



Original article

Xanthium orientale L. (Asteraceae) as an invasive species in Ukraine: its distribution and ecological characteristics

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ABSTRACT

Xanthium orientale L. is one of the most aggressive invasive plant species in Ukraine. It strongly transforms natural and anthropogenically disturbed habitats, especially in riparian landscapes. This study aimed to analyse the distribution, biotope affiliation, ecological characteristics, and phytosociological role of *X. orientale* in Ukraine. The analysis integrated herbarium collections, published literature, online biodiversity databases, and 67 geobotanical relevés collected from 2021 to 2025, comprising a total of 1137 localities. Vegetation classification was performed using the Braun–Blanquet approach. Ecological preferences were assessed using phytoindication methods, and differences between vegetation units were tested with the Mann–Whitney U test and visualised using box-plot diagrams. Two main vegetation types involving *X. orientale* were identified: the floodplain-associated *Bidentifrondosae–Xanthietum albinum* and ruderal derivative communities dominated by *X. orientale* with *Elytrigia repens*. The species was recorded across ten vegetation classes, demonstrating high ecological plasticity. Phytoindication analysis revealed significant differences between the two syntaxa in moisture, soil carbonate content, and temperature regime, indicating habitat differentiation and niche expansion. The results confirm the high invasive potential of *Xanthium orientale* in Ukraine and emphasise the need for continuous monitoring and targeted management, particularly in river valleys and floodplain ecosystems.

KEY WORDS: biological invasion, riverine habitats, habitat differentiation, phytoindication, vegetation classification

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1. Introduction

The introduction of alien species, particularly invasive ones, is one of the key drivers of global ecological change, affecting the structure and functioning of natural ecosystems (Pyšek et al., 2020). Biological invasions cause significant transformations in the spatial distribution of living organisms on the planet, reduce biotic and landscape diversity, and also threaten the survival of native species (Leroy et al., 2023; Aulus-Giacosa et al., 2024; Bellard et

al., 2021). In addition to ecological consequences, they affect ecosystem stability, ecosystem services, and the socio-economic well-being of people (Pérez et al., 2022; Diagne et al., 2021). This global negative phenomenon requires systematic monitoring and inventory of invasive alien species at local, regional, and national levels to develop preventive measures for limiting their spread and impact on natural ecosystems (Kenis et al., 2007; Roy et al., 2014; Seebens et al., 2021).

Xanthium orientale L. (Asteraceae) is one of the most aggressive alien plant species currently spreading in Ukraine, capable of profoundly altering the structure and functioning of both natural and anthropogenically transformed plant communities. The species was introduced into Ukraine in the early 20th century, with the first confirmed records dating back to 1928, and subsequently expanded rapidly along river corridors, transportation routes, and disturbed habitats. Its invasion success is associated with high ecological plasticity, effective seed dispersal, and the ability to form dense monospecific stands that displace native vegetation. According to the Unified Classification of Alien Plant Species by Their Environmental Impacts (BLACKBURN ET AL., 2014), *X. orientale* belongs to the highest impact category, causing irreversible changes in local ecosystems and biodiversity (HAWKINS ET AL., 2015). In Ukraine, the species has become widely naturalised in settlements, agricultural landscapes, and river floodplains, where it threatens native plant communities and alters successional processes. Therefore, detailed studies of its distribution, ecological preferences, and phyto-coenological role are essential for understanding invasion dynamics and developing effective management strategies.

The aim of the study was 1) to analyse the current distribution of *Xanthium orientale* in Ukraine; 2) to assess the syntaxonomic status of communities with a predominance of *X. orientale* in natural and transformed biotopes; 3) to undertake a phytoindication assessment of two syntaxa.

2. Material and methods

Data sources and distribution analysis. The current distribution of *Xanthium orientale* L. in Ukraine was analysed using multiple data sources, including original geobotanical surveys (GPS-referenced vegetation relevés), herbarium collections of the M.G. Kholodny Institute of Botany of the NAS of Ukraine (KW, Kyiv), Chernivtsi National University (CHER, Chernivtsi), and the Kryvyi Rih Botanical Garden of the NAS of Ukraine (KRW, Kryvyi Rih). In addition, published floristic and geobotanical records were compiled from available literature (BORTNIAK, 1978; TOKHTAR, 1996; KUCHEREVSKIY, 2004; PROTOPOVA ET AL., 2006, 2014; BAIRAK & STETSIUK, 2008; BONDARENKO, 2009; ZAVIALOVA, 2010; ZVIAHINTSEVA, 2013; BAGRIKOVA, 2013; VYKHOR & PROTS, 2014; MAKHYNIA, 2015; OLIINYK & GUBAR, 2019; ONYSHCHENKO ET AL., 2016;

TOKARYUK ET AL., 2018; SHYNDER ET AL., 2018, 2022, 2024; FEDORONCHUK ET AL., 2020; DAVYDOV & HOMLIA, 2021; LIUBINSKA & MATVIEIEV, 2021; *Records of alien plant...*, 2023; KONIAKIN ET AL., 2024; SHEVCHYK ET AL., 2025). Online biodiversity databases, namely UkrBIN (UKRBIN, 2026) and iNaturalist (iNATURALIST, 2026), were also consulted. The identification of biotopes occupied by *X. orientale* followed the National Catalogue of Biotopes of Ukraine (KUZEMKO ET AL., 2018).

Field survey and vegetation sampling. Geobotanical field investigations were conducted using the route method in combination with the standard vegetation plot approach (BRAUN-BLANQUET, 1964; MUELLER-DOMBOIS & ELLENBERG, 1974; KENT, 2012). A total of 67 relevés were recorded during the period from 2021 to 2025. Species nomenclature was standardised according to the Euro+Med PlantBase checklist (EURO+MED, 2026).

Vegetation classification and phytosociological analysis. Vegetation classification was performed following the Braun-Blanquet phytosociological system (BRAUN-BLANQUET, 1964). Differential species were determined based on their fidelity to individual syntaxa (BARKMAN, 1989; CHYTRÝ ET AL., 2002; WILLNER, 2006; KUSBACH, 2012). Species fidelity was quantitatively assessed using the Ochiai coefficient (OCHIAI, 1957; CHYTRÝ ET AL., 2002; DE CÁCERES ET AL., 2008). In the final assignment of relevés to syntaxa, species dominance was also considered, which is particularly relevant for anthropogenic vegetation types where characteristic species are often absent.

Phytosociological structure of communities. The phytosociological analysis of plant communities involving *Xanthium orientale* was based on the proportional contribution of diagnostic species belonging to different Braun-Blanquet vegetation classes. Species affiliation to vegetation classes followed the EuroVegChecklist system (MUCINA ET AL., 2016). The dominant vegetation classes, defined by the highest number of species contributing to the floristic structure of the communities, were identified.

Ecological assessment. The ecological characteristics of *Xanthium orientale* were evaluated using the phytoindication method (ELLENBERG, 1988; DIDUKH, 2011). Ecological indicator values were derived from the system of Ya.P. Didukh, adapted for the Ukrainian flora (DIDUKH, 2011). Weighted mean values were calculated based on the projective cover of species. To allow comparison among ecological factors, the obtained scores were transformed to a unified 100-point scale (GONCHARENKO, 2017).

