Koniakin S.M., Gubar L.M. m. Zhytomyr (50.244680N 28.657391E). Floodplain of the Kamianka River.

Relevé 2. 14.07.2022. Koniakin S.M., Gubar L.M. Zaliznychna Street, Hlevakha village, Fastiv district, Kyiv region (50.256122N 30.300860E). A ruderal site near an abandoned yard.

Relevé 3. 23.07.2022. Koniakin S.M., Gubar L.M. Lisna Street, Stavyshche village, Bila Tserkva district, Kyiv region (49.382641N 30.165325E). Floodplain forest of the river Hnylyi Tikych.

Relevé 4. 24.08.2022. Koniakin S.M. Chabany village, Fastiv district, Kyiv region (50.336105N 30.428080E). Agrophytocenosis.

Relevé 5. 16.06.2022. Koniakin S.M. Chabany village, Fastiv district, Kyiv region (50.337566N 30.428967E). Habitat of nitrophilous ruderal perennials, under vegetable gardens.

Relevé 6. 3.08.2020. Koniakin S.M., Gubar L.M. m. Kamianets-Podilskyi, Khmelnytskyi region (48.669031N 26.580162E). Ruderal plot under the fence of the botanical garden.

Relevé 7. 8.10.2008. Tokaryuk A.I., Chorney I.I., Budzhak V.V., Protopopova V.V., Shevera M.V., Korzhan K.V. & Volutsa O.D. 2018. Invasive plants in Bukovyna Cis-Carpathian. Druk Art, Chernivtsi. Chernivtsi (48.086117N 25.655098E). Table 5.7, relevé 12.

Relevés 8-10. 2015. Pashkevych N.A. 2018. Ruderal vegetation of Skhidnytsia village-resort (Lviv region, Ukraine). Biol. Stud. 2018: 12(2): 63-76. Table 3, relevés 56, 81–82.

an average of 53%. The number of species varies from 11 to 39, with an average of 20. The floristic composition of the association includes a total of 125 species. In the tree layer the species *A. negundo* (0.2–0.1), *Fraxinus excelsior* (0.3), *Alnus glutinosa* (0.2) grow. *A. negundo* forms an undergrowth. The liana *Parthenocissus inserta* is characteristic. The herbaceous cover is divided into three sublayers. The first sublayer (1.5–4.5 m) is formed by *H. mantegazzianum*, *Arcticum lappa*, *Lactuca serriola*, etc. The height of the dominant species *H. mantegazzianum* reaches 3–4.5 m. The second sublayer (0.5–1.2 m) is formed by *Urtica dioica, Elytrigia repens, Dactylis glomerata*; the third one (up to 0.6 m) with *Plantago lanceolata, Geum urbanum, Glechoma hederacea*.

Phytosociological proportions of diagnostic species

Table 3 shows the phytosociological proportions of diagnostic species of vegetation classes in two associations *Urtico dioicae-Heracleetum sosnowskyi* and *Urtico dioicae-Heracleetum mantegazzianii*. In addition, similar values are calculated for communities from the regions where these associations were first described.

The species composition of the *Urtico dioicae-Heracleetum sosnowskyi* association is dominated by *Molinio-Arrhenatherea* species, with a share of 46.9% (Table 3, column A). The dominant position of the *Molinio-Arrhenatheretea* class is also typical for *Urtico dioicae-Heracleetum sosnowskyi* communities from eastern regions (Panasenko et al., 2014). This class ranks first with a share of 26% of species (Table 3, column B). The class *Carpino-Fagetea* is second with a share of 17.1% (Table 3, column A). This can be explained by the fact that the communities are more often formed in shaded habitats, along forest edges and forest glades. Differences in species shares are shown in column A vs B of Table 3, where

Table 3. Phytosociological proportions of diagnostic species of different classes of vegetation in two *Urtico-Heracleetum*-associations from different regions. UHs – *Urtico dioicae-Heracleetum sosnowskyi*, Uhm – *Urtico dioicae-Heracleetum mantegazzianii*. Numbers are fractions, ranks are in parentheses. Asterisks indicate nomenclatural types of the associations.

Association	UHs (A)	UHs* (B)	UHm (C)	UHm* (D)	Difference in shares of species	
Region	Ukraine	Russia	Ukraine	Germany	A vs B	C vs D
Artemisietea vulgaris (ART)	3.8 (6)	19 (3)	2.4 (9)	1 (6)	–15.2	1.4
Carpino-Fagetea (FAG)	17.1 (2)	12.9 (4)	11.1 (4)	21.6 (2)	4.2	–10.5
Crataego-Prunetea (CRA)	3.1 (9)	0.2 (10)	3 (7)	0.4 (7)	2.9	2.6
Galio-Urticetea (GAL)	10.9 (3)	21 (2)	30.9 (1)	49.5 (1)	–10.1	–18.6
Festuco-Brometea (FEB)	3.7 (7)	3.2 (7)	2.8 (8)	0.1 (10)	0.5	2.8
Molinio-Arrhenatheretea (MOL)	46.9 (1)	26 (1)	27.5 (2)	7.9 (4)	20.9	19.6
Quercetea robori-petraeae (QUE)	1.2 (10)	0.4 (9)	0.1 (10)	0.3 (8)	0.8	–0.3
Robinietea (ROB)	3.3 (8)	7.8 (5)	6.8 (5)	15.7 (3)	–4.5	–8.9
Sisymbrietea (SIS)	5.2 (4)	6.7 (6)	12.1 (3)	3.5 (5)	–1.5	8.6
Trifolio-Geranietea (GER)	4.8 (5)	2.8 (8)	3.4 (6)	0.1 (9)	2.0	3.3
Dominant classes:						
1st class	MOL	MOL	GAL	GAL		
2nd class	FAG	GAL	MOL	FAG		
3rd class	GAL	ART	SIS	ROB		
Total shares of 3 first classes	74.9	66.0	70.5	86.8		
Total shares of all classes	100	100	100	100		

Table 4. Distribution of syntaxa at the level of vegetation classes in which *Heracleum* L. species occur according to different sources (numbers of sources in table cells). This table is an aggregated data based on the full version of Table S3.

