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ECOLOGICAL–COENOTIC FEATURES AND CURRENT DISTRIBUTION *Echinocystis lobata* (Michx.) Torr. et A. Gray (*Cucurbitaceae*) IN UKRAINE

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Abstract

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The information on the spontaneous spread (1152 localities) of the invasive species *Echinocystis lobata* is summarized. It was found that this alien species is timed to coastal water biotopes, floodplain meadows, mesophytic forests, wetlands, as well as disturbed ecotopes. The syntaxonomic scheme of vegetation with the participation of *E. lobata* includes 13 classes, 7 orders, 8 alliances, and 8 associations. It is predicted that under the conditions of a temperature increase of 3 °C, there will likely be changes in the carbonate content (Ca), water regime (Hd) of the soil, thermal regime (Tm), and climate humidity (Om), which will cause a reduction in the secondary range of the species in Ukraine, and the changed acid regime of the soil will cause (Rc) its disappearance in some localities. The obtained data can be used to carry out preventive measures regarding the emergence and further distribution of *E. lobata* in new habitats with different degrees of anthropogenic transformation.

Key words: *Echinocystis lobata*, invasive alien species, Ukraine, communities.

Introduction

The problem of the appearance of alien species of plants outside their primary habitats, subsequent naturalization with invasion of natural ecosystems, except for anthropogenically altered territories, is a global threat to the preservation of natural biodiversity, especially against the background of global climate warming (Chaudhary et al., 2022; Bakacsy et al., 2023; Yang et al., 2023). The spread of adventitious plant species is significantly influenced by anthropogenic factors (introduction, urbanization, transport, tourism, and trade) and, directly, the adaptive capacity of species (Kornaś, 1968; Protopopova, 1991; Burda, 1991; Dawson et al., 2017; Chen et al., 2021; Capinhaa et al., 2023). Invasive species are often characterized by aggressive life strategies, so they successfully compete with native species, displacing them and reducing their numbers (Zavialova et al., 2021; Bakacsy et al., 2023). This leads to fragmentation of populations of local species, contamination of the genetic resources of native species (formation of new ecotypes, hybridization), transfer of phytoinfections, disruption of the structure of natural plant communities and ecosystems as a whole (Burda et al., 2015; Protopopova, Shevera, 2019; Goncharenko et al., 2024).

Climatic changes is an additional factor to anthropogenic pressure, which can have a decisive influence on the direction and degree of changes in the state of the vegetation cover, since certain species, both native and alien, can gain advantages for their settlement or limit their spread under such conditions. With climate change, a rapid increase in the number of biological invasions and areas affected by invasions is expected in the future (Didukh et al., 2016; Wan et al., 2016; Commission…, 2022; Puchałka et al., 2023; Yang et al., 2023). This will cause undesirable environmental, economic, and social consequences, and threaten the environmental security of any country and the health of people (Vilà et al., 2010; Haubrock et al., 2021). The severity of the problem is evidenced by the adoption of a number of international legislative acts to prevent the spread of invasive alien species (IAS) (Convention…, 1992; McNeely et al., 2001; Genovesi et al., 2015; Commission…, 2022; Biodiversity strategy for 2030). Many countries of the world have developed national strategies for the prevention and control of invasions on a legislative basis in accordance with the specifics of natural conditions and economic development of countries, which provide for monitoring studies of the spread of adventitious plant species, the assessment of their invasive potential, the degree of naturalization in natural, semi-natural, and anthropogenic habitats (Pyšek, Prach, 2003; Szatmari, 2012; Halford et al., 2014; Burda, 2018).

Given the close relationship between plant introductions and anthropogenic factors, increasing public awareness of the damage and problems that alien species can cause is important to prevent the emergence and spread of invasive alien species (Protopopova et al., 2006, 2015; Chaudhary et al., 2022; Bălăcenoiu et al., 2023; Capinhaa et al., 2023).

In Ukraine, numerous multifaceted studies of the adventitious fraction of the flora have been conducted for a long time, a

methodology for researching the adaptive strategy of alien plant species in an urbanized environment has been developed, monitoring is carried out of the spread of invasive plant species on the territory of protected fund objects, agricultural lands, etc. (Burda, 1991; Kucherevskyi, 2004; Burda, Ignatyuk, 2011; Zavialova, 2017; Shol, 2016; Fedoronchuk et al., 2020; Gubar, Koniakin 2021; Koniakin et al., 2022; Burda et al., 2023). However, the study of invasions of adventitious plant species under the influence of climate change and anthropogenic activity, the development of measures to limit their spread is relevant and will remain so in the future.

Of all the diversity of the adventive flora of Ukraine, invasive species that are capable of spontaneous spread deserve special attention. Some of them are wild introducers that were once brought to Europe from other parts of the world, particularly from North America as food, fodder, technical, medicinal, or ornamental culture. Over time, their spread got out of human control, they began to gradually displace the native flora of the local phytocenoses of many European countries (Pyšek et al., 2012; Protopopova, Shevera, 2019; Capinhaa et al., 2023). One of the representatives of wild introducers of North American origin, which changes the structure of plant communities in natural and transformed habitats in Ukraine and beyond, is *Echinocystis lobata* (Michx.) Torr. and A. Gray (Flora of the USSR, 1961; Vasic, 2005; Priede, 2008; DAISIE, 2014; Flora of North America, 2016; Shol, 2016; Zavialova et al., 2021).

E. lobata is a summer green, rosetteless, tap-rooted herbaceous annual liana, euneophyte, ergasiophyte, agriophyte, sciogeliophyte, invasive, medicinal, decorative, honey weed (Protopopova, 1991; Kucherevskyi, 2004; Didukh et al., 2010; Tarasov, 2012; Kotsun, Kuzmishina, 2016). The species is characterized by entomophilia, anemo-, and hydrochory. It is characterized by a ribbon type of distribution, because the predominant type of spread of diaspores is hydrochory (Vykhor, Prots, 2014). The species has become naturalized in riverside shrubs, as well as forest floodplain complexes. Forms a large biomass, as a result of which it suppresses the renewal and development of aboriginal species, significantly impoverishing biodiversity (Konogray, 2008; Didukh et al., 2016; Protopopova et al., 2015).