Statistical analysis. Differences in ecological indicator values between the two syntaxa involving *Xanthium orientale* were assessed using the non-parametric Mann–Whitney U test (MANN & WHITNEY, 1947), which is appropriate for non-normally distributed ecological data. Box-plot diagrams were used to visualise the distribution, central tendency, and variability of environmental indicator values for *X. orientale* across the analysed syntaxa. All graphical representations, including box-plots of ecological factors, were generated using the *ggplot2* package within the R environment. Statistical analyses and data visualisation were performed in R, version 5.3 (R CORE TEAM, 2020), with significance evaluated at a standard confidence level.

3. Results

3.1. Distribution patterns and biotope affiliation of *Xanthium orientale* in Ukraine

Based on an integrated analysis of herbarium collections, published literature, online biodiversity databases, and original field observations, a total of 1,137 records of *Xanthium orientale* have been documented within the territory of Ukraine. The highest concentration of records is confined to Crimea, whereas occurrences in central Ukraine are more scattered but show distinct clustering near large urban centres, particularly Kyiv. Considerably fewer localities have been reported from Polissia, the

Carpathians, and the eastern regions of the country. A pronounced spatial pattern indicates that the spread of *X. orientale* is closely associated with river systems, especially along major watercourses, which act as a primary dispersal corridor (Fig. 1).

According to the National Catalogue of Biotopes of Ukraine (KUZEMKO ET AL., 2018), *X. orientale* occurs in several types of natural and semi-natural biotopes. It was established that within continental water bodies and watercourses (B), the species is most frequently associated with riparian and aquatic habitats (B4), particularly with nitrophilous annual vegetation of muddy river banks (B4.1.5), belonging to the class *Bidentetia* Tx. Et al. ex von Rochow 1951. In these habitats, the species occurs sporadically, typically occupying limited patches on silted banks of eutrophic flowing or standing waters, including rivers, ox-bows, ponds, canals, and drainage ditches (Fig. 2).

Within herbaceous biotopes (T), *X. orientale* is recorded in wet herbaceous communities (T3), especially wet meadows under pasture use (T3.2) of the class *Molinio-Arrhenatheretea* Tx. 1937. These biotopes usually develop on formerly fresh or wet meadows subjected to intensive grazing, which leads to anthropogenic transformation of meadow vegetation and facilitates the establishment and spread of invasive species. The presence of *X. orientale* in such habitats reflects its ability to exploit disturbed ecological niches created by land-use pressure.

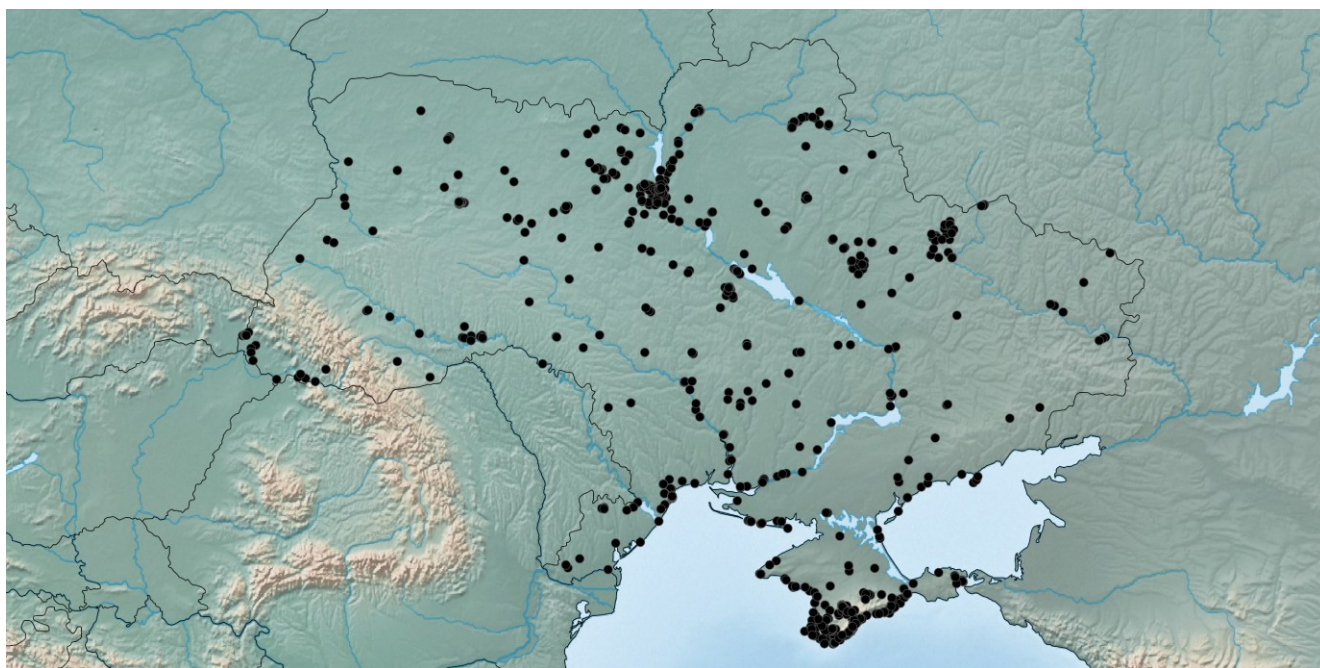


Fig 1. Distribution of *Xanthium orientale* in Ukraine (iNaturalist, 2026; UkrBIN, 2026)



Fig. 2. Distribution of *Xanthium orientale* in different biotopes of Ukraine. 2a – *X. orientale* in the floodplain of Kholodnyi pond (Kholodnianske village, Cherkasy district, Cherkasy region); 2b – *X. orientale* on the shore of Khotivskiy pond (Khotiv village, Obukhiv district, Kyiv region); 2c – *X. orientale* in the floodplain of the River Dobra (Dobrovelychivka village, Novoukrainskyi district, Kirovohrad region); 2d – *X. orientale* in the floodplain of the River Uzh (Uzhhorod city, Uzhhorod district, Zakarpattia region); 2e – *X. orientale* in the floodplain of the River Desna (Chernihiv city, Chernihiv district, Chernihiv region); 2f – *X. orientale* on the Black Sea coast (Zaliznyi Port village, Skadovskyi district, Kherson region). Photos by S. Koniakin and O. Leshcheniuk

It was found that the species also occurs in shrub and semi-shrub habitats (Ch), particularly in shrub communities on sands (Ch8) belonging to the class *Salicetea purpureae* Moor 1958. These communities represent early successional stages on sandy river terraces and floodplains, where unstable substrates and periodic flooding create favourable conditions for colonisation by invasive annuals.

Overall, *Xanthium orientale* demonstrates a clear preference for excessively or moderately moist soils in riparian environments, where it often becomes a

dominant component of wet herbaceous habitats and sandy river shoals. Its tolerance to slight soil salinity further enhances its competitive ability in coastal and floodplain biotopes, allowing it to outcompete native riparian and meadow species. These ecological traits, combined with efficient hydrochorous and zoochorous dispersal, explain the strong association of *X. orientale* with river corridors and underline its high invasive potential across a wide range of Ukrainian biotopes.