No.	Vegetation classes	*Heracleum mantegazzianum*	*Heracleum sosnowskyi*
1.	*Artemisietea vulgaris*	3	4
2.	*Bidentetea tripartitae*	0	2
3.	*Carpino-Fagetea sylvaticae*	2	1
4.	*Epilobietea angustifolii*	5	2
5.	*Galio-Urticetea*	7	9
6.	*Molinio-Arrhenatheretea*	3	3
7.	*Phragmito-Magnocaricetea*	0	1
8.	*Polygono-poetea annuae*	0	1
9.	*Pyrolo-Pinetea sylvestris*	0	1
10.	*Rhamno-Prunetea*	0	1
11.	*Robinietea*	2	3
12.	*Salicetea purpureae*	1	4
13.	*Stellarietea mediae*	0	2
14.	*Trifolio-Geranietea sanguinei*	1	1
15.	*Vaccinio-Piceetea*	0	1
	Sum of frequencies	24	36
	Count of non-zero values (classes)	8	15

we can see that the largest differences are for classes *Molinio-Arrhenatheretea* (20.9%) and *Artemisietea vulgaris* (–15.2%). The floristic core is based on a combination of species of three classes MOL + FAG + GAL, which account for 74.9% of the total species composition.

The species composition of the *Urtico dioicae-Heracleetum mantegazzianii* association is dominated by *Galio-Urticetea* species, with a share of 30.9% (Table 3, column C). The communities from Germany are also dominated by *Galio-Urticetea* species, with a share of 49.5% (Table 3, column D). The classes occupying the second and third places are different: in our communities, they are *Molinio-Arrhenatheretea* (27.5%) and *Sisymbrietea* (12.1%) (Table 3, column C). The largest differences in the proportions of species are observed in the classes *Molinio-Arrhenatheretea* (19.6%) and *Galio-Urticetea* (–18.6%) (Table. 3, column C vs D).

Thus, there is a similarity at the level of the first classes in phytosociological proportions of the compared communities from different regions.

Distribution of giant hogweed species in different vegetation classes

In addition to the communities in which giant hogweeds are the main coenosis formers (two associations shown in the syntaxonomic scheme), they occur in a much larger number of communities of different classes. This indicates their invasive potential. Table 4 summarises the data on the occurrence of giant hogweeds in different vegetation classes. The full list of syntaxa where these species grow is given in Supplementary Table S5.

The long list of syntaxa in which giant hogweed species are listed by different authors indicates their wide invasive potential. In particular, the species *H. mantegazzianum* is recorded in 8 classes, *H. sosnowskyi* – in 15 classes (Table 4). The number of orders and alliances is even higher. According to Supplementary Table S5, *H. mantegazzianum* occurs in communities of 11 orders and 14 alliances, and *H. sosnowskyi* – in 17 orders and 20 alliances. The class *Galio-Urticetea* ranks first in terms of the number of references. If we also take into account the records for the class *Epilobietea angustifolii*, this trend becomes even more pronounced. The next places in the distribution are occupied by *Artemisietea vulgaris*, *Molinio-Arrhenatheretea* and *Robinietea*. For *H. mantegazzianum* and *H. sosnowskyi*, the above class ratios are similar in general, but the latter has almost twice in class total counts (15 to 8, Table 4). This indicates its greater invasive potential. The distribution of classes in which *H. mantegazzianum* and *H. sosnowskyi* are reported in the papers (Table 4) is similar to the phytosociological proportions of the species composition of the communities studied by us (Table 3).

Comparison of the syntax from different regions

Table 5 shows the common and differential species of the two *Urtico-Heracleetum* associations. There are groups of common species of clusters A & B (ass. *Urtico dioicae-Heracleetum sosnowskyi*) and clusters C & D (ass. *Urtico dioicae-Heracleetum mantegazzianii*), as well as common species for all clusters (A, B, C, D).

The floristic similarity of both associations is ensured by species of the classes *Galio-Urticetea* (*Urtica dioica, Geum urbanum, Glechoma hederacea*, etc.) and *Molinio-Arrhenatheretea* (*Elytrigia repens, Dactylis glomerata*) (Table 5). The order of syntaxa agglomeration is shown in the dendrogram in Fig. 3.

The dendrogram shows two separate groups: A + B – ass. *Urtico dioicae-Heracleetum sosnowskyi*, and C + D – ass. *Urtico dioicae-Heracleetum mantegazzianii*. The order of agglomeration confirms the syntaxonomical scheme presented in the article.

However, the communities with *Heracleum mantegazzianum* and *Heracleum sosnowskyi* species, although belonging to the same vegetation class, differ floristically (Table 5). The degree of similarity in both associations is approximately the same, as evidenced by the level of grouping of the dendrogram branches (Fig. 3).

Table 5. Comparison of the two *Urtico-Heracleetum* associations from different regions (short version). For the full version see Table S4. Lower case numbers are species frequencies and upper case numbers are fidelities. Fields in grey indicate frequency values greater than 40%. Clusters: A, B – ass. *Urtico dioicae-Heracleetum sosnowskyi*, C and D – ass. *Urtico dioicae-Heracleetum mantegazzianii*. Asterisks symbolise nomenclature types of associations.