In connection with the above, there is an urgent need to assess the dynamics of the current and future distribution of *E. lobata* in Ukraine against the background of climate change, to find out the nature of its influence on plant biodiversity. Based on the obtained data, it is necessary to develop recommendations for limiting its spread in natural and with varying degrees of anthropogenic transformation coenoses.

Material and methods

The study of the distribution of *E. lobata* on the territory of Ukraine was carried out on the basis of the data of our own field studies (174 localities), herbarium materials of scientific institutions of Ukraine (M.G. Kholodny Institute of Botany of the NAS of Ukraine (KW), Institute of Ecology of the Carpathians of the NAS of Ukraine (LWKS), Yuriy Fedkovych Chernivtsi National University (CHER), Donetsk Botanical Garden of the NAS of Ukraine (DNZ), Kryvyi Rih Botanical Garden of the NAS of Ukraine (KRW)) (87), analysis of literary sources (Panchenko, 2005; Zavyalova, 2010; Sychak, 2012; Vykhor, Prots, 2014; Golivets, 2014; Hutsman, Hutsman 2014; Protopopova et al., 2015; Burda et al., 2015; Kotsun, Kuzmishina, 2016; Zavialova, 2017; Tokaryuk et al., 2018) (329), and Internet resources-UkrBIN (https://ukrbin.com) (136) and INaturalist (https://www.inaturalist.org) (426). Our findings *E. lobata* (174), which were studied during 2014–2022, have been uploaded to the iNaturalist database.

The maps of the distribution of *E. lobata* were made by the method of grid mapping according to the "Atlas Florae Europaeae" (1972) method in the MapInfo program environment MapInfo Professional 7.5 (Product-20MIRU750WP Serial Number–MIPWRS0750400147).

Floristic and geobotanical studies were carried out by the route method using ecological and floristic criteria for the description of plant communities (Braun-Blanquet, 1964; Mirkin et al., 2001). The total array of data contains 86 descriptions with the participation of *E. lobata*, carried out on the territory of four natural zones of Ukraine (Ukrainian Carpathians, zones of mixed and broad-leaved forests, Forest-Steppe) (National Atlas of Ukraine, 2007).

The database formation and merging of geobotanical descriptions was carried out in the program Turboveg for Windows v. 2.142a (Hennekens, Schaminee, 2001) with further export to Juice 7.1 (Tichy, 2002). The nomenclature standard of species has been brought into line with the Internet resource "The Euro+Med PlantBase" (https://europlusmed.org/). To identify diagnostic species, the fidelity indicator—the phi coefficient—was used. The confidence threshold for identifying diagnostic species is 25%.

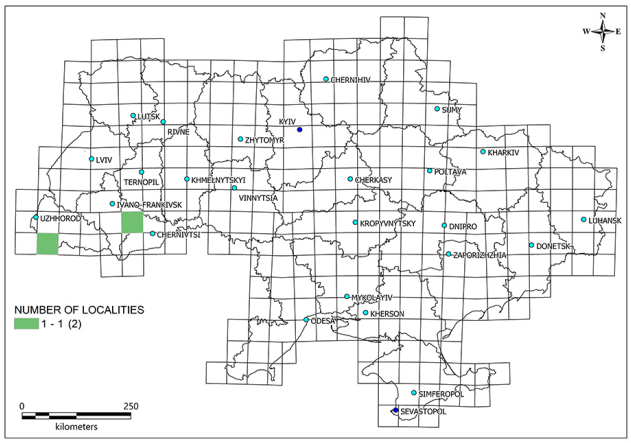
The identification of selected syntaxons was carried out taking into account the works of domestic and foreign phytocenologists (Jarolimek et al., 1997; Solomakha, 2008; Mucina et al., 2016; Dubyna et al., 2019). The group of invasive plants that grow plant habitat with the participation of *E. lobata* was determined using classical methods of flora structure analysis (Meusel et al., 1965; Kornas, 1968; Protopopova, 1991).

Based on the methodology of Didukh (2011) in the environment of the JUICE program (Tichy, 2002), a phytoindicative evaluation of the selected syntaxons was carried out according to the indicators of 12 ecofactors: water regime of the soil (soil humidity) (Hd), variability of damping (fH), acid regime of the soil (acidity) (Rc), saline regime (total salt regime) (Sl), carbonate content in the soil (Ca), the content of assimilated forms of nitrogen (nitrogen content) (Nt), aeration of soil (Ae), thermoclimate (thermomode) (Tm), ombrorezhym (humidity) (Om), continental climate (Kn), severity of winters (cryoclimate) (Cr), and lighting (light in community) (Lc).

The construction of the cyclogram of the distribution of the quantitative indicators of the leading ecofactors and the establishment of the ecological valence of the species were carried out using our own program for automating the process of calculating the point indicators of the ecological factors (Didukh, Budzhak, 2020).

Results

Based on the analysis of herbarium collections, scientific publications, Internet resources, and own observations, 1152 localities have been reliably established on the territory of Ukraine *E. lobata*. As evidenced by the spatiotemporal analysis of the dynamics of the distribution of the species (Fig. 1), its expansion in Ukraine began in the western regions and, to date, has covered