3.2. Phytocoenotic affinity of *Xanthium orientale*

The spectrum of communities in which *X. orientale* was recorded is extensive. It was noted that the communities in which this species occurs most

frequently belong to two classes – *Bidentetea* and *Artemisietea vulgaris*. A syntaxonomic scheme of communities with the participation of *X. orientale* is presented below:

Syntaxonomic scheme of communities with the participation of X. orientale

Cl. *Bidentetea* TX. et al. ex Von Rochow 1951

Ord. *Bidentetalia* Br.-Bl. et Tx. ex Klika et Hadač 1944

All. *Bidention tripartitae* Nordhagen ex Klika et Hadač 1944

Ass. *Bidenti frondosae–Xanthietum albin* Panasenکو et al. 2015

Cl. *Artemisietea vulgaris* Lohmeyer et al. in Tx. ex Von. Rochow 1951

Ord. *Agropyretalia intermedio-repentis* T. Müller et Görs 1969

All. *Convolvulo arvensis–Agropyron repentis* Görs 1967

Com. *Xanthium orientale + Elytrigia repens*

Thus, the species occurs primarily within two types of communities–the association *Bidenti frondosae–Xanthietum albin* [*Bidentetea*] and the community *Xanthium orientale + Elytrigia repens* [*Artemisietea vulgaris*]. A description of the association *Bidenti frondosae–Xanthietum albin* and the community

Xanthium orientale + Elytrigia repens is presented below:

Association *Bidenti frondosae–Xanthietum albin* [*Bidentetea*] (Table 1). Diagnostic species: *Xanthium orientale*, *Bidens frondosa* (dominant). Constant species: *Persicaria lapathifolia*, *Chenopodium album*.

Table 1. Phytosociological table of the *Bidenti frondosae–Xanthietum albin* association

Relevé numbers	1	2	3	4	5	6	7	8	9	10	Constancy (%)
Number of species	14	15	17	19	22	21	9	16	15	13	
Cover of trees, %	20	-	-	-	-	-	-	-	-	-	
Cover of shrubs, %	25	-	-	5	-	-	-	30	55	-	
Cover of herbs, %	70	55	70	80	100	90	55	55	50	90	
Phytoindicational variables											
Hd, moisture	42.28	45.6	60.3	38.5	48.0	49.6	33.8	55.6	46.2	61.8	
Rc, soil acidity	63.63	61.3	59.5	58.1	61.7	60.7	64.3	61.7	57.8	63.7	
Nt, nitrogen	56.9	63.4	69.3	59.1	53.9	68.9	60.8	60.2	57.8	66.4	
Lc, light regime	64.9	72.1	67.0	70.4	69.0	69.0	79.7	65.7	66.2	68.5	
Tm, temperature	68.8	64.8	58.7	65.5	65.3	63.9	72.6	63.1	69.6	63.8	
D.s. ass. <i>Bidenti frondosae–Xanthietum albin</i>											
<i>Xanthium orientale</i>	5	+	+	5	3	3	5	3	3	3	100
<i>Bidens frondosa</i>	3	4	3	5	+	4		+	3	+	90
<i>Persicaria lapathifolia</i>		+						+	+		30
<i>Chenopodium album</i>	+					3	+				30
<i>Persicaria maculosa</i>		3	+			3					30
<i>Ambrosia artemisiifolia</i>	+	+	+		+	4	3			+	70
<i>Erigeron canadensis</i>	+	+			+			+	+		50
<i>Lycopus europaeus</i>					+	+		+	+		40
<i>Phragmites australis</i>						+		4		+	30
<i>Lactuca serriola</i>	+	3		4	+		3				50
<i>Atriplex prostrata</i>		+		4	3						30
<i>Lolium perenne</i>			3					+		+	30
<i>Plantago major</i>						+		+	+		30
<i>Ranunculus repens</i>			+	3						+	30
<i>Amorpha fruticosa</i>	4							5	5		30
<i>Salix alba</i>	3					+		+	+		40
<i>Digitaria sanguinalis</i>	+					+			+		30
<i>Argentina anserina</i>				5	+	3					30

Species recorded (in less than two relevés): *Acer negundo* 4 (+), 10 (+); *Achillea millefolium* 6 (+); *Agrostis stolonifera* 3 (5), 8 (+); *Alisma plantago-aquatica* 10 (3); *Althaea officinalis* 5 (+); *Amaranthus blitum* 10 (+); *A. retroflexus* 6 (+), 7 (3); *Anisantha tectorum* 1 (4); *Atriplex patula* 4 (+); *Bromus arvensis* 2 (+); *Bolboschoenus maritimus* 10 (5); *Calystegia sepium* 3 (3), 6 (+); *Carex hirta* 6 (+); *C. praecox* 5 (5); *Carex* sp. 3 (+); *C. vulpina* 4 (3); *Cenchrus longispinus* 7 (5), 9 (3); *Chenopodium strictum* 2 (+), 52 (+); *Cirsium arvense* 2 (3), 4 (3); *C. vulgare* 4 (+); *Convolvulus arvensis* 1 (4); *Daucus carota* 2 (+); *Echinocystis lobata* 3 (4), 4 (+); *Elytrigia repens* 4 (4); *Eragrostis pilosa* 9 (+); *E. minor* 9 (+); *Galium mollugo* 3 (+); *Geranium collinum* 5 (+); *Glyceria fluitans* 3 (4); *Heracleum sosnowskyi* 3 (+); *Hordeum murinum* 1 (+), 7 (4); *Humulus lupulus* 6 (+); *Juncus articulatus* 8 (+); *J. conglomeratus* 4 (+); *Lactuca tatarica* 8 (+); *Leersia oryzoides* 3 (5); *Lythrum salicaria* 5 (+); *Myosoton aquaticum* 3 (+); *Oenothera biennis* 9 (+); *Persicaria hydropiper* 3 (+), 4 (+); *Phalaroides arundinacea* 4 (+); *Polygonum aviculare* 2 (+), 10 (+); *Populus nigra* 1 (+), 8 (+); *Portulaca oleracea* 10 (+); *Potentilla reptans* 5 (+); *P. supina* 8 (+); *Rumex hydrolapathum* 10 (+); *R. crispus* 4 (3); *Setaria viridis* 6 (+); *S. pumila* 9 (+); *Solanum nigrum* 6 (+); *S. dulcomara* 6 (+); *Taraxacum* sect. *Taraxacum* 6 (+); *Trifolium repens* 3 (3); *Typha latifolia* 2 (+); *Ulmus glabra* 1 (+), *Urtica dioica* 4 (+).

