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Alien weed *Xanthium spinosum* in Slovakia II: ecological requirements and coenotic affinity

Nepôvodná burina *Xanthium spinosum* na Slovensku II: ekologické nároky a cenotická afinita

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ABSTRACT

Xanthium spinosum is a noxious weed spreading from South America to almost all the whole world. In this study, we focused on ecological demands and coenotic affinity of *X. spinosum* in Slovakia. Analyses were performed on the basis of 20 own, unpublished as well as published phytosociological relevés and Borhidi's ecological indication values. The results show that *X. spinosum* prefers sunny to semi-shadow areas on mesotrophic and moderately nutrient rich soils in semidry, sub-montane as well as thermophilous habitats in a wide range of climatic conditions from oceanic and sub-oceanic to subcontinental. It was mainly recorded in ruderal vegetation units of class *Stellarietea mediae*, however, the species has occurred in the stands of classes *Bidentetea* and *Molinio-Arrhenatheretea*. It is expected to occur in other plant ruderal communities as well.

Keywords: weeds, Central Europe, communities, ecological requirements, introduced species

ABSTRAKT

Xanthium spinosum je škodlivá burina šíriaca sa z Južnej Ameriky takmer do celého sveta. V predloženej štúdii sme sa zamerali na ekologické požiadavky a cenotickú afinitu tohoto druhu na Slovensku. Analýzy boli vykonané na základe dvadsiatich vlastných, nepublikovaných a publikovaných fytocenologických snímok a ekologických indikačných čísiel podľa Borhidiho. Výsledky ukazujú, že *X. spinosum* uprednostňuje výslnné až mierne zatienené miesta na mezotrofných až na živiny mierne bohatých pôdach v mezofilných podhorských i nížinných biotopoch v širokej škále klimatických podmienok od oceánických a sub-oceánických až po subkontinentálne. Druh bol najčastejšie zaznamenaný hlavne v ruderálnych spoločenstvách triedy *Stellarietea mediae*, avšak vyskytoval sa i v porastoch tried *Bidentetea* a *Molinio-Arrhenatheretea*. Očakáva sa, že sa vyskytne aj v iných ruderálnych rastlinných spoločenstvách.

Kľúčové slová: buriny, stredná Európa, spoločenstvá, ekologické nároky, introdukovaný druh

INTRODUCTION

According to Greuter (2006), the genus *Xanthium* is represented by five plant species in Europe. Only one of them, namely *Xanthium strumarium* L., is indigenous (as archeophyte) in Central Europe, while *X. ambrosioides* Hook. & Arn., *X. orientale* L., *X. pungens* Wallr., and *X. spinosum* L. belong to noxious alien weeds (Marhold and Hindák, 1998; Terpó et al., 1999; Danihelka et al., 2012). In Slovakia, naturalised neophytes *X. orientale* and *X. spinosum* are present (Medvecká et al., 2012) and are important weeds, for example, in sugar beet (Tóth and Sikora, 2016).

The native range of *Xanthium spinosum* is in subtropical South America, including Argentina, Bolivia, Chile, Ecuador, Peru, Uruguay, and southern Brazil. As a noxious weed, the species has spread over the continent north and southward (Löve and Dansereau, 1959; Holm et al., 1977). Nowadays, it is the second most commonly distributed weed in Europe, Australia, northern and southern Africa, and North America. The weed prefers semi-arid and arid environments in sub-tropical and temperate areas of the world; however, it can also be found in the tropics (Pitcher, 1989; Strother, 2006).

A survey of occurrence and habitat analysis of *X. spinosum* in Slovakia was currently studied by Dudáš and Eliáš (2020), however, the analysis of ecological requirements as well as coenotic affinity have not yet been carried out. Therefore, this study builds on the above article on distribution and habitats to a) characterize ecological requirements of *X. spinosum* stands using indication values, and b) describe its coenological affinity in Slovakia.

MATERIALS AND METHODS

Twenty phytosociological relevés were used for the analysis of ecological requirements of *Xanthium spinosum*. Indication values for light, humidity, temperature, soil reaction, continentality, and nutrients are based on the work of Borhidi (1995) which includes most of the species present in Central Europe. Indication values are shown on histograms processed in Statistica7 programme (Hilbe, 2007) with mean, standard deviation, maximum and minimum value. These values were calculated as the average values of all species present in the relevé. The resulting indication values of phytosociological relevés were weighted by the cover of individual species that occurred in the area. The calculated ecological indication values represent the characteristics of the habitat of the sampled community and thus also express the demands of the individual species that inhabit it, especially those that are dominant in the community.