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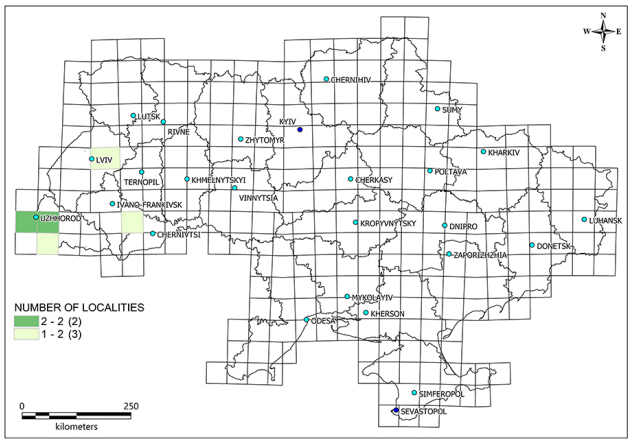
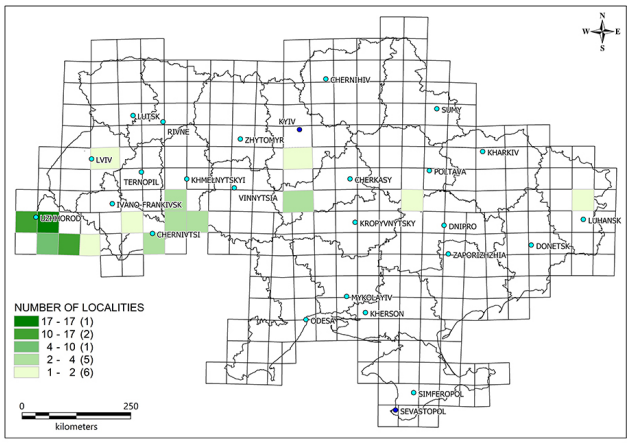
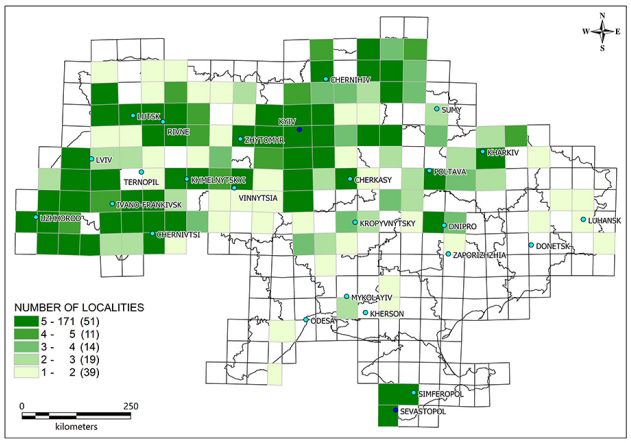


1975



2000



2022

Fig. 1. *Echinocystis lobata* expansion in Ukraine.

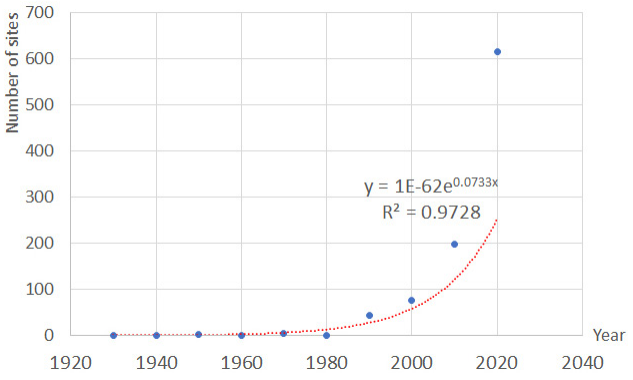


Fig. 2. Dynamics of *Echinocystis lobata* sites detection on the territory of Ukraine.

almost the entire territory. Moreover, it is worth noting the significant distribution of the species in the western and northern parts of Ukraine, which is facilitated by a dense river network and the presence of large territories with excess moisture. In the central, eastern, and southern regions, the advancement of the species is limited, most likely due to the aridity of the climate.

The analysis of the dynamics of the emergence of local growths of *E. lobata* in the last 40 years shows its exponential nature (Fig. 2). Today, this is facilitated by the presence of a large number of potential places (econiches) for its existence, especially in the western, northern, and central regions of the country. It is worth noting that exponential population growth is almost never observed in natural ecosystems. However, if such a fact occurs, it is noted for a short time. Thus, the rapid (geometric) growth of the number of *E. lobata* localities in Ukraine will take on a different, linear or a power-law nature due to a decrease in the number of potential econishes not occupied by it.

Currently, the majority of habitats are recorded in the Ukrainian Carpathians, the zone of mixed and broad-leaved forests, Forest-Steppe (in the western and northern parts). On the other hand, the least number of finds is in the Steppe zone, especially its southern part, which is due to the natural and climatic conditions and ecological requirements for the growth and distribution of this species (Kucherevskyi, 2004; Sychak, 2012; Bagrikova, 2013; Vykhor, Prots 2014; Didukh et al., 2016; Lykholat et al., 2019).

According to the results of our field research and on the basis of literature information (Galchenko, 2006; Lukash, 2008; Protopopova et al., 2015; Didukh, et al., 2016; Zavialova, 2017; Tokaryuk et al., 2018; Zvyagintseva et al., 2019; Lyubinska, Mat-

veev, 2021; Miskova, 2023) a modern syntaxonomic scheme of vegetation with the participation of *E. lobata* on the territory of Ukraine is proposed:

Kl. ***PHRAGMITO-MAGNOCARICETEA*** **KLIKA IN KLIKA ET NOVÁK 1941**
Ord. *Nasturtio-Glycerietalia* Pignatti 1953
All. *Glycerio-Sparganion* Br.-Bl. et Sissingh in Boer 1942
Ass. *Glycerietum fluitantis* Nowiński 1930
Kl. ***MOLINIO-ARRHENATHERETEA*** **TX. 1937**
Kl. ***CARPINO-FAGETEA SYLVATICAE*** **JAKUCS EX PASSARGE 1968**
Ord. *Alno-Fraxinetalia excelsioris* Passarge 1968
All. *Alnion incanae* Pawłowski et al. 1928
Ass. *Ficario-Ulmetum minoris* Knapp 1942
Kl. ***SALICETEA PURPUREAE*** **MOOR 1958**
Kl. ***ALNETEA GLUTINOSAE*** **BR.-BL. ET TX. EX WESTHOFF ET AL. 1946**
Kl. ***RHAMNO-PRUNETEA*** **RIVAS GODAY ET BORJA CARBONELL EX TX. 1962**
Kl. ***FRANGULETEA*** **DOING EX WESTHOFF IN WESTHOFF ET DEN HELD 1969**
Ord. *Salicetalia auri*tae Doing 1962
All. *Salicion cinereae* T. Müller et Görs ex Passarge 1961
Ass. *Salicetum pentandro-cinereae* Passarge 1961
Kl. ***ROBINIETEA*** **JURKO EX HADAČ ET SOFRON 1980**
Ord. *Chelidonio-Robinietalia pseudoacaciae* Jurko ex Hadač et Sofron 1980
All. *Chelidonio-Acerion negundi* L. Ishbirdina et A. Ishbirdin 1991
Ass. *Chelidonio-Aceretum negundi* L. Ishbirdina et A. Ishbirdin 1991
All. *Chelidonio majoris-Robinion pseudoacaciae* Hadač et Sofron ex Vítková in Chytrý 2013
Ass. *Chelidonio*-Robinietum Jurko 1963
Kl. ***EPILOBIETEA ANGUSTIFOLII*** **TX. ET PREISING EX VON ROCHOW 1951**
Ord. *Convolvuletalia sepium* Tx. ex Moor 1958
All. *Senecionion fluviatilis* Tüxen ex Moor 1958
Ass. *Calystegio sepium-Impatientetum glanduliferae* Hilbig 1972
Kl. ***STELLARIETEA MEDIAE*** **TX. ET AL. IN TX. 1950**
Ord. *Papaveretalia rhoeadis* Hüppe et Hofmeister ex Theurillat et al. 1995
All. *Sisymbrion officinalis* Tx. et al. ex von Rochow 1951
Ass. *Erigeronto-Lactucetum serriolae* Lohmeyer in Oberd. 1957
Kl. ***ARTEMISIETEA VULGARIS*** **LOHME YER ET AL . IN TX. EX VON ROCHOW 1951**
Kl. ***GALIO-URTICETEA*** **PASSARGE EX KOPECKÝ 1969**
Kl. ***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. *Bidentetum tripartitae* Miljan 1933