Location and other metadata of relevés with the occurrence of *X. orientale*: Relevé 1. Kyiv city, Dniprovs'kyi district, bank of the River Dnipro, 10.09.2023, 50.449315° N, 30.585771° E (S.M. Koniakin). Relevé 2. Kholodnyanske village, Cherkasy district, Cherkasy region, shore of Kholodnyi pond, 16.08.2025, 49.192005° N, 31.8761249997° E (S.M. Koniakin). Relevé 3. Uzhhorod city, Uzhhorod district, Zakarpattia region, bank of the River Uzh, 17.09.2022, 48.622237° N, 22.286160° E (S.M. Koniakin). Relevé 4. Khotiv village, Obukhiv district, Kyiv region, roadside of Partizanska street, ruderal coenosis, 27.07.2025, 50.3299129722° N, 30.473863° E (S.M. Koniakin). Relevé 5. Cherkasy district, Cherkasy region, local landscape «Palanka», transformed meadow, 18.08.2025, 49.2414264306° N, 31.8946959622° E (S.M. Koniakin). Relevé 6. Smila city, Cherkasy district, Cherkasy region, bank of the Smila reservoir, 15.09.2024, 49.2345472° N, 31.8983647997° E (S.M. Koniakin). Relevé 7. Zaliznyi Port village, Skadovs'kyi district, Kherson region, Black Sea coast, 15.07.2021, 46.120432° N, 32.277861° E (S.M. Koniakin). Relevé 8. Cherkasy city, Cherkasy district, Cherkasy region, bank of the River Dnipro, 19.08.2025, 49.4537965997° N, 32.0612366° E (S.M. Koniakin). Relevé 9. Kyiv city, Obolons'kyi district, Obolons'kyi Island, bank of the River Dnipro, 28.08.2025, 50.502615° N, 30.522219° E (S.M. Koniakin, O.M. Leshcheniuk). Relevé 10. Kropyvnyts'kyi city, Kirovohrad region, bank of the River Ingul, 01.07.2024, 48.507938° N 32.254210° E (S.M. Koniakin)

These communities are confined to sandy shoals, screes, and riverbank deposits, and are mostly ribbon-shaped, 0.5–2.5 m wide and up to 25 m long, elongated along the shoreline.

The total projective cover of the herb layer ranges from 50 to 100%, with an average height of 35–70 cm. Species richness per relevé varies from 9 to 22 species. The percentage cover of *Xanthium orientale* is 60–85%. The floristic composition of the association includes species from several classes, in particular: *Bidentetea* (*Persicaria lapathifolia*, *Chenopodium album*, *Persicaria maculosa*), *Artemisietea vulgaris* (*Lactuca serriola*, *Atriplex prostrata*), and *Polygono-Poetea annuae* (*Lolium perenne*, *Plantago major*, *Ranunculus repens*). Invasive species include *Ambrosia artemisiifolia*, *Amorpha fruticosa*, *Bidens frondosa*, and *Erigeron canadensis*.

A two-layer vertical structure is observed. The first sublayer (45–95 cm) is formed by *Xanthium orientale*, *Bidens frondosa*, *Chenopodium album*, *Atriplex prostrata*, and the second sublayer (10–40 cm) by *Plantago major*, *Ranunculus repens*, and *Argentina anserina*.

Community *Xanthium orientale* + *Elytrigia repens* [*Artemisietea vulgaris*] (Table 2). Diagnostic species: *Xanthium orientale* (dominant), *Elytrigia repens* (dominant). Constant species: *Ambrosia artemisiifolia*, and *Achillea millefolium*.

The community *Xanthium orientale* + *Elytrigia repens* is confined to ruderal habitats and includes

tall biennial and perennial plants widespread in nitrified ecotopes with varying moisture and light regimes.

The total projective cover of the herb layer ranges from 45 to 80%, with an average height of 30–80 cm. Species richness per relevé varies from 9 to 27, with a mean of 17 species. The percentage cover of *Xanthium orientale* accounts for 65–90%. In the derivative community *Xanthium orientale* + *Elytrigia repens*, a total of 79 species of vascular plants were recorded.

The floristic composition of the association includes species from several vegetation classes, in particular *Artemisietea vulgaris* (*Elytrigia repens*, *Achillea millefolium*, *Ambrosia artemisiifolia*), *Molinio-Arrhenatheretea* (*Lolium perenne*, *Daucus carota*, *Dactylis glomerata*), and *Polygono-Poetea annuae* (*Plantago major*, *Polygonum aviculare*). Among the invasive species, *Ambrosia artemisiifolia* and *Erigeron canadensis* were recorded.

A three-layer vertical structure is observed. The first sublayer (65–200 cm) is formed by *Xanthium orientale*, *Elytrigia repens*, *Lactuca serriola*, and others. The height of the dominant species, *Xanthium orientale*, reaches 70–200 cm. The second sublayer (50–115 cm) is formed by *Lolium perenne*, *Ambrosia artemisiifolia*, and *Dactylis glomerata*, while the third sublayer (up to 45 cm) is composed of *Plantago major* and *Polygonum aviculare*.

Table 2. Phytosociological table of *Xanthium orientale* + *Elytrigia repens* community

Relevé numbers	1	2	3	4	5	6	7	8	9	10	Constancy (%)
Number of species	19	17	13	21	17	24	27	10	9	14	
Cover of trees, %	1	-	-	-	-	-	-	-	-	-	
Cover of shrubs, %	5	-	-	15	10	35	-	-	-	-	
Cover of herbs, %	60	65	60	65	80	50	60	60	75	45	
Phytoindicational variables											
Hd, moisture	43.3	38.3	49.3	43.1	46.4	48.9	42.4	39.1	50.0	43.5	
Rc, soil acidity	54.9	59.1	61.6	58.0	57.2	60.9	59.4	60.9	66.8	60.0	
Nt, nitrogen	62.6	56.5	57.6	62.3	58.5	60.7	63.1	55.2	57.5	53.3	
Lc, temperature	67.4	70.8	69.8	61.4	70.1	68.9	66.1	70.7	73.5	72.3	
Tm, continuity	59.8	59.9	61.2	58.9	60.9	60.3	59.6	63.1	63.7	62.5	
D.s. com. <i>Xanthium orientale</i> [Artemisieta vulgaris]											
<i>Xanthium orientale</i>	5	4	+	+	3	3	+	4	5	+	100
<i>Elytrigia repens</i>	4	4	3	+	4	4	4	4	+		90
<i>Ambrosia artemisiifolia</i>		5	3		3	3	3	5	3	+	80
<i>Achillea millefolium</i>	+	3		+	+			3			50
<i>Lactuca serriola</i>	+	+	+		+					+	50
<i>Cirsium arvense</i>	3			+		+					30
<i>Artemisia vulgaris</i>	+			+			+				30
<i>Lolium perenne</i>		+			+		4			+	40
<i>Daucus carota</i>		+	+	+		+		+		+	60
<i>Trifolium repens</i>		+				+	3				30
<i>Trifolium pratense</i>		+				+	3				30
<i>Dactylis glomerata</i>				3	+	+	3				40
<i>Plantago major</i>	4		+	+	+		+			+	60
<i>Polygonum aviculare</i>	4						+		+	4	40
<i>Taraxacum</i> sect. <i>Taraxacum</i>	+	+				+	3				40
<i>Erigeron canadensis</i>	+					+				3	30
<i>Juncus compressus</i>	+	3	4					4		+	50
<i>Trifolium fragiferum</i>			4		3	3			3		40
<i>Phragmites australis</i>			+			+				+	30