Coenotic affinity of *Xanthium spinosum* was processed using eight own original relevés sampled in 2013 and 2018 as well as twelve relevés from the Central database of phytosociological samples (CDF) stored at the Institute of Botany of the Slovak Academy of Sciences (Hegedüšová, 2007). All phytosociological relevés were sampled using the Braun-Blanquet approach (Braun-Blanquet, 1964). Nomenclature of syntaxa follows Jarolímek and Šibík (2008). If the community is not mentioned in this work, it is present with the author(s) and year of the description. Flowering plant nomenclature follows Marhold and Hindák (1998).

RESULTS AND DISCUSSION

Ecological requirements

The determination of ecological requirements according to ecological indicative values (Borhidi, 1995) reflects the requirements of the community and thus indirectly the requirements of its individual species (especially those that are dominant). Therefore, based on the analysis of 20 phytosociological relevés, *Xanthium spinosum* was confirmed heliophilous plant mostly living in full light, but it can tolerate slight shade in terms of light requirements (Figure 1). For this reason, it competes with relatively tall agricultural crops such as cotton (Auld and Say, 1999).

In observing moisture, temperature and continentality, the species prefers semidry, sub-montane as well as thermophilous habitats in a wide range of climatic conditions from oceanic and sub-oceanic to subcontinental (Figure 2, 3, 4).

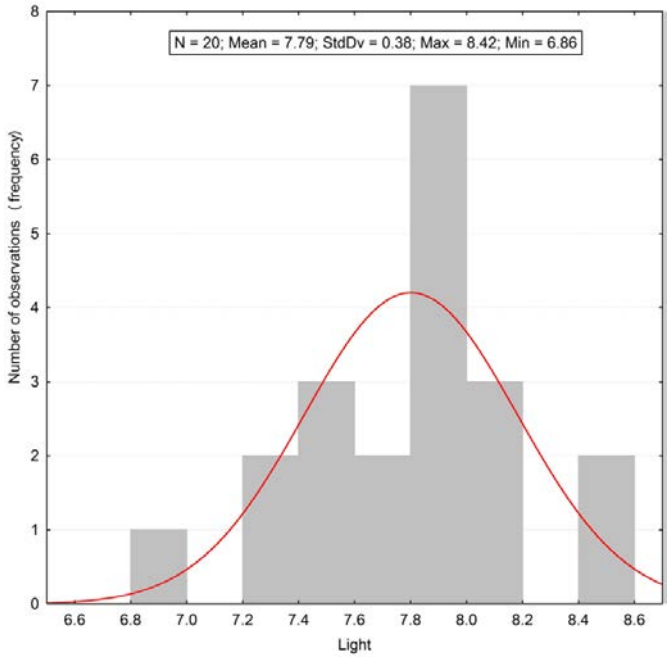

Figure 1. The histogram of *Xanthium spinosum* ecological requirements for light based on Borhidi's 9-grade scale from the full shadow to full light conditions

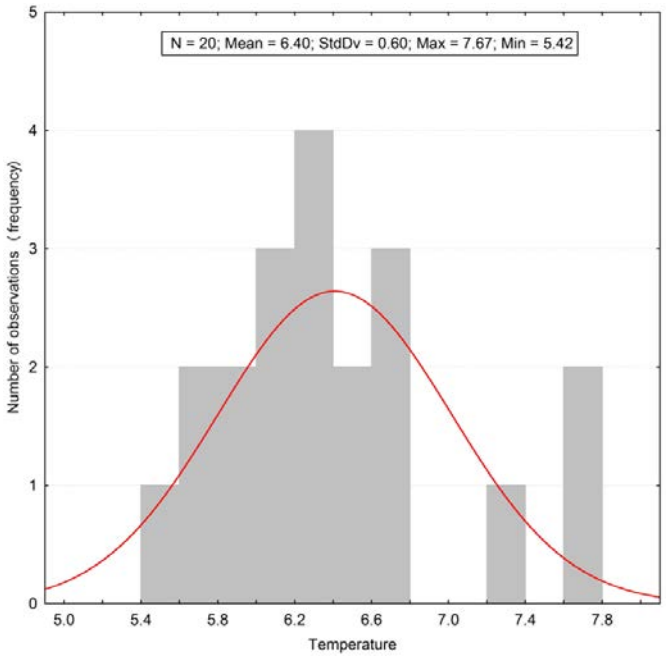

Figure 3. The histogram of the *Xanthium spinosum* ecological requirements for temperature based on Borhidi's 9-grade scale from the coldest to the warmest conditions