It was established that in the communities of the *Glycerietum fluitantis* Nowiński 1930 association, which are formed in shallow and coastal strips of mesoeutrophic and eutrophic flowing water bodies with sandy, silty-sandy, and muddy-peat bottom sediments, *E. lobata* grows in the coastal strips of water bodies of the Transcarpathian Plain (floodplain Uzh) and the Forest-Steppe (floodplain of the Gnyliy Tikich River). The vegetation cover (total projective cover 75–80%) is dominated by: *Agrostis stolonifera* L., *Bidens frondosa* L., *Carex acuta* L., codominant–*Echinochloa crus-galli* (L.) P. Beauv., *Leersia oryzoides* (L.) Sw., and *Scirpus sylvaticus* L. The number of species in coenoses varies between 12 and 18. A total of 55 species were found in the floristic composition of the association groups, among which there are species with high invasive activity–*Ambrosia artemisiifolia* L., *Bidens frondosa* L., *Impatiens parviflora* DC., *Heracleum sosnowskyi* Manden., *Xanthium orientale* L., *Helianthus tuberosus* L., and *Impatiens glandulifera* Royle.

As part of the communities of the association *Erigeronto-Lactucetum* serriolae Lohmeyer in Oberd. 1957, which forms on compacted nitrified and loose substrates on the meadow salt marshes of the plain part of Ukraine, *Echinocystis lobata* was noted on the plowed floodplain of the Gnyliy Rig River (Cherepki tract, Fig. 3) and in the coastal strip of the Ustya River. In these groups, the species occurs both as single specimens and forms small curtains (up to 15% of the projective cover). Vegetation cover (total projective cover 65–95%) is dominated by: *Cirsium arvense* (L.) Scop., *Argentina anserina* (L.) Rydb., codominate–*Bidens frondosa, Elytrigia repens* (L.) Nevski, and *Phalaroides arundinacea* (L) Rauschert. The number of species in coenoses varies from 10 to 19. In total, species diversity is represented by 45 species. A high percentage of projective coverage is noted for and species-transformers–*Xanthium orientale* and *Bidens frondosa.*

Fig. 3. *Echinocystis lobata* in the floodplain of the Hnyliy Rih river, Rivne region (photo by S. Koniakin, 2022).

Fig. 4. *Echinocystis lobata* along the railway in the city of Smila, Cherkasy region (photo by S. Koniakin, 2021).

Table 1. Phytoindicative assessment of *Echinocystis lobata* in the study.

EDAPHOTOPE																							
Soil water regime (hydromorpha)				**Moistening variability**				**Soil aeration**				**Soil acid regime**				**Salt regime**				**The content of carbonates in the soil**				**The content of absorbable forms of nitrogen**			
Hd				**fH**				**Ae**				**Rc**				**Sl**				**Ca**				**Nt**			
M	**min**	**max**	**SD**	**M**	**min**	**max**	**SD**	**M**	**min**	**max**	**SD**	**M**	**min**	**max**	**SD**	**M**	**min**	**max**	**SD**	**M**	**min**	**max**	**SD**	**M**	**min**	**max**	**SD**
12.33	10.47	15.32	0.89	6.63	5.85	7.54	0.41	7.64	6.22	10.43	0.73	8.10	7.25	8.64	0.24	7.66	6.98	8.54	0.36	6.52	5.23	7.82	0.43	7.19	6.00	8.15	0.39
Hemistenotope				Hemistenotope				Hemistenotope				Hemistenotope				Hemistenotope				Hemistenotope				Hemistenotope			
Hygromesophyte				Hydrocontrasto-phile				Hemiaerophobe				Subacidophile				Semieutroph				Acarbonatophile				Nitrophil			

CLIMATOPE																			
Thermoclimate (thermomode)				**Climate humidity (humidity)**				**Climate continentality (contrast regime)**				**Severity of winters (cryo regime)**				**Lighting**			
Tm				**Om**				**Kn**				**Cr**				**Lc**			
M	**min**	**max**	**SD**	**M**	**min**	**max**	**SD**	**M**	**min**	**max**	**SD**	**M**	**min**	**max**	**SD**	**M**	**min**	**max**	**SD**
10.00	8.00	12.00	0.29	13.50	9.00	18.00	0.40	11.00	6.00	16.00	0.28	8.50	5.00	12.00	0.34	6.50	4.00	9.00	0.38
Hemistenotope				Hemistenotope				Hemieurytop				Hemistenotope				Eurytop			
Submesotherm				Subombrophyte				Subcontinental				Hemicryophyte				Subheliophyte			

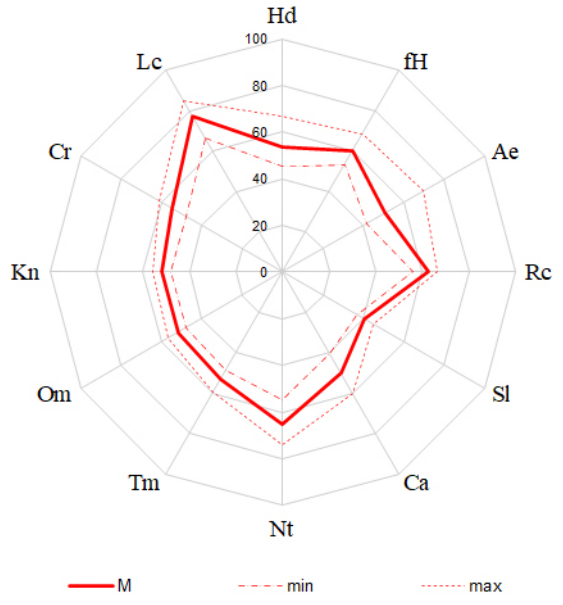


Fig. 5. Potential and realized ecological niches of *Echinocystis lobata* in the study region.
Notes: M – arithmetic mean; Hd – soil humidity; fH – variability of damping; Ae – aeration of soil; Rc – acidity; Sl – total salt regime; Ca – carbonate content in soil; Nt – nitrogen content; Tm – thermal climate; Om – humidity; Kn – continental climate; Cr – cryoclimate; Lc – light in community.