Species recorded (in less than two relevés): *Acer negundo* 1 (+), 4 (+); *A. pseudoplatanus* 4 (+); *Ailanthus altissima* 7 (+); *Althaea officinalis* 3 (+); *Anisantha tectorum* 2 (4), 9 (4); *Atriplex prostrata* 9 (+); *Bidens frondosa* 5 (+), 6 (+); *Bolboschoenus maritimus* 9 (+); *Carex hirta* 1 (+), 5 (+); *C. otrubae* 3 (+); *Chenopodium album* 1 (+); *C. strictum* 6 (3); *Cichorium intybus* 7 (+); *Cirsium vulgare* 2 (+), 8 (+); *Clematis vitalba* 7 (+); *Conium maculatum* 2 (+); *Cyperus fuscus* 10 (+); *Equisetum arvense* 5 (+), 7 (+); *Erigeron annuus* 4 (3), 6 (+); *Fallopia convolvulus* 5 (3), 6 (+); *Fraxinus excelsior* 4 (3); *Galinsoga parviflora* 1 (+); *Galium mollugo* 4 (+), 7 (+); *G. rivale* 6 (+); *Geranium collinum* 3 (+); *Glechoma hederacea* 4 (+); *Heracleum sphondylium sibiricum* 1 (+); *H. sosnowskyi* 7 (4); *Humulus lupulus* 6 (+); *Lotus corniculatus* 2 (3), 8 (1); *Lycopus europaeus* 5 (+); *Lythrum salicaria* 8 (+); *Melilotus albus* 6 (+); *Mentha longifolia* 6 (+), 7 (3); *Parthenocissus inserta* 7 (+); *Persicaria lapathifolia* 10 (4); *Phleum pratense* 3 (3); *Plantago lanceolata* 2 (+), 7 (+); *Picris hieracioides* 4 (+); *Poa angustifolia* 4 (+); *P. pratensis* 5 (+); *P. trivialis* 1 (3), 6 (4); *Populus nigra* 8 (+); *Portulaca oleracea* 7 (+); *Rumex stenophyllus* 9 (+); *R. obtusifolius* 7 (+); *Salix triandra* 6 (5); *Saponaria officinalis* 7 (+); *Schedonorus arundinaceus* 6 (+); *Setaria pumila* 1 (+), 7 (3); *Silene latifolia* 7 (+); *S. vulgaris* 7 (+); *Solidago canadensis* 4 (4), 6 (+); *Thlaspi arvense* 4 (+); *Trifolium dubium* 6 (+); *T. pannonicum* 10 (3); *Ulmus glabra* 4 (+); *Urtica dioica* 7 (+); *Verbascum lychnitis* 2 (+); *Vicia sativa* 4 (3).

Location and other metadata of relevés with the occurrence of *X. orientale*: Relevé 1. Rivne district, Rivne region, floodplain of the River Viliya, along the dirt path, 31.08. 2023, 50.330743° N, 26.537614° E (S.M. Koniakin). Relevé 2. Dobrovelichivka village, Novoukrainskyi district, Kirovohrad region, 15.08.2025, 48.375835° N, 31.186998° E (O.M. Leshcheniuk, S.M. Koniakin). Relevé 3. Cherkasy district, Cherkasy region, local landscape "Palanka", 18.08.2025, 49.2417966° N, 31.8954883° E (S.M. Konyakin). Relevé 4. Kyiv city, Holosiivskyi district, Kyiv region, transformed meadow, 11.06.2025, 50.365951° N, 30.469423° E (S.M. Koniakin, O.M.

Lescheniuk). Relevé 5. Khotiv village, Obukhiv district, Kyiv region, shore of Khotiv pond, 27.07.2025, 50.3286538341° N, 30.4817221016° E (S.M. Koniakin). Relevé 6. Khotiv village, Obukhiv district, Kyiv region, coastal cenosis of Vita Stream, 27.07.2025, 50.3299129722° N, 30.473863° E (S.M. Koniakin). Relevé 7. Uzhhorod city, Uzhhorod district, Zakarpattia region, floodplain meadow of the River Uzh, 18.09.2022, 48.623680° N, 22.291757° E (S.M. Koniakin). Relevé 8. Dobrovelichivka village, Novoukrainskyi district, Kirovohrad region, 19.08.2025, 48.374972° N, 31.187209° E (O.M. Leshcheniuk, S.M. Koniakin). Relevé 9. Kropyvnytskyi city, Kirovohrad region, floodplain meadow of the River Sugokleia, 25.06.2025, 48.48096° N, 32.25670° E (S.M. Koniakin). Relevé 10. Kholodnianske village, Cherkasy district, Cherkasy region, shore of Kholodnyi pond, 16.08.2025, 49.1914348384° N, 31.871701293° E (S.M. Koniakin)

3.3. Phytosociological structure of communities with the participation of *Xanthium orientale*

Figure 3 shows the proportions of species belonging to different vegetation classes (the phytosociological spectrum) in the communities with the participation *X. orientale* that were studied. The shares of species of the different vegetation classes are indicated.

The phytosociological spectrum of communities with the participation of *Xanthium orientale* demonstrates differences in the representation of two syntaxa between the association *Bidenti frondosae*–*Xanthietum albin* and the ruderal *Xanthium orientale* + *Elytrigia repens* derivative community. In the composition of the ruderal derivative community (*X. orientale* + *E. repens*), species of the class *Molinio-Arrhenatheretea* clearly dominate, accounting for more than 40%. This indicates a significant contribution of mesophytic meadow species and points to the formation of these communities under

relatively stable, moderately moist conditions, often associated with secondary meadows. In the association *Bidenti frondosae*–*Xanthietum albin*, alongside *Molinio-Arrhenatheretea*, species of the classes *Phragmito-Magnocaricetea* and *Artemisietea vulgaris* also play a leading role. The increased proportion of hygrophilous species of the class *Phragmito-Magnocaricetea* (20.4%) indicates a close association of these communities with moist, often alluvial or riparian habitats, whereas the substantial contribution of *Artemisietea vulgaris* reflects their ruderal character and a high level of anthropogenic transformation. The lower but stable presence of the classes *Epilobietea angustifolii*, *Alno-Populetea albae*, *Alnetea glutinosae*, and *Robinietae* in both syntaxa indicates the contribution of forest, riparian-aquatic, and ruderal species. This demonstrates the high ecological plasticity of *X. orientale* and its ability to establish itself in various types of plant communities.