Cluster	A	B*	C	D*
Region	Ukraine	Russia	Ukraine	Germany
Number of relevés	10	32	10	18
Differentiating species of cluster A				
Acer negundo	90^{78}	3^{3}	40^{35}	
Parthenocissus inserta	40^{48}		30^{36}	
Differentiating species of cluster B				
Anthriscus sylvestris		50^{51}	20^{20}	28^{28}
Common species of clusters A & B (ass. *Urtico dioicae-Heracleetum sosnowskyi*)				
Heracleum sosnowskyi	100^{71}	100^{71}		
Artemisia vulgaris	70^{58}	62^{51}	10^{8}	6^{5}
Arctium tomentosum	50^{49}	44^{43}	10^{10}	
Taraxacum sect. Taraxacum	50^{47}	44^{41}	20^{19}	
Differentiating species of cluster C				
Erigeron annuus	30^{29}	16^{16}	60^{58}	
Agrostis capillaris			30^{55}	
Humulus lupulus	20^{26}		40^{52}	
Differentiating species of cluster D				
Stellaria media				56^{75}
Aegopodium podagraria	10^{10}		20^{19}	61^{59}
Calystegia sepium	10^{13}	6^{8}		44^{57}
Impatiens parviflora	10^{12}		10^{12}	44^{55}
Common species of clusters C & D (ass. *Urtico dioicae-Heracleetum mantegazzianii*)				
Heracleum mantegazzianum			100^{71}	100^{71}
Common species of all clusters				
Urtica dioica	100^{53}	91^{48}	70^{37}	100^{53}
Elytrigia repens	70^{46}	50^{33}	70^{46}	44^{29}
Dactylis glomerata	70^{50}	50^{35}	40^{28}	39^{28}
Solidago canadensis	50^{55}	6^{7}	20^{22}	6^{7}
Geum urbanum	40^{44}	6^{7}	30^{33}	6^{7}
Cirsium arvense	20^{19}	53^{49}	20^{19}	22^{21}
Galium aparine	60^{46}	16^{12}	30^{23}	67^{51}
Glechoma hederacea	50^{39}	22^{17}	30^{23}	61^{48}

Ecological characteristic

Table 6 shows the phytoindicators (environmental variables) that characterise the ecological amplitudes of *H. mantegazzianum* and *H. sosnowskyi* according to the vegetation plots where these species occur.

Both species *H. mantegazzianum* and *H. sosnowskyi* occur in mesophytic, neutral, nitrogen-enriched habitats (Didukh, 2011). In terms of Hd, Rc, Nt, and Sl, there are no significant differences between *Heracleum* species, as p-values are greater than 0.05. *Heracleum sosnowskyi* has a larger amplitude, as evidenced by the higher values in the Sd and range columns (Table 6). If we compare the factors by the coefficient of variation (CV), which does not depend on the mean value, the amplitude of the Hd factor, moisture, is the widest for both *H. sosnowskyi* and *H. mantegazzianum* (10.7% and 13.2%, Table 6). And the narrowest amplitude for the acidity factor, Rc, namely 4.4% and 3.1% for *H. sosnowskyi* and *H. mantegazzianum* respectively.

Box plots show differences in ecological amplitudes for two *Heracleum* species considering those factors where p-values are less than 0.05 (Fig. 4).

The optimum of *Heracleum sosnowskyi* (boxplots on the left) is shifted towards lower values of light, temperature and continentality. However, these differences are moderate, as the amplitudes overlap. Given the absence of significant differences in the factors Hd, Rc, Nt, and Sl and the overlapping amplitudes of the factors Tm, Kn, and Lc (Fig. 4), we can assert a significant ecological similarity of both *Heracleum* species.

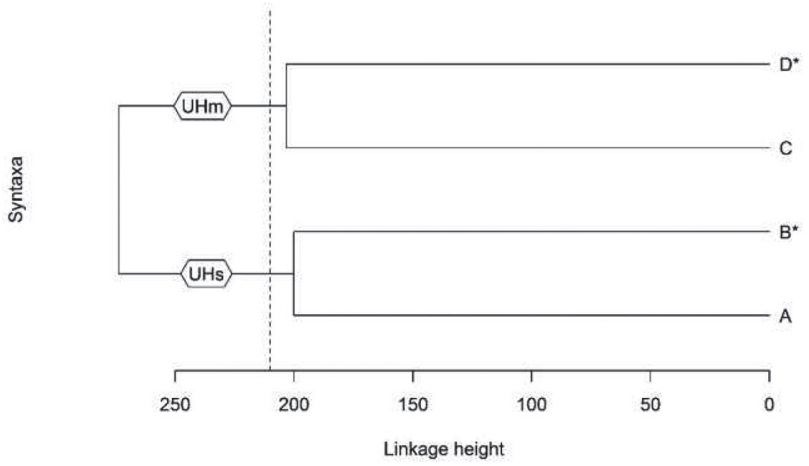

Fig. 3. Dendrogram of two *Urtico-Heracleetum*-associations including studied syntaxa and nomenclatural types of the associations. Clusters: A, B – ass. *Urtico dioicae-Heracleetum sosnowskyi*, C and D – ass. *Urtico dioicae-Heracleetum mantegazzianii*. Region: A, C – Ukraine, B – Russia, D – Germany. Asterisks symbolise nomenclature types of associations.

Table 6. Phytoindicational assessment of the communities with two *Heracleum* species (*Heracleum mantegazzianum* and *Heracleum sosnowskyi*). Basic statistics (mean, standard deviation, coefficient of variation, minimum, maximum and range) are calculated for grouped communities concerning their distribution among two *Heracleum*-associations.

Variable	Ass 1. *Urtico dioicae-Heracleetum sosnowskyi*						Ass 2. *Urtico dioicae-Heracleetum mantegazzianii*						Mann-Whitney U test	
	Mean	Sd	CV (%)	Min	Max	Range	Mean	Sd	CV (%)	Min	Max	Range	p-value	Signif
Hd, moisture	49.7	5.3	10.7	38.2	65.3	27.1	47.7	6.3	13.2	40.5	60.3	19.8	0.2792	ns
Rc, soil acidity	58.9	2.6	4.4	51.2	68.6	17.5	59.7	1.9	3.1	57.2	62.6	5.3	0.3099	ns
Sl, salt regime	36.5	2.8	7.8	27.9	43.2	15.4	38.3	4.3	11.3	34.2	44.4	10.2	0.445	ns
Nt, nitrogen	69.0	7.0	10.1	47.6	85.8	38.2	69.2	5.0	7.2	60.9	77.8	16.9	0.7158	ns
Lc, light	59.8	4.3	7.2	50.0	70.2	20.2	64.7	5.0	7.7	58.6	74.0	15.5	0.0074	**
Tm, temperature	56.2	2.5	4.5	50.2	64.0	13.8	60.3	3.0	5.0	57.6	66.5	8.8	0.0006	***
Kn, continentality	38.6	3.0	7.8	31.8	50.3	18.5	43.9	5.1	11.7	37.4	53.1	15.8	0.0012	**

Notation for signif: ns – not significant, *p < 0.05; **p < 0.01; ***p < 0.001.