It was found that in the territory of Transcarpathia, Polissia, and Forest-Steppe, *Echinocystis lobata* also penetrates into communities *Chelidonio-Aceretum negundi* that are formed mostly on dense substrates under conditions of sufficient moisture (Fig. 4). It dominates in the tree layer *Acer negundo* L., in the shrub layer–*Rubus caesius* L., *Sambucus nigra* L. The species composition of the groups is represented by 125 species of vascular plants. The grass layer is dominated by *Chelidonium majus* L., *Elytrigia repens, Geum urbanum* L., and *Urtica dioica* L. A well-defined spring synusion of geophytes dominated by *Galium aparine* L. In some localities, the participation of *Echinocystis lobata* in the projective cover can reach 40%. Species with high invasive activity are present in coenoses: *Ambrosia artemisiifolia, Impatiens parviflora*, *Impatiens glandulifera, Heracleum sosnowskyi*, *Helianthus tuberosus, Reynoutria x bohemica* Chrtek and Chrtková, and species-transformers–*Acer negundo*, *Parthenocissus inserta* (A. Kern.) Fritsch.

Based on the phytoindicative assessment that is based on indicators of 12 ecological factors (Table 1), it was established that in the conditions of Ukraine *Echinocystis lobata* is: according to the edaphotope–hemistenotopic hygromesophyte, subacidophile, hemiaerophobe, semieutroph, acarbonatophil, and nitrophil; according to the climatotope–submesotherm, subaridophyte, subombrophyte, subcontinental, subcryophyte, and subheliophyte. It was established that the indicators of water (Hd) and acid (Rc) regimes of the soil, thermal regime (Tm), climate humidity (Om), and lighting regime (Lc) are limiting factors for the ecological niche of *E. lobata* in the conditions of the secondary area of the species in Ukraine (Fig. 5).

Based on the methodological approaches of J. P. Didukh (Didukh, 2011), the reaction of the species to an increase in the average annual air temperature from +1, +2, +3 °C is predicted. The degree of change in indicators of each of 12 ecofactors with increasing temperature relative to the existing amplitude of growth conditions was evaluated. It was determined which of them could become limiting (values exceeding the values of the tolerance range) for the existence of *E. lobata*. If the amplitudes overlap by more than half, then it is considered that there are no threats to the existence of the species, with a 25–50% overlap, there is a threat of reduction, and at 0–25%—a threat of extinction (Fig. 6).

It was found that by +1 °C increase in temperature is not critical for *E. lobata,* since the change in the values of the leading ecofactors does not exceed the values of the tolerance limits of the species and does not go beyond the limits of its ecological niche, or overlap of tolerance zones exceeds 50% (Fig. 6). However, a change in the acidic regime of the soil (Rc) will probably lead to the reduction of the secondary area of *E. lobata* in Ukraine. When the temperature rises by +2 °C, a change in the thermal regime (Tm) will lead to a decrease in the area inhabited by the species under study, and a change in soil acidity (Rc) will cause its existence on the verge of extinction. An increase in temperature by +3 °C will have the greatest impact on the viability of *E. lobata.* Under such conditions, a change in the temperature regime (Tm) and climate humidity (Om) will significantly affect the edaphic properties of the soil, in particular, the water regime (Hd) and carbonate content (Ca), which will lead to a reduction in the secondary area of *E. lobata*, and a change in the acidic regime of the soil (Rc) will cause the species to disappear.

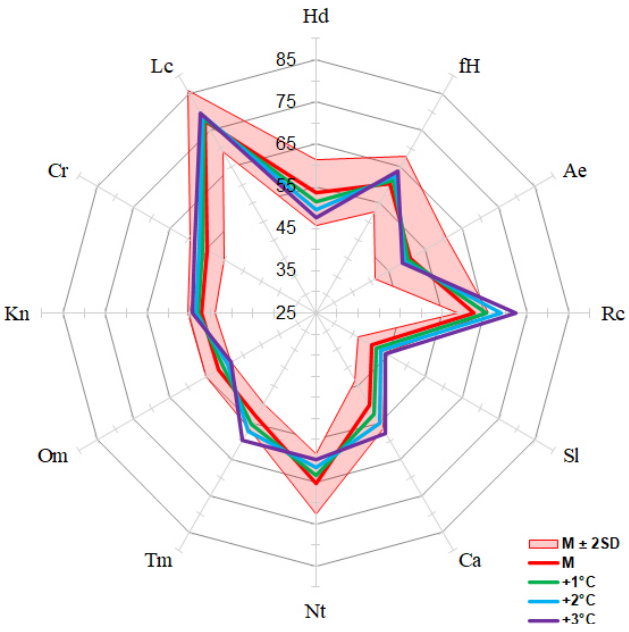


Fig. 6. Cyclogram of changes in ecological indicators of *Echinocystis lobata* when the average annual temperature increases by +1, +2, +3 °C.
Notes: M – arithmetic mean; SD – standard deviation; Hd – soil humidity; fH – variability of damping; Ae – aeration of soil; Rc – acidity; Sl – total salt regime; Ca – carbonate content in soil; Nt – nitrogen content; Tm – thermal climate; Om – humidity; Kn – continental climate; Cr – cryoclimate; Lc – light in community.

Discussion

The primary area of *E. lobata* was formed on the territory of the United States (the entire territory, except for the extreme southwestern and southeastern states) and Canada (provinces of Manitoba, Saskatchewan, Ontario, New Brunswick, Nova Scotia, Quebec City, and Prince Edward Island) (A flora of North America, 1838; Stocking, 1955; Scoggan, 1979). Over time, the species quickly spread and naturalized throughout the United States (Mack, 1991; Flora of North America, 2016).