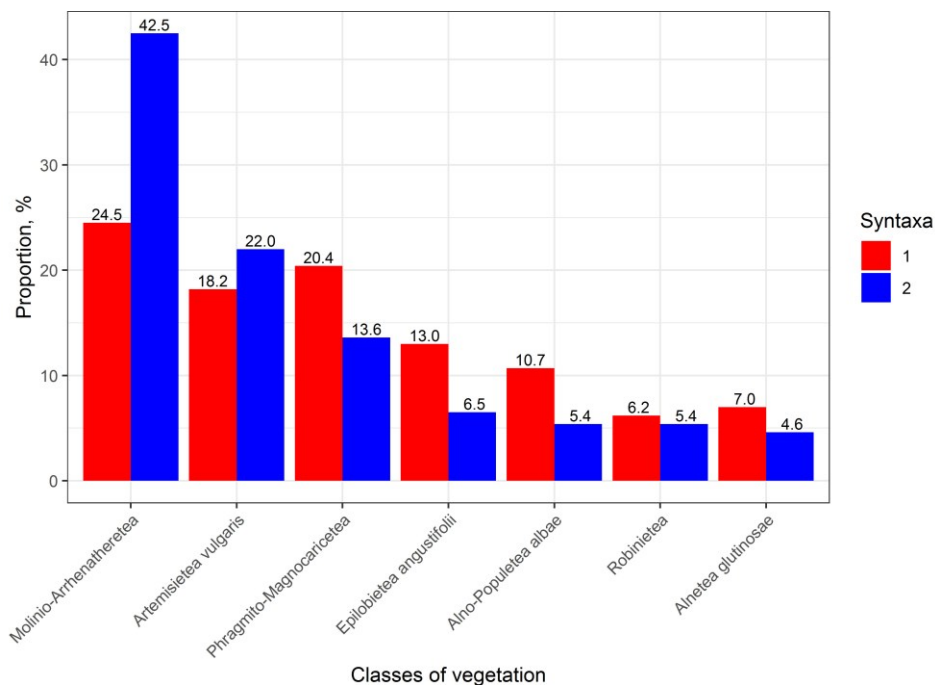


Fig. 3. Phytosociological spectrum of communities with the participation of *X. orientale*. Classes are sorted by the proportion of their species. Syntaxon designations are the first – ass. *Bidenti frondosae*–*Xanthietum albin* (red), the second – ruderal *Xanthium orientale* + *Elytrigia repens* derivative communities (blue)

3.4. Phytoindicational assessment

Table 3 presents the phytoindication values for the two main types of communities in which we identified the association *Bidentifrondosae-Xanthietum albin* and the ruderal *Xanthium orientale + Elytrigia repens* derivative community.

Comparison of the phytoindication assessment of the two communities – the association *Bidentifrondosae-Xanthietum albin* and the derivative community *Xanthium orientale + Elytrigia repens* – revealed both similarities in general ecological-coenotic conditions and statistically significant differences for certain ecological factors.

– Water regime (Hd) and moisture variability (fH). Both communities are confined to moist habitats with moderate fluctuations in moisture levels. However, the derivative community is characterised by lower moisture variability and lower mean fH values, indicating its confinement to more stable, less flood-prone sites. This difference is statistically confirmed ($p = 0.03569$, $p < 0.05$), pointing to the adaptation of *X. orientale* to more stable moisture conditions compared to the typically meadow-marsh complex of the association *Bidentifrondosae-Xanthietum albin*.

– Soil carbonate content (Ca). Significantly higher Ca values were recorded for the derivative community *Xanthium orientale + Elytrigia repens* (mean = 46.6 vs. 39.6; $p = 5.8E-05$, ***), indicating the affinity of *X. orientale* for more carbonate-rich, structurally stable alluvial or anthropogenic substrates. This may be one of the factors underlying the species' competitive advantage in urbanized and transformed areas.

– Thermal regime (Tm). The difference between the communities is also statistically significant ($p = 0.00013$, **). The derivative community is characterized by lower Tm values, indicating its association with more moderate or slightly shaded conditions, whereas the association *Bidentifrondosae-Xanthietum albin* develops in open, warmer floodplain sites.

– Other ecological factors (Rc – acidity, Sl – total salt regime, Nt – nitrogen content, Ae – aeration of soil, Kn – continental climate, Om – humidity, Cr – cryo-climate). No statistically significant differences were detected for these parameters ($p > 0.05$). This indicates that soil reaction, salinity regime, nitrogen availability, aeration, and climatic characteristics are similar for both types of communities.

Table 3. Phytoindication assessment of communities with the participation of *Xanthium orientale*

Variable	ass. <i>Bidentifrondosae-Xanthietum albin</i>						derivative comm. <i>Xanthium orientale + Elytrigia repens</i>						Mann-Whitney U test	
	Mean	Sd	CV, %	Min	Max	Range	Mean	Sd	CV, %	Min	Max	Range	p.value	p.signif
Hd, moisture	48.6	11.4	23.4	33.3	69.8	36.5	49.5	9.3	18.7	38.3	68.1	29.8	0.53133	ns
Rc, soil acidity	60.8	2.0	3.3	56.0	66.1	10.1	60.5	3.2	5.2	53.3	66.8	13.5	0.88387	ns
Sl, salt regime	41.4	3.4	8.2	34.7	50.6	15.9	42.3	3.9	9.2	35.8	52.6	16.8	0.44837	ns
Nt, nitrogen	61.3	5.2	8.4	49.8	71.4	21.6	59.7	4.7	7.8	51.4	72.0	20.6	0.16211	ns
Lc, light	59.8	3.5	5.8	63.3	79.7	16.4	68.2	3.3	4.8	61.4	73.5	12.1	0.75958	ns
fH, moisture variability	64.7	7.4	11.4	49.9	83.3	33.4	60.4	4.3	7.1	47.4	68.0	20.6	0.03569	**
Ae, aeration of soil	39.9	13.7	34.3	21.5	71.7	50.2	40.7	9.5	23.3	28.6	58.0	29.4	0.41181	ns
Ca, carbonate content in soil	39.6	5.5	13.8	21.1	49.7	28.6	46.6	5.6	12.0	36.9	59.2	22.3	5.80E-05	****
Tm, temperature	64.1	3.2	4.9	57.0	72.6	15.6	60.8	2.1	3.4	58.0	65.5	7.5	0.00013	***
Kn, continentality	44.9	3.9	8.6	38.3	53.8	15.5	43.0	3.1	7.2	36.6	49.0	12.4	0.16847	ns
Om, humidity	50.7	4.0	7.8	43.9	60.7	16.8	50.5	2.6	5.1	46.1	56.3	10.2	0.86743	ns
Cr, cryoclimate	55.6	4.0	7.1	41.6	63.8	22.2	53.7	3.7	6.8	46.3	58.4	12.1	0.08085	ns

Note: ns – not significant, $p < 0.5$; * $p < 0.01$; ** $p < 0.001$; *** $p < 0.0001$; **** $p < 0.00001$

The obtained results indicate that derivative communities dominated by *Xanthium orientale* are characterised by greater tolerance to soil carbonate content and stable moisture conditions, demonstrating a shift in the species' ecological niche toward mesophytic, warmer, moderately transformed biotopes. This confirms the species' evolution from

a hygrophilous component of floodplain coenoses to a synanthropic, ruderal-type species capable of establishing under anthropogenic influence.

Box-plot diagrams illustrate differences in ecological amplitude between the two syntaxa with the participation of *Xanthium orientale* for those factors where the p -value < 0.00001 (Fig. 4).