Conclusions

The article summarises the data on the current distribution of two dangerous invasive species *H. mantegazzianum* and *H. sosnowskyi* in Ukraine and also provides an ecological and coenotic analysis of their main communities.

According to our survey and literature data, there are 102 locations of *H. mantegazzianum* and 405 locations of *H. sosnowskyi*. The latter has occupied larger areas compared to H. mantegazzianum. Both species are more common in the western and northern parts of the region. In the south, their distribution is limited by the more arid climate of the steppe zone and the lower availability of favourable habitats.

The results of phytoindication showed the predominant occurrence of both studied *Heracleum* species in mesophytic, neutral, nitrogen-enriched habitats. According to most factors, *H. mantegazzianum* and *H. sosnowskyi* have a significant overlap in amplitudes. Differences in the average values of environmental indicators are observed in light, temperature and continentality, but the amplitudes of both species also overlap in these variables.

From the syntaxonomic point of view, the communities with *H. mantegazzianum* and *H. sosnowskyi* are divided into two types – the first with a pronounced dominance of these species and the second, where the species are present, but not as the main component. The first type corresponds to the optimum of *Urtico dioicae-Heracleetum sosnowskyi* and *Urtico dioicae-Heracleetum mantegazziani* associations. However, the syntaxonomic spectrum of communities with the participation of giant hogweeds is much wider, which indicates the possibility of introducing and transforming a wider range of vegetation types. In particular, *H. mantegazzianum* occurs in communities of 8 vegetation classes, 11 orders and 14 alliances, and *H. sosnowskyi* – for 15 classes, 17 orders and 20 alliances.

Cluster analysis showed significant similarity of both associations *Urtico dioicae-Heracleetum sosnowskyi* and *Urtico dioicae-Heracleetum mantegazziani*. The block of common species is formed by diagnostic species of the classes *Galio-Urticetea*, *Artemisietea vulgaris*, and *Molinio-Arrhenatheretea*. Differences between our communities and similar ones from other regions are due to the

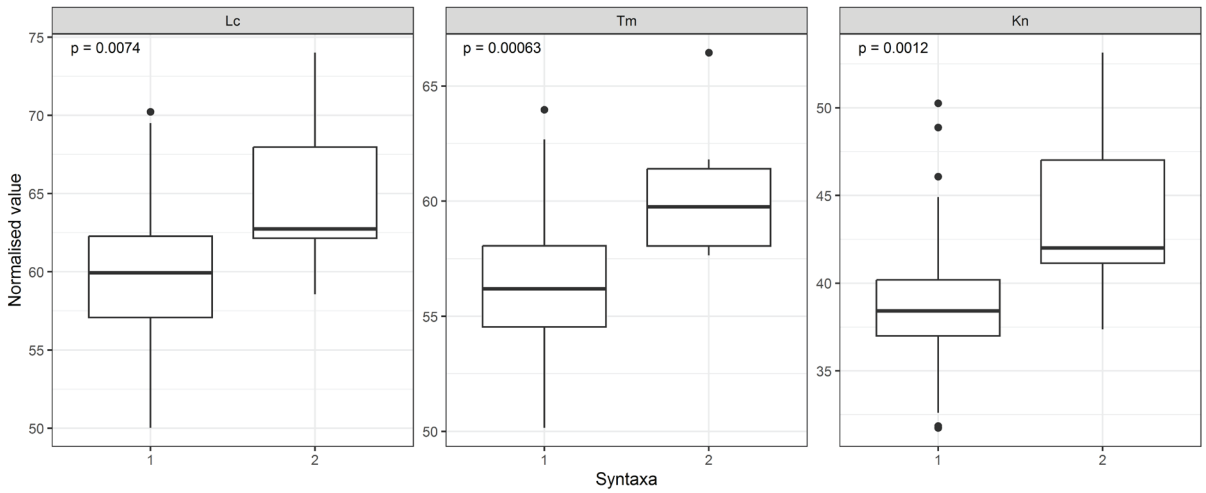

Fig. 4. Box-plot diagrams of environmental values for two *Heracleum* species. Lc – light, Tm – temperature, Kn – continentality. Notation for syntaxa: 1 – ass. *Urtico dioicae-Heracleetum sosnowskyi*, 2 – ass. *Urtico dioicae-Heracleetum mantegazzianii*.

presence of a more formed tree layer with the participation of another transformer *Acer negundo*. This is explained by anthropogenic impact, which favours all alien species and represents an advanced stage of succession in the absence of biomass alienation factors, such as haymaking or fires.

Both species of giant hogweeds pose a serious biological threat, given the favourable climate of most of Ukraine, as well as their wide ecological amplitude and tendency to spontaneously spread. Their ability to transform the structure and composition of phytocoenoses is most clearly manifested in the formation of two independent associations, where they are the main forming agents.

The impact of active hostilities leads to the destruction of natural vegetation, which is a natural factor in deterring invasive species. As a result of mining, there is an increase in the area of restricted territories, especially in the northern part of Ukraine, where the climatic conditions for the growth of giant hogweeds are favourable. This may be an additional factor in their further spread in the coming years. We assume an increase in the expansion of both studied *Heracleum* species and an increase in the nomenclature of syntaxa in which these species can grow. This is based on the fact that our study did not reveal any factors that would hinder this process, and it applies primarily to the northern regions of Ukraine, especially agricultural-abandoned areas and post-war territories with limited access.