The beginning of the formation of the secondary area of *E. lobata* in Europe is indicated in the first half of the 20th century. At that time, the species was grown in this territory as an ornamental and medicinal crop in botanical and private gardens, parks, from where the plant spread into natural and seminatural environments (Tokarska-Guzik, 2005). Individual finds of *E. lobata* plants were recorded in Estonia (1807), Hungary (1904), Slovakia (1906), the Czech Republic (1911), Austria (1920), Germany (1922), and Poland (1937) (Hegi, 1917; Pyšek, Prach, 2003; Vasic 2005; Szatmari, 2012; CABI, 2019). After its re-introduction to Europe during the Second World War, *E. lobata* significantly expanded its area. New finds were noted in Poland (1955), Germany (1955), Romania (1955), Bulgaria (1967), Lithuania (1987), Norway (1996), and Sweden (2003) (Tutin et al., 1968; CABI, 2021). In the 1970s, the species covered almost all of Eastern Europe, and later it acquired the status of a potential invasive species in this territory as well (Vasic, 2005). Currently, the secondary range of *E. lobata* covers most of Europe, Siberia, the Far East, Central and East Asia (DAISIE, 2014).

To this day, *E. lobata* is often cultivated as an ornamental plant in gardens and allotments in many countries of the world, even despite the prohibition of cultivation in some of them (Vasic 2005; Commission…, 2022). As a result, it often goes wild and spreads mainly in disturbed biotopes near settlements, and from there it moves to semi-natural and natural habitats similar to the conditions of the primary habitat—coastal zones, floodplain meadows and forests, and wetlands (Protopopova et al., 2006; Priede, 2008).

In Ukraine, the habitat of *E. lobata* was first noted on the territory of Transcarpathia (Dyida village, Berehiv district) in 1933 (Margittai, 1933). Later, in 1946–1947, the species was recorded in the Eastern Carpathians, where it had already naturalized at that time (LE—herbarium of the Botanical Institute named after V. L. Komarova RAS, St. Petersburg, M. G. Popov) (Protopopova, 1973). Generalized data on the localities of *E. lobata* in the regions of Ukraine are described in the Appendix. Further distribution of the species in Ukraine during the period 1950–1960 is indicated only for the Transcarpathian region—on the banks of the Latoritsa, Turya, Uzh rivers, and near the cities of Mukachevo and Uzhhorod (Flora ot the USSR, 1961). In 1965, the species was noted on the territory of the Dnipropetrovsk region (Tarasov, 2012). In the late 1970s, centers of *E. lobata* were discovered in Khmelnytskyi and Chernivtsi regions. In the early 1980s, new localities of *E. lobata* were noted in the Khmelnytskyi region. In the 1990s of the 20th century, *E. lobata* was sporadically distributed throughout Ukraine mainly as an ergasiophyte and, rarely, as an agrophyte (Dnipropetrovsk, Khmelnytskyi, Luhansk, Cherkasy, Chernivtsi, and Donetsk regions), mainly along the banks of the urban rivers (Protopopova, 1991; Burda et. al., 1998; Appendix).

From the beginning of the 21st century until now, further expansion and naturalization of the species has been observed in Ukraine. New habitats of *E. lobata* were found in Chernivtsi, Ivano-Frankivsk, Lviv, Volyn, Rivne, Kyiv, Chernihiv, Kharkiv, Sumy, Luhansk, Cherkasy, Poltava, Khmelnytskyi, and Mykolaiv regions (Koval, 2005; Kuzmyshyna et al., 2021; Appendix). In the Volyn, Zhytomyr, and Chernihiv Polissias, *E. lobata* grows in wooded floodplains of rivers with mosaic vegetation, ditches, shrub-willow thickets, along drainage channels, on drained

eutrophic swamps, roadsides, on forest edges, and near railway tracks (Tarasevich, Orlov, 2013; Protopopova, et al., 2015). For the Middle Dnieper region (within Kyiv, Poltava (partly), and Cherkasy regions), *E. lobata* is indicated in coastal water communities, where the species suppresses the shrub layer and helps to displace heliophyte species (Fedoronchuk et al., 2020). In the city of Poltava and the Poltava region, finds of *E. lobata* plants were recorded among river floodplains and on anthropogenically altered territories (Bayrak, Stetsiuk, 2008; Davydov, Gomlya, 2021). Wild plants of *E. lobata* were also noted among shrubs, on littered places in abandoned villages and in the green zone of cities of the Right Bank Steppe of the Dnieper region (Kucherevskyi, 2004; Shol, 2016; Lykholat et al., 2019). In the Transcarpathian region and the Ukrainian Carpathians, *E. lobata* grows mainly in wet coastal and shrub communities, which causes a negative impact on the phytodiversity of the local flora (Vykhor, Prots 2014; Didukh et al., 2016; Tokaryuk et al., 2018).

In addition, the expansion of *E. lobata* is constantly noted for the objects of the nature reserve fund to this day. The plant is actively spreading in national nature parks: «Bug Gard," "Desniansko-Starohutskyi," "Vyzhnytsia," "Hetman," "Holosiivskyi," "Homilsha Woods," "Hutsulshchyna," "Zalissya," "Ichnia," "Karmelyukove Podillia," "Carpathian," "Mezyn," "Pyriatyn," "Podilsks Tovtry," and "Slobozhanskyi" (Burda et al., 2015). It is also present in nature reserves—Dnieper-Oril, Kaniv, and biosphere reserves—Danube, Carpathian (Panchenko, 2005; Zavialova, 2017). Findings of *E. lobata* were noted in the territory of the regional landscape park "Kremenchuk Plavni" (Poltava region) (Galchenko, 2006). Also, this species has overcome the cenotic barrier and is an aggressive invasive species of the adventive fraction for the objects of the nature reserve fund of the Dnipropetrovsk region (Baranovskyi et al., 2019). In recent years, *E. lobata* has been actively spreading across the territory of the Seymskiy regional landscape park (Sumy region) (Miskova, 2023).