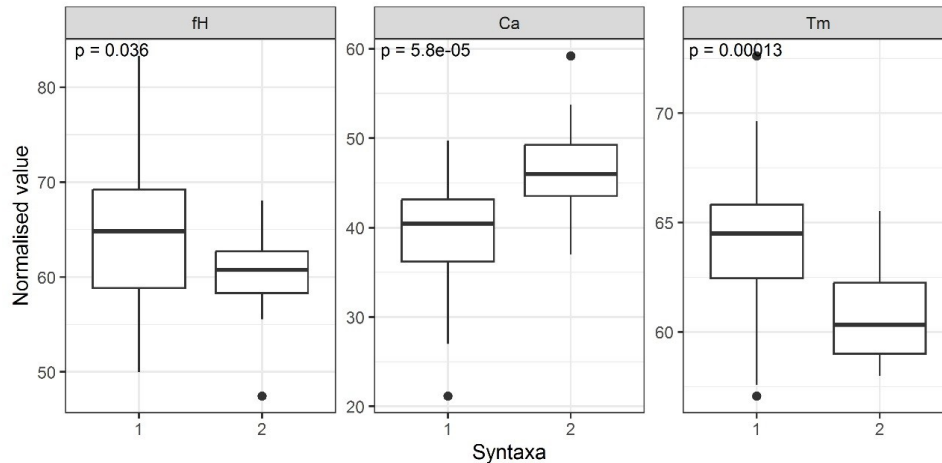


Fig. 4. Box-plot diagrams of environmental values of the species *Xanthium orientale*: fH – moisture variability, Ca – carbonate content in the soil, Tm – temperature. Syntaxon number: 1 – ass. *Bidenti frondosae*–*Xanthietum albi*, 2 – ruderal *Xanthium orientale* + *Elytrigia repens* derivative communities

3.5. Moisture variability (fH).

The association *Bidenti frondosae*–*Xanthietum albi* (1) is characterised by higher fH values, indicating a more contrasting water regime and frequent fluctuations in soil moisture, typical of floodplain sites prone to periodic inundation.

Soil carbonate content (Ca). Ca values are significantly higher in the community *Xanthium orientale* + *Elytrigia repens* ($p = 5.8e-05$), reflecting the affinity of *X. orientale* for carbonate or neutral to alkaline substrates.

Thermal regime (Tm). A statistically significant difference ($p = 0.00013$) is also observed for the temperature factor: lower Tm values in the derivative community indicate its formation under more moderate microclimatic conditions, possibly with greater shading or lower site openness.

Graphical analysis confirms that communities dominated by *Xanthium orientale* exhibit a shift in the species' ecological niche toward more stable, carbonate-rich, and thermally moderate habitats. This indicates a gradual adaptation of the species to anthropogenically altered biotopes, where it forms new derivative coenoses with the participation of synanthropic components, in particular *Elytrigia repens*.

4. Discussion

4.1. Systematics and history of its distribution

The studied *Xanthium orientale* L. (Asteraceae) belongs to the genus *Xanthium* L., which comprises seven species and one hybrid: *X. ambrosioides* Hook. & Arn., *X. argenteum* Widder, *X. catharticum* Kunth, *X. chinense* Mill., *X. orientale* L., *X. spinosum* L., *X. strumarium* L., and *X. × vayredae* Sennen (ROYAL BOTANIC GARDENS, KEW, 2026). This species is one of the most aggressive alien plant species affecting the structure of plant communities in both natural and anthropogenically transformed biotopes in Ukraine and beyond. Three species of this genus occur in the flora of Ukraine: *X. orientale* (= *X. albinum* (Widder) Scholz and Sukopp; *X. brasiliicum* Vell.; *X. californicum* Greene; *X. italicum* Moretti; *X. orientale* subsp. *riparium* (Čelak.) Greuter; *X. pensylvanicum* Wallr.; *X. ripicola* Holub, and *X. saccharatum* Wallr.), *X. strumarium* L. (= *X. sibiricum* Patrin ex Widder), and *X. spinosum* L. (MOSYAKIN & FEDORONCHUK, 1999; ROYAL BOTANIC GARDENS, KEW, 2026).

The primary native range of *Xanthium orientale* is Central and South America, whereas its secondary range includes North America, Eurasia, and eastern Australia (LÖVE & DANSEREAU, 1959; STROTHER, 2006).

This distribution pattern classifies the species as an invasive taxon with a transcontinental range. In countries bordering Ukraine, *X. orientale* has been recorded in Poland (SUDNIK-WÓJCIKOWSKA, 2011; POPIELA ET AL., 2015; TOKARSKA-GUZIŁ ET AL., 2021), Slovakia (MEDVECKÁ ET AL., 2012), Belarus (DUBOVİK ET AL., 2021), Romania (PAZMANY, 2021), Moldova (TOFAN-DOROFEEV & CIUBOTARU, 2022), Hungary (CSIKY ET AL., 2023), and the European part of the Russian Federation (VINOGRADOVA ET AL., 2010; AREP'EVA, 2011; PANASENKO ET AL., 2015).

The introduction of *Xanthium orientale* to Ukraine dates back to the early 20th century, with the first reliable records reported in 1928 from the Kherson region and the city of Mykolaiv. During World War II, a secondary centre of distribution was formed in the Kyiv region, from where the species subsequently spread over most of the territory of Ukraine (BURDA ET AL., 2015). The earliest published record from Kyiv was provided by M. I. Kotov, who in 1946 documented the species near a pier on the River Dnipro and described it as a new adventive element of the flora of the Ukrainian SSR (KOTOV, 1949). In later publications, the species was reported under different names (*X. orientale*, *X. californicum*, *X. albinum*), all of which are currently treated as synonyms of *X. orientale* (KOTOV, 1962, 1979; PROTOPOPOVA, 1964; ROYAL BOTANIC GARDENS, KEW, 2026).

The frequent occurrence of intermediate forms and pronounced polymorphism considerably complicates species identification (PROTOPOPOVA & SHEVERA, 2019). Moreover, pronounced nomenclatural variability hampers the analysis of distribution patterns based on literature data and is likely related to the alien origin of the species and the diversity of its American forms (TACIK, 1971; SUDNIK-WÓJCIKOWSKA, 2011). At present, *Xanthium orientale* is widely naturalised throughout Ukraine, occurring both within settlements and in natural and anthropogenically disturbed river floodplains (PROTOPOPOVA & SHEVERA, 2019).

4.2. Ecological and biological traits of *Xanthium orientale*

Xanthium orientale L. is a densely pubescent annual plant characterised by a well-developed taproot system. The stem is erect, simple or branched,

reaching 50–200 cm in height and often marked with reddish-brown spots. Leaves are triangular, 5–11 cm long and 6–11 cm wide, cordate at the base and tapering to a short-pointed apex (VINOGRADOVA ET AL., 2010; BURDA & STRATIIEVSKYI, 2013). The species is monoecious, bearing unisexual flowers. Male inflorescences are greenish, spherical, and located at the apices of shoots, whereas female flowers occur in the leaf axils, either singly or in small clusters. Following pollination, female flowers develop into spiny, burr-like fruits (achenes). Seeds are capable of germinating from soil depths of up to 18–20 cm, which enhances the species' persistence in disturbed habitats (KOTOV, 1962). Owing to the presence of hooked spines, the diaspores are readily dispersed by animals and human activity, and are also effectively transported by water, particularly along river corridors.