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Supplementary material

The Supplementary material for this article can be found online at: https://goo.su/rJpr.

References

Bagatska, T.S., 2008. Novi mistseznakhodzhennia zanosnykh roslyn Artemisia argyi Leveillie et Vaniot i Heracleum sosnowskyi Manden. na berehakh kyivskykh vodoim [Finds of new localities of alien plants Artemisia argyi Leveilie et Vaniot and Heracleum sosnowskyi Manden. near Kyiv waterbodies]. *Ukrainskyi Botanichnyi Zhurnal*, 65 (4): 535–543. (In Ukrainian).

Balezentiene, L., Renco, M., 2014. Phytotoxicity and accumulation of secondary metabolites in Heracleum mantegazzianum (Apiaceae). *Allelopathy Journal*, 33 (2): 267–276.

Barkman, J., 1989. Fidelity and character-species, a critical evaluation. *Vegetatio*, 85 (1–2): 105–116.

Berko, Y.M., 1964. Hihantskyi borshchivnyk (Heracleum mantegazzianum Sommier & Levier) v Ukraini [Giant hogweed (Heracleum mantegazzianum Sommier & Levier) in the Ukrainian Carpathians]. *Ukrainskyi Botanichnyi Zhurnal*, 21: 104–106. (In Ukrainian).

Bradley, B.A., Blumenthal, D.M., Early, R., Grosholz, E.D., Lawler, J.J., Miller, L.P., Sorte, C.J.B., D'Antonio, C.M., Diez, J.M., Dukes, J.S., Ibanez, I., Olden, J.D., 2012. Global change, global trade, and the next wave of plant invasions. *Frontiers in Ecology and the Environment*, 10: 20–28. https://doi: 10.1890/110145.

Braun-Blanquet, J., 1964. *Pflanzensoziologie. Grundzüge der Vegetationskunde* [Plant sociology. Fundamentals of vegetation science]. 3rd edition. Wien-New York:Springer Verlag. 865 p.

Bray, J.R., Curtis, J.T., 1957. An ordination of the upland forest communities of Southern Wisconsin. *Ecological Monographs*, 27: 325–349.

Burda, R.I., 2007. Nebezpeka roslynnykh invazii u Holosiivskomu lisi [*The danger of plant invasions in the Holosiivskyi forest. Ecology of Holosiivskyi forest*]. In *Ekolohiia Holosiivskoho lisu: Monohrafiia*. Kyiv: Fenix, p.

42–60. (In Ukrainian).

Cai, H., Lu, H., Tian, Y., Liu, Z., Huang, Y., Jian, S., 2020. Effects of invasive plants on the health of forest ecosystems on small tropical coral islands. *Ecological Indicators*, 117: 106656. https://doi:10.1016/j.ecolind.2020.106656.

Centre for Agriculture and Biosciences International (CABI), 2023. [online]. [cit. 2023-10-20]. https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.108958.

Chytrý, M., Tichý, L., Holt, J., Botta-Dukát, Z., 2002. Determination of diagnostic species with statistical fidelity measures. *Journal of Vegetation Science*, 13 (1): 79–90.

Chytrý, M. (ed.), 2009. *Vegetace České republiky 2. Ruderální, plevelová, skalní a suťová vegetace* [Vegetation of the Czech Republic 2. Ruderal, weed, rock and scree vegetation]. Praha: Academia. 524 p. (In Czech).

De Cáceres, M., Font, X., Oliva, F., 2008. Assessing species diagnostic value in large data sets: A comparison between phi-coefficient and Ochiai index. *Journal of Vegetation Science*, 19 (6): 779–788.

Didukh, Ya. P., 2011. *The ecological scales for the species of Ukrainian flora and their use in synphytoindication.* Kyiv: Phytosociocentre. 176 p.

Didukh, Ya. P., 2023. *Roslynnyi svit Ukrainy v aspekti klimatychnykh zmin* [World of plants of Ukraine in aspect of the climate change]. Kyiv: Naukova Dumka. 202 p. (In Ukrainian).

Didukh, Ya.P., Chorney, I.I., Budzhak, V.V., Tokariuk, A.I., Kish, R.Ya., Protopopova, V.V., Shevera, M.V., Kozak, O.M., Kontar, I.S., Rozenblit, Yu.V., Norenko, K.M., 2016. In Didukh, Ya.P., Chorney, I.I. (eds). Klimatohenni zminy roslynnoho svitu Ukrainskykh Karpat [*Climatogenic changes of plant life of the Ukrainian Carpathians*]. Chernivtsi: DrukArt. 280 p. (In Ukrainian).

Didukh, Ya.P., Plyuta, P.G., 1994. *Fitoindykatsiia ekolohichnykh faktoriv* [Phytoindication of ecological factors]. Kyiv: Naukova dumka. 280 p. (In Ukrainian).

Dubyna, D.V., Dzyuba, T.P., Iemelyanova, S.O., Bagrikova, N.O., Borysova, O.V., Borsukevych, L.M., Vynokurov, D.S., Gapon, S.V., Gapon, Yu.V., Davydov, D.A., Dvoretsky, T.V., Didukh, Ya.P., Zhmud O.I., Kozyr, M.S., Konishchuk, V.V., Kuzemko, A.A., Pashkevych, N.A., Ryff, L.E., Solomakha, V.A., Felbaba-Klushyna, L.M., Fitsailo, T.V., Chorna, G.A., Chorney, I.I., Shelyag-Sosonko, Yu.R., Iakushenko, D.M., 2019. *Prodromus roslynnosti Ukrainy* [Prodrome of the vegetation of Ukraine]. Kyiv: Naukova Dumka. 784 p. (In Ukrainian).

Dubyna, D.V., Iemelianova, S.M., Dziuba, T.P., Tymoshenko, P.A., Protopopova, V.V., Shevera, M.V., 2021. Alien plant invasion in the ruderal vegetation of Ukraine. *Environmental and Socio-economic Studies*, 9 (4): 57–70. https://doi.org/10.2478/environ-2021-0025.