So, *E. lobata* has a significant negative impact on the state of the natural vegetation cover of Ukraine, intensively spreads to new areas, especially along valley–river corridors, expanding the geography of its presence. An important aspect of preventing the introduction and distribution of *E. lobata* is raising public awareness of the harm and consequences of the spontaneous introduction of invasive species. Effective means of slowing down the spread of *E. lobata* are mechanical methods of control (timely weeding, mowing, or uprooting of plants).

Conclusion

Totally, 1152 localities of *E. lobata* have been established in the territory of Ukraine. The syntaxonomic scheme of vegetation with the participation of *E. lobata* includes 13 classes, 7 orders, 8 alliances, and 8 associations. The presence of *E. lobata* in the synanthropic class *Stellarietea mediae* (assoc. *Erigeronto-Lactucetum serriolae*) was noted for the first time. In Ukraine, the studied species has a tendency to spread spontaneously and changes the composition and structure of plant communities. It was found that in the secondary habitat in Ukraine, *Echinocystis lobata* is a hemistenotopic hygromesophyte, subacidophile, semieutrophy, submesotherm, subombrophyte, and subheliophyte. Owing to climate change, the limiting factors for the spread of this species are the thermal regime and the humidity of the climate. The obtained research results expand information about the ecological–coenotic features of the species within the secondary range and can be used to predict the future state of its secondary populations.

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Appendix. The information about herbarium collection of the *Echinocystis lobata* in the regions of Ukraine.

Date	Region/Habitat	Collector/s	Herbarium
Dnipropetrovsk Region			
15.07.1993	Kamianske District, vill. Borodaivka	Kucherevskyi V., Krasova O., Semchuk O.	KRW, s.n.
25.07.2008	Vill. Motronivka, among the thickets of shrubs	Kucherevskyi V., Shol N., Provozhenko T., Tsurenkov A.	KRW, s.n.
25.07.2008	Tomakivka District, vill. Novoukrainka, among the thickets of shrubs	Kucherevskyi V., Shol N., Provozhenko T., Tsurenkov A.	KRW, s.n.
Donetsk Region			
08.09.1978	Druzhkivka, on the fence	Kozlov Ye.L., Burda R.I.	DNZ, s.n.
22.05.1985	Mariupol, railway along the seashore, wet place	Burda R.I., Ostapko V.M	DNZ, s.n.
07.08.1985	Makiivka, vill. Ganzivka, in the wasteland, solid thickets	Hrynievska O.G.	DNZ, s.n.
24.07.1988	Pershotravnevyi district, vill. Melekine, Belosarai Spit	Gumech V.S.	DNZ, s.n.
08.08.1988	Vill. Melekine, among thickets of reeds on the side of the road in the middle of the estuary	Kuskov A.Ye.	DNZ, s.n.
21.09.1990	Railway section between Donetsk and Yasynuvata, in the shrubs	Tokhtar V.K., Bochkin V.V.	DNZ, s.n.
15.08.1991	Donetsk, metallurgical plant, near garden plots	Tokhtar V.K.	DNZ, s.n.
Zhytomyr Region			
11.09.2017	Zhytomyr, in a drainless swamp-saucer on willows	Orlov O., Kushnir L.	KW, 128468
20.09.2017	Zhytomyr, the floodplain of the Kamianka River, in the liquefied floodplain forest	Orlov O., Kushnir L.	KW, 128466
20.09.2017	Vicinity of Radomyshl, the banks of the Teteriv River	Orlov O., Kushnir L.	KW, 128465
22.09.2017	Korosten District, vill. Nedashki, eutrophic swamp	Orlov O., Kushnir L.	KW, 128467
Transcarpathian Region			
28.08.1958	Uzhhorod, Uzh River valley, shrubs	Artemchuk I., Gorokhova Z.	CHER, s.n.
14.07.1960	Uzhgorod, in the shrubs of the Uzh River	Kotov M.	KW, 008457; 008458
Ivano-Frankivsk Region			
26.08.1947	Kolomyia, under the fence	Artemchuk I.	CHER, s.n.
26.07.2002	Verkhovynskyi District, vill. Shibene, Black Cheremosh River valley	Chorney I., Budzhak V.	CHER, s.n.
08.09.2002	Ivano-Frankivsk District, vill. Medukha	Kagalo O.	LWKS, 19903
18.07.2003	Vicinity of vill. Zhuravenky	Nakonechnyy Yu.	LWKS, ON-00040
17.08.2005	Vicinity of vill. Dibrova	Kahalo O., Skybitska M., Andryeyeva O., Bednarska I.	LWKS, 23641
31.08.2009	Vill. Demyaniv, the bank of the Burshtyn Reservoir	Sychak N., Kahalo O.	LWKS, 27737
05.07.2012	Vill. Yaglush	Sychak N.	LWKS, 29138
Kyiv Region			
07.08.2014	Fastiv District, vill. Volitsia, floodplain meadow Unava River	Kolomiychuk V.	KW, 00112691
Luhansk Region			
14.07.1985	Stanytsia-Luhanska District, Kindrashivska-Nova junction railway station	Burda R.S., Kuskov A.E., Hrynievska O.G.	DNZ, s.n.
14.07.1986	Luhansk, park named after May 1, flood of the Luhan River	Burda R.I., Humech V.S., Kharkhota H.I	DNZ, s.n.
24.06.1990	Luhansk, on the shore of the swamp, in the shrubs, Veselenke stop	Ostapko V.M	DNZ, s.n.
01.09.1997	Shchastynskyi District, Stanichno-Luhansk Reserve	Sova T.	KW, 001071
16.01.2004	Dovzhansk district, vill. Cheremshyne	Zavialova L.	KW, 026694
Mykolaiv Region			
15.10.2006	Pervomaisk District, vill. Myhiya, Myhiia, the bank of the Southern Bug River	Kolomiychuk V.	KW, 117935
Poltava Region			
01.08.2013	Myrhorod Bistrict, village Pisky, coast Artopolot River	Olshanskyi I., Dvirna T.	KW, 00109829
02.08.2013	Poltava District, vill. Lelyukhivka, the bank of the Vorona River	Dvirna T.	KW, 00109745

Appendix. Continued.