From an ecological and biological perspective, *X. orientale* is classified as a therophyte, neophyte, xenophyte, agrio-epheophyte, mesophyte-mesohygrophite, and heliophyte, and is recognised as a highly invasive species. In addition to its ecological significance, the species has been utilised as a medicinal, dye, oil, and industrial plant. Its spontaneous spread has been documented in riparian habitats, ruderal and roadside communities, fallows, and various agrocoenoses, indicating a high degree of ecological plasticity (KUCHEREVSKYI, 2004; BURDA ET AL., 2015).

4.3. Distribution of *Xanthium orientale* in different vegetation classes

Table 4, gives a list of syntaxa in which *X. orientale* occurs as a dominant or associate species based on data from various literature sources.

Such a broad spectrum of syntaxa with the participation of *X. orientale* indicates its high invasive potential in both natural and transformed biotopes. In particular, *X. orientale* is reported for 10 vegetation classes, 12 orders, 13 alliances, and 16 associations (Table 4). In terms of the number of associations in which *X. orientale* occurs, the class *Bidentetea* dominates (7 associations). The class *Artemisietea vulgaris* is also well represented (5 associations). The species penetrates sporadically into the classes *Molinio-Arrhenatheretea*, *Phragmito-Magnocaricetea*, and *Stellarietea mediae*. Most of these classes belong to riparian, grassland, and ruderal biotopes.

Table 4. List of syntaxa in which *Xanthium orientale* occurs according to the literature

Class	Order	Allianc	Association	Literature
According to research by Ukrainian scientists				
Aquatic vegetation				
Phragmito-Magnocaricetea	Phragmitetalia	Phragmition communis	Phalarido arundinaceae-Bolboschoenetum laticarpi	Liubinska & Matvieiev, 2021
Meadow vegetation				
Molinio-Arrhenatheretea	Potentillo-Polygonetalia avicularis	Potentillion anserinae	ruderal derivative community Xanthium albinum [Potentillion anserinae/Bidentetea]	Kyrienko & Mekhed, 2023
Psammophytic vegetation				
Festucetea vaginatae	not defined	not defined	not specified	Osypenko & Shevchyk, 2001
Forest vegetation				
Salicetea purpureae	Salicetalia purpureae	Salicion albae	Salicetum albae	Osypenko & Shevchyk, 2001; Tokaryuk et al., 2018
Littoral vegetation				
Cakiletea maritimae	Thero-Atriplicetalia	not specified	not specified	Dubyna et al., 2019
Anthropogenic vegetation				
Stellarietea mediae	Atriplici-Chenopodietalia albi	Amarantho blitoidis-Echinochloion cruris-galli	not specified	Dubyna et al., 2019; Osypenko & Shevchyk, 2001
		Panico-Setarion Sissingh	Cynodonto-Xanthietum spinosi	
	Sisymbrietalia sophiae	Sisymbrium officinalis	not specified	
	Eragrostietalia	Eragrostion	Digitario sanguinalis-Eragrostietum minoris;	Tokaryuk et al., 2018
Artemisietea vulgaris	Onopordetalia acanthii	Onopordion acanthii	Ambrosio artemisiifoliae-Xanthietum strumariae Kostylev; Xanthietum californici-spinosi; Xanthietum strumarii; derivative community Xanthium albinum	Dubyna et al., 2019
Bidentetea	Bidentetalia	Chenopodion rubri	Xanthio riparii-Chenopodietum rubri; Bidenti frondosae-Atriplicetum prostratae; Xanthium albinum-Chenopodium rubrum	Dubyna et al., 2019
		Bidention tripartitae	Bidentetum frondoso-connatae; Bidentetum tripartitae; Polygonetum hydropiperis; Bidentetum cernuae	Makhynia, 2015
According to research by foreign scientists				
Aquatic vegetation				
Isoëto-Nanojuncetea	Nanocyperetalia	Eleocharition soloniensis	Cyperetum micheliani	Vegetace..., 2011
Phragmito-Magnocaricetea	Nasturtio-Glycerietalia	Phalaridion arundinaceae	Phalaridetum arundinaceae	Kaçki & Dajdok, 2009

Meadow vegetation				
<i>Molinio-Arrhenatheretea</i>	<i>Arrhenatheretalia elatioris</i>	<i>Cynosurion cristati</i>	<i>Lolietum perennis</i>	Bulokhov & Kharin, 2008
Anthropogenic vegetation				
<i>Artemisietea vulgaris</i>	<i>Agropyretalia intermedio-repentis</i>	<i>Convolvulo arvensis-Agropyron repens</i>	not specified	Arep'eva, 2011
<i>Plantaginetea majoris</i>	<i>Potentillo-Polygonetalia avicularis</i>	<i>Potentillion anserinae</i>	<i>Potentilletum anserinae</i>	Panasenko et al., 2015

5. Conclusions

In this article, we analysed the current distribution of *Xanthium orientale*, assessed the syntaxonomic status of communities dominated by *X. orientale* in natural and transformed biotopes, and conducted a phytoindication assessment of two syntaxa.

According to current data on the distribution of *X. orientale* and the results of field studies in Ukraine, 1137 localities are known. Most records are concentrated in the southern regions, particularly in Crimea, with a clear association with the valleys of large rivers, primarily the River Dnipro and its tributaries. The species occurs much less frequently in northern regions and in the Carpathians. This pattern of expansion is explained by migration routes from south to north and by its dispersal mechanisms, the main ones being hydrochory, anthropochory, and zoochory.

It was established that *Xanthium orientale* is associated with a range of biotopes, including nitrophilous annual vegetation on muddy riverbanks and exposed shallows (B4.1.5), wet meadows used as pastures (T3.2), as well as psammophytic shrub communities (Ch8).

According to our studies, the species occurs predominantly within two types of communities – the association *Bidentif frondosae-Xanthietum albini* [Bidentetia] and the community *Xanthium orientale + Elytrigia repens* [Artemisietea vulgaris]. At the same time, the syntaxonomic spectrum of communities with the participation of *X. orientale* is much broader, indicating the species' ability to establish in various vegetation types and to drive their transformation. Overall, the species occurs in communities belonging to 10 vegetation classes, 12 orders, 13 alliances, and 16 associations.

It is shown that the proportion of species of the class *Molinio-Arrhenatheretea* is dominant in the derivative community *Xanthium orientale + Elytrigia repens* (42.5%), whereas in the association *Bidentif frondosae-Xanthietum albini* it is significantly lower (24.5%). Differences in the phytosociological structure

of the two syntaxa are also evident in the representation of the classes *Artemisietea vulgaris* and *Phragmito-Magnocaricetea*.

For most ecological factors, *Xanthium orientale* shows a substantial overlap of ecological amplitudes. Differences in mean phytoindication values are observed for factors such as moisture variability, thermal regime, and soil carbonate content. Overall, *X. orientale* demonstrates high ecological plasticity, rapidly occupying ecological niches in both natural and transformed coenoses, successfully self-regenerating within them, and forming numerous populations with considerable projective cover in plant communities.

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