Ellenberg, H., 1988. *Vegetation ecology of Central Europe*. Cambridge: Cambridge University Press. 731 p.

Fedoronchuk, M.M., 2022. Cheklist flory Ukrainy. 3: rodyny Apiaceae (= Umbelliferae), Araliaceae (Apiales, Angiosperms) [Ukrainian flora checklist. 3: families Apiaceae (= Umbelliferae), Araliaceae (Apiales, Angiosperms). *Chornomorskyi Botanichnyi Zhurnal*, 18 (3): 203–221. DOI: 10.32999/ksu1990-553X/2022-18-3-1. (In Ukrainian).

Goncharenko, I.V., 2017. *Fitoindykatsiia antropohennoho navantazhennia* [Phytoindication of anthropogenic factor]. Dnipro: Serednyak. 127 p. (In Ukrainian).

Grygus, I., Lyko, S., Stasiuk, M., Zubkovych, I., Zukow, W., 2018. Risks posed by Heracleum sosnowskyi Manden in the Rivne region. *Ecological Questions*, 29 (4): 35–42. https://doi:10.12775/EQ.2018.032.

Gubar, L.M., Koniakin, S.M., 2020. Invaziini chuzhoridni vydy roslyn urochyshcha «Feofaniya» [Invasive alien species of plants of the local landscape Feofanya]. *Naukovo-praktychnyi Zhurnal Ekolohichni Nauky,* 31: 167–173. (In Ukrainian).

Gubar, L., Koniakin, S., 2021. Populations of Heracleum sosnowskyi and H. mantegazzianum (Apiaceae) in Kyiv (Ukraine). *Folia Oecologica*, 48 (2): 215–228. https://doi: 10.2478/foecol-2021-0022.

Gudžinskas, Z., Rašomavičius, V., Uogintas, D., 2015. Changes of plant communities in areas invaded by Heracleum sosnowskyi. In Chytrý, M., Zelený, D., Hettenbergerová, E., (eds). *58th annual symposium of the International Association for Vegetation Science: Understanding Broad-Scale Management Patterns. Brno, Czech Republic, 19–24 July 2015.). Abstracts.* Brno: Masaryk University, p. 311.

Hulme, P.E, Brundu, G., Carboni, M., Dehnen-Schmutz, K., Dullinger, S., Early, R., Essl, F., González-Moreno, P., Groom, Q.J., Kueffer, C., Kühn, I., Maurel, N., Novoa, A., Pergl, J., Pyšek, P., Seebens, H., Tanner, R., Touza, J.M., Kleunen, M. van., Verbrugge, L.N.H., 2018. Integrating invasive species policies across ornamental horticulture supply chains to prevent plant invasions. *Journal of Applied Ecology*, 55: 92–98. https://doi: 10.1111/1365-2664.12953.

iNaturalist org., 2023. [online]. [cit. 2023-10-20]. https://www.inaturalist.org/observations?project_id=35396&taxon_id=499936&place_id=any&verifiable=any.

Jahodová, Š., Fröberg, L., Pyšek, P., Geltman, D., Trybush, S., Karp, A., 2007. Taxonomy, identification, genetic relationships and distribution of large Heracleum species in Europe. In Pyšek, P., Cock, M.J.W., Nentwig, W., Ravn, H.P. (eds). *Ecology and management of Giant Hogweed (Heracleum mantegazzianum)*. Wallingford, UK: CAB International, p. 1–19.

Khomyak, I., Demchuk, N., Kotsyuba, I., Yastrebova, Ya., 2019. Ekoloho-tsenotychna kharakterystyka populiatsii Heracleum sosnowskyi Manden na terytorii Tsentralnoho Polissia [Ecological-cenotic population characteristic Heracleum sosnowsky in the territory of Central Polissya]. *Ekolohichni Nauky: Naukovo-praktychnyi Zhurnal*, 24 (1): 126–129. https://doi.org/10.32846/2306-9716-2019- 1-24-2-25. (In Ukrainian).

Klauck, E.J., 1988. Das Urtico-Heracleetum mantegazzianii. Eine neue Pflanzengesellschaft der nitrophytischen Stauden- und Saumgesellschaften (Glechometalia hederaceae) [The Urtico-Hercleetum mantegazzianii. A new plant community of the nitratophytic perennial and fringing communities (Glehometalia hederaceae)]. *Tuexenia*, 8: 263–267.

Koniakin, S.M., Burda, R.I., Budzhak, V.V., 2023. Chuzhoridni vydy v yrbanoflori Kyivskoi miskoi ahlomeratsii, 2003–2022 roky: poperedni notatky [The alien flora of the Kyiv urban area, 2003–2022: prelude notes]. *Chornomorskyi Botanichnyi Zhurnal*, 19 (2): 200–225. DOI: 10.32999/ksu1990-553X/2023-19-2-4. (In Ukrainian).

Koniakin, S.M., Gubar, L.M., Budzhak, V.V., 2022. Im-

patiens glandulifera (Balsaminaceae) in Ukraine: its current distribution, ecological and coenotic features. *Environmental and Socio-economic Studies*, 10: 46–58. https://doi.org/10.2478/environ-2022-0023.

Korsun, O.S., 2022. Osoblyvosti ontohenezu Heracleum mantegazzianum Sommier & Levier. na terytorii Kamianechchyny [Peculiarities of ontogeny of Heracleum mantegazzianum Sommier & Levier on the territory of Kamenetz region]. *Biolohiia ta Ekolohiia*, 8 (2): 106–118. https://doi.org/10.33989/2022.8.2.285315. (In Ukrainian).

Kovács, J.A., 2003. Contribution to the biology and the vegetation ecology of Heracleum mantegazzianum populations in West Transdanubia (Hungary). *Acta Acadamiae. Paedagogicae. Agriensis, Sectio Biológiáé,* XXIV: 273–289.