Date	Region/Habitat	Collector/s	Herbarium
Rivne Region			
27.07.2004	Rivne District, Ostroh, the bank of the Viliia River	Gubar L.	KW, 060804
29.06.2016	vicinity vill. Gubkiv, the bank of the Sluch River	Baransky A.R	KW, s.n.
Sumy Region			
06.08.2013	Konotop District, vill. Nechaiivka, left bank of the Seim River	Burlaka M.	KW, 00109922
Kharkiv Region			
27.07.2013	Kharkiv, Levada railway station	Zvyaginceva K.	KW, 113423
Khmelnytskyi Region			
21.07.1978	Kamianets-Podilskyi District, urban-type vill. Stara Ushytsia	Zaverukha B.	KW, s.n.
22.07.1982	Horodok, roadside	Klots O.	KW, 034301
14.07.1996	Kamianets-Podilskyi, Smotrych River	Kovtun I.	KW, 041754
07.09.1997	Kamianets-Podilskyi, Smotrych River	Kovtun I.	KW, 034407
29.05.1998	Vill. Verbka	Kovtun I.	KW, 034301
03.07.2002	Netishyn, along the banks of the spring	Gubar L.	KW, 060886
16.08.2002	Netishyn, Horyn River	Gubar L.	KW, 060302
Cherkasy Region			
04.07.1999	Uman District, vill. Dmytrushky	Chorna G.	KW, s.n.
26.08.2000	Vill. Vorone, the bank of the Hirskyi Tikych River	Chorna G.	KW, 008457; 008458
18.05.2001	Uman, Umanka River	Chorna G.	KW, 008819
27.05.2001	Zvenyhorodka District, vill. Talyanky, the bank of the Tsymbal pond	Chorna G.	KW, 008818
02.08.2014	Uman, Umanka River	Kolomiychuk V.	KW, 113427
Chernivtsi Region			
25.06.1979	Dnistrovsky District, vill. Rozkopantsi, the bank of the Sokyriany River	Totyul O.	CHER, s.n.
15.06.2000	Chernivtsi, „Zhovtnevyi“ park, stream	Khlystun N.	CHER, s.n.
29.08.2000	Chernivtsi District, vill. Lunka, floodplain of the Prut River	Volutsa O., Volutsa A.	CHER, s.n.
26.05.2003	Chernivtsi, Prut River	Tokariuk A.	CHER, s.n.
14.08.2005	Herts, along the Hertsushka River	Volutsa O.	CHER, s.n.
30.07.2006	Storozhynets, left bank of the Seret River	Tokariuk A.	CHER, s.n.
29.05.2007	Vicinity of vill. Tarasivtsi, landscape reserve „Prut floodplain,“ floodplain forest of the Prut River	Chorney I., Volutsa O., Tokariuk A.	CHER, s.n.
14.07.2007	Vill. Strointsi, Stara Granitsa River valley	Volutsa O., Korzhan K.	CHER, s.n.
19.07.2007	Chernivtsi, fence	Korzhan K.	CHER, s.n.
26.07.2007	Chernivtsi, along the road	Korzhan K., Volutsa O.	CHER, s.n.
16.08.2007	Chernivtsi District, shrubs along the Hertsushka River	Volutsa O., Lytvyn N.	CHER, s.n.
05.09.2007	Chernivtsi, along the railway track	Chorney I., Tokaryuk A., Volutsa O., Korzhan K.	CHER, s.n.
11.09.2007	Chernivtsi, side of the street	Korzhan K., Tokariuk A.	CHER, s.n.
16.09.2007	Storozhynets	Tokariuk A.	CHER, s.n.
21.07.2008	Chernivtsi, planting trees	Korzhan K.	CHER, s.n.
22.07.2008	Chernivtsi Airport	Korzhan K.	CHER, s.n.
29.07.2008	Urban-type settlement Hlyboka, along the railway track	Tokariuk A., Lytvyn N.	CHER, s.n.
05.08.2008	Vill. Kamianka, „Bugaets“ protected tract, edge of an oak forest	Chorney I., Budzhak V., Tokariuk A., Korzhan K., Kazemirska M.	CHER, s.n.
08.08.2008	Chernivtsi, the bank of the Prut River	Tokariuk A., Korzhan K., Bucha O.	CHER, s.n.
31.07.2009	Vill. Bila Krynytsia, Varnytsia tract	Tokariuk A.	CHER, s.n.
14.08.2009	Vill.Verkhni Sinivtsi, near the gardens	Chorney I.	CHER, s.n.
15.08.2010	Vicinity of vill. Lunka	Volutsa O., Tkachuk S.	CHER, s.n.
15.09.2010	Vill. Molnytsia, valley of the Molnytsia River	Volutsa O.	CHER, s.n.

Appendix. Continued

Date	Region/Habitat	Collector/s	Herbarium
21.05.2014	Vill. Bancheny, a spontaneous dump near the bus stop	Volutsa O.	CHER, s.n.
25.07.2014	Vill. Ostrytsia, on the banks of the Dereluy River	Volutsa O.	CHER, s.n.
25.07.2014	Vill. Horbova, the bank of the Molnytsia River	Volutsa O.	CHER, s.n.
25.07.2014	Vill. Godynivka, thickets of shrubs on the bank of a stream	Volutsa O.	CHER, s.n.
07.09.2014	Along the reclamation channel between the vill. of Horbivtsi and Terebleche	Chorney I.	CHER, s.n.
07.09.2014	Vill. Bairaky, shrubs on the bank of the tributary of the Molnytsia River	Volutsa O.	CHER, s.n.
07.09.2014	Vicinity of vill. of Pidvalne, thickets of reeds on the banks of a stream	Volutsa O.	CHER, s.n.
28.09.2014	Vill. Prosika, the bank of the tributary of the Seret River	Volutsa O.	CHER, s.n.
12.07.2015	Vill. Velykosilya, the bank of the tributary of the Baranka River	Volutsa O., Tkachuk S.	CHER, s.n.
19.08.2016	Vicinity of vill. Kulykivka, on the slopes of the ravine	Volutsa O.	CHER, s.n.
Chernihiv Region			
10.06.2001	Chernihiv, city park of recreation	Zavialova L.	KW, 00111166
07.07.2001	Chernihiv, Park Cordivka	Zavialova L.	KW, 00111163; 00111167
27.07.2001	Chernihiv, Liskovytskyi sand quarry	Zavialova L.	KW, 00111165
15.09.2012	Pryluky District, vill. Luchkivka, a beam near the gardens	Shyian N., Zavialova L.	KW, 00106352; 00106351