Koynova, I.B., Shtoyko, R.I., 2015. Heoekolohichni zahrozy poshyrennia borshchivnyka sosnovskoho na terytorii Turkivskoho raionu Lvivskoi oblasti [Geoecological threats of the spread of Heracleum sosnowskyi on the territory in Turkivskyi district of Lviv region]. *Liudyna ta Dovkillia. Problemy Neoekolohii*, 1–2: 115–122. (In Ukrainian).

Kusbach, A., Long, J.N., Van Miegroet, H., Shultz, L.M., 2012. Fidelity and diagnostic species concepts in vegetation classification in the Rocky Mountains, northern Utah, USA. *Botany*, 90 (8): 678–693.

Laiviņš, M., Gavrilova, Ģ., 2003. Neofītās Sosnovska latvāņa Heracleum sosnowskyi sabiedrības Latvijā [Heracleum sosnowskyi in Latvia: sociology, ecology and distribution]. *Latvijas Veģetācija*, 7: 45–65. (In Latvian).

Lance, G.N., Williams, W.T., 1967. A general theory of classificatory sorting strategies. *The Computer Journal*, 9 (4): 373–380.

Lukash, O.V., 2007. Novi mistseznakhodzhennia invazii zdychavilykh introdutsentiv na Livoberezhnomu Polissi [New localities of invasions of the feral introducents in the Left-Bank of Polissia]. *Introduktsiia Roslyn*, 1: 16–21. (In Ukrainian).

Lukash, O.V., Zavyalova, L.V., 2003. Heracleum mantegazzianum Sommier & Levier (Apiaceae) na Chernihivs komu Polissi [Heracleum mantegazzianum Sommier et Levier (Apiaceae) in Chernihiv Polissya]. *Ukrainskyi Botanichnyi Zhurnal*, 60 (5): 561–566. (In Ukrainian).

Lyubinska, L., Matvieiev, M., 2021. Invazyvni vydy flory ta fauny Natsionalnoho pryrodnoho parku Podilski Tovtry (Ukraina) [Invasive species in the flora and fauna of Podilski Tovtry National Nature Park (Ukraine)]. *GEO&BIO*, 20: 70–78. (In Ukrainian).

Mandenova, I.P., 1944. Fragmentyi monografii kavkazskih borschevikov [Fragments of the monograph of Caucasian hogweeds]. *Zametki o Sistematike i Geografii Rastenii*, Metsniereba, Tbilisi, 12: 15–19. (In Ukrainian).

Mandenova, I.P., 1950. *Kavkazskiye vidy roda Heracleum* [Caucasian species of the genus Heracleum]. Monographs. Tbilisi, Georgia: Georgian Academy of Sciences. 104 p.

Mann, H.B., Whitney, D.R., 1947. On a test of whether one of two random variables is stochastically larger than the other. *Annals of Mathematical Statistics*, 18: 50–60.

Mirkin, B.M., Naumova, L.G., Solomesh, A.I., 2001. *Sovremennaya nauka o rastitelnosti* [Modern plant science]. Moscow: Logos. 264 p. (In Russian).

Mucina, L., Bültmann, H., Dierssen, K., Theurillat, J.-P., Raus, T., Čarni, A., Šumberová, K., Willner, W., Dengler, J., García, R.G., Chytrý, M., Hájek, M., Di Pietro, R., Iakushenko, D., Pallas, J., Daniëls, F.J.A., Bergmeier, E., Santos Guerra, A., Ermakov, N., Valachovič, M., Schaminée, J.H.J., Lysenko, T., Didukh, Y.P., Pignatti, S., Rodwell, J.S., Capelo, J., Weber, H.E., Solomeshch, A., Dimopoulos, P., Aguiar, C., Hennekens, S.M., Tichý, L., 2016. Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. *Applied Vegetation Science*, 19 (S1): 3–264.

Mykhalyuk, I.M., Halahan, O.K., Duh, O.I., 2017. Ekobiolohichni zahrozy poshyrennia vydiv rodu Heracleum na terytorii mista Krementsia Ternopilskoi oblasti [Ecobiological threats of species distribution of the genus Heracleum on the territory of Kremenets, Ternopil region]. *Ukrainian Journal of Ecology*, 7 (4): 506–510. https://doi: 10.15421/2017_152. (In Ukrainian).

Naumov, S.Yu., Yena, A.V., Kraynyuk, E.S., 2009. Hyhantskye borshchevyky v Krymu: Heracleum mantegazzianum vmesto H. pubescens [Giant hogweeds in the Crimea: Heracleum mantegazzianum instead H. pubescens]. *Visnyk Luhanskoho Natsionalnoho Universytetu*, 8: 18–22. (In Ukrainian).

Nielsen, C., Ravn, H.P., Nentwig, W., Wade, M., 2005. *The Giant Hogweed best practice manual: guidelines for the management and control of an invasive weed in Europe*. Hørsholm, Denmark: Forest and Landscape Denmark. 44 p.

Ochiai, A., 1957. Zoogeographic studies on the soleoid fishes found in Japan and its neighbouring regions. *Bulletin of the Japanese Society for Fish Science*, 22 (9): 526–530.

Oitsius, L.V., Volovyk, H.P., Doletskyi, S.P., Lysytsya, A.V., 2020. Distribution of adventive species Solidago canadensis, Phalacroloma annuum, Ambrosia artemisiifolia, Heracleum sosnowskyi in phytocenoses of Volyn' Polissya (Ukraine). *Biosystems Diversity*, 28 (4): 343–349. https://doi:10.15421/012043.

Panasenko, N.N., Kulikova, E.Ya., Kharin, A.V., Ivenkova, I.M., 2014. Soobschestva rasteniy-transformerov: assotsiatsiya Urtico dioicae-Heracleetum sosnowsky [Communities of plants¬transformers: association Urtico dioicae–Heracleetum sosnowskyi]. *Bulletin Byul. Bryanskogo Otdel. Russkoe Botanicheskoe Obschestvo*, 2 (4): 48–53. (In Russian).

Pashkevych, N.A., 2018. Ruderalna roslynnist selyshcha-kurortu Skhidnytsia (Lvivska oblast, Ukraina) [Ruderal vegetation of Skhidnytsia village-resort (Lviv region, Ukraine)]. *Biologichni Studii*, 12 (2): 63–76. https://doi.org/10.30970/sbi.1202.554.

Pergl J., Pyšek P., Perglová I., Jarošík, V., 2012. Low persistence of a monocarpic invasive plant in historical sites biases our perception of its actual distribution. *Journal of Biogeography*, 39 (7): 1293–1302. doi: 10.1111/j.1365-2699.2011.02677.x

POWO. *Plants of the World Online*. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet, (10 November 2023). http://www.plantsoftheworldonline.org.

Pimenov, M.G., Leonov, M.V., 1993. *The genera of the Umbelliferae – a nomenclator*. Royal Botanical Garden Kew, London and Botanical Garden, Moscow University. 156 p.

Protopopova, V., Shevera, M., 2005. Heracleum mantegazzianum Sommier & Levier in Ukraine. In *The ecology and management of the Giant Alien Heracleum man*

tegazzianum. Final international workshop of the "Giant Alien". Giessen, 21–23 February 2005. Programme and Proceedings. Giessen, Germany: Justus-Liebig-University Giessen, Division of Landscape Ecology and Lanscape Planning, p. 21–23.

Protopopova, V.V, Mosyakin, S.L., Shevera, M.V., 2002. *Fitoinvazii v Ukrainiyak zahroza bioriznomanittiu: suchasnyi stan i zavdannia na maibutnie* [Plant invasions in Ukraine as a threat to biodiversity the present situation and tasks for the future]. Kyiv: M.G. Kholodny Institute of Botany of the National Academy of Sciences of Ukraine. 32 p. (In Ukrainian).

Protopopova, V., Shevera, M., Orlov, O., Panchenko, S., 2015. The transformer species of the Ukrainian Polissya. *Biodiversity Research and Conservation*, 39: 7–18.

Pysek, P., Cock, M.J.W., Nentwig, W., Ravn, H.P., 2007. *Ecology and management of giant hohweed (Heracleum mantegazzianum)*. Wallingford: CABI Publ. 324 p.

R Core Team, 2020. A language and environment for statistical com-puting. In *R: a language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing [online]. [cited 2023-10-24]. https://www.R-project.org/.

Ramenskii, L.G., Tsatsenkin, I.A., Chizhikov, O.N., Antipin, N.A., 1956. *Ekologicheskaya otsenka kormovyih ugodiy po rastitelnomu pokrovu* [Ecological assessment of feeding grounds by vegetation cover]. Moscow: Sel'khozgiz. 470 p. (In Russian).

Rani, S., Ahmed, M.K., Xiongzhi, X., Yuhuan, J., Keliang, C., Islam, M.M., 2020. Economic valuation and conservation, restoration and management strategies of Saint Martin's coral island, Bangladesh. *Ocean and Coastal Management*, 183: 105024. https://doi:10.1016/j.ocecoaman.2019.105024

Sax, D.F., Gaines, S.D., 2008. Species invasions and extinction: the future of native biodiversity on islands. *Proceedings of the National Academy of Science USA*, 105 (Suppl. 1): 11490–11497. https://doi:10.1073/pnas.0802290105

Sazyperova, I.F., 1984. *Borshheviki flory SSSR – novye kormovye rastenija* [Heracleum species within flora of USSR – new fodder plants]. Leningrad: Nauka. 223 p. (In Russian).

Simpson, M., Prots, B., Vykhor, B., 2011. Modeling of the invasive plant distribution: case study of Sosnowski's hogweed Heracleum sosnowskyi Manden. in the Ukrainian Carpathian Mts. *Journal of Biological Systems*, 3 (1): 80–89.

Sobisz, Z., 2007. Phytocenoses with Heracleum sosnowskyi Manden. in Central Pomerania. *Roczniki Akademii Rolniczej w Poznaniu, 386, Botanika – Steciana*, 11: 53–56.

The Euro+Med PlantBase. (10 November 2023). https://europlusmed.org.

Thiele, J. Otte, A., 2006. Analysis of habitats and communities invaded by Heracleum mantegazzianum Somm. et Lev. (Giant Hogweed) in Germany. *Phytocoenologia*, 36: 280–312.

Tokaryuk, A.I., Chorney, I.I., Korzhan, K.V., Budzhak, V.V., Velychko, M.V., Protopopova, V.V., Shevera, M.V., 2012. The participation of invasive plants in the synanthropic plant communities in the Bukovinian Cis-Carpathian (Ukraine). *Thaiszia – Journal of Botany*, 22 (2): 243–254.

Tokaryuk, A.I., Chorney, I.I., Budzhak, V.V., Protopopova, V.V., Shevera, M.V., Korzhan, K.V., Volutsa, O.D., 2018. *Invaziini roslyny v Bukovynskomu Peredkarpatti: monohrafiia* [Invasive plants in Bukovyna Cis-Carpathian]. Chernivtsi: Druk Art. 176 p. [In Ukrainian).

UkrBIN. (10 November 2023). *Ukrainian Biodiversity Information Network*. https://ukrbin.com.

Vykhor, B., Prots B., 2012. Borshchivnyk Sosnovskoho (Heracleum sosnowskyi Manden.) na Zakarpatti: ekolohiia, poshyrennia ta vplyv na dovkillia [Sosnowsky's hogweed (Heracleum sosnowskyi Manden.) in the Transcarpathia: ecology, distribution and the impact on environment]. *Studia Biologica*, 6 (3): 185–196.

Willner, W., 2006. The association concept revisited. *Phytocoenologia*, 36 (1): 67–76. *Znakhidky chuzhoridnykh vydiv roslyn ta tvaryn v Ukraini* [Records of alien plant and animal species in Ukraine]. Series: Conservation Biology in Ukraine, iss. 29. Kyiv, Chernivtsi: Druk Art. 520 p. (In Ukrainian).

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