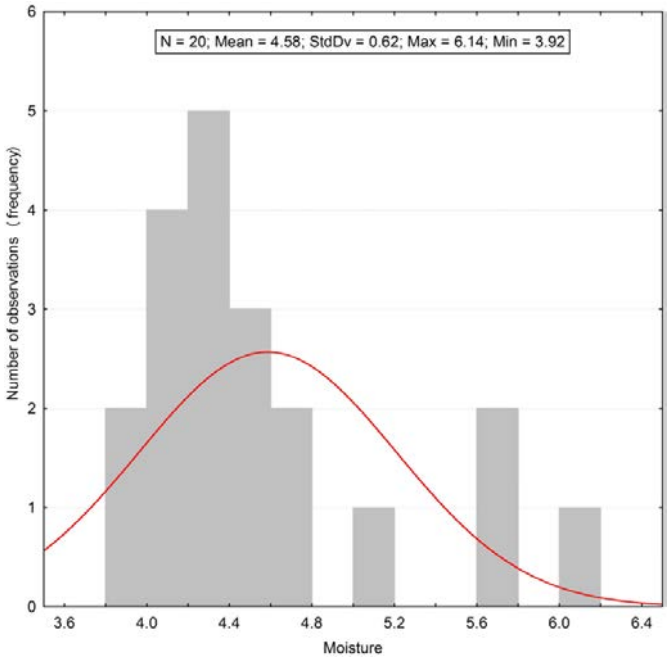

Figure 2. The histogram of the *Xanthium spinosum* ecological requirements for moisture based on Borhidi's 12-grade scale from the driest to the most humid conditions

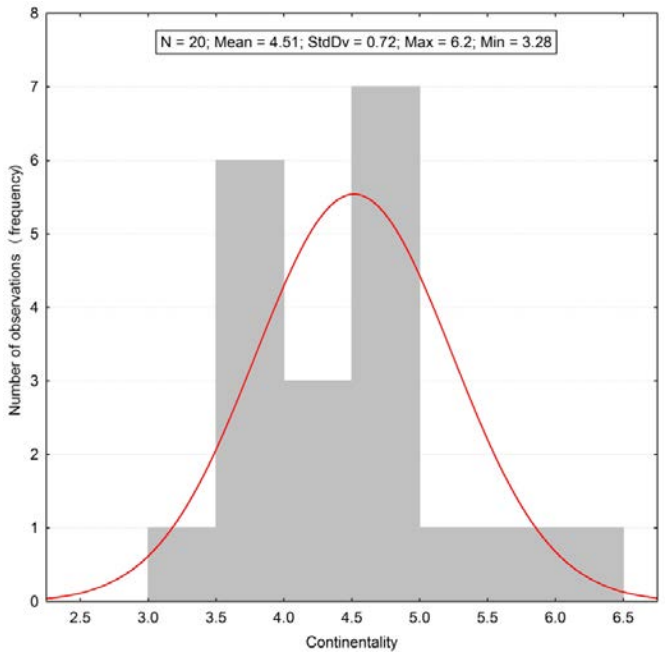

Figure 4. The histogram of the *Xanthium spinosum* ecological requirements for continentality based on Borhidi's 9-grade scale from Eu-oceanic species to continental species

The analysis showed that the species is not demanding on nutrients in the soil. It can be considered as a slightly baziphilous as well as generally pH widely tolerant plant of mesotrophic and moderately nutrient rich soils (Figure 5, 6). This explains the great success of the species colonizing new habitats almost everywhere in the world, from marine coastal areas to desert grasslands and oases (Parsons and Cuthbertson, 1992; Song et al., 2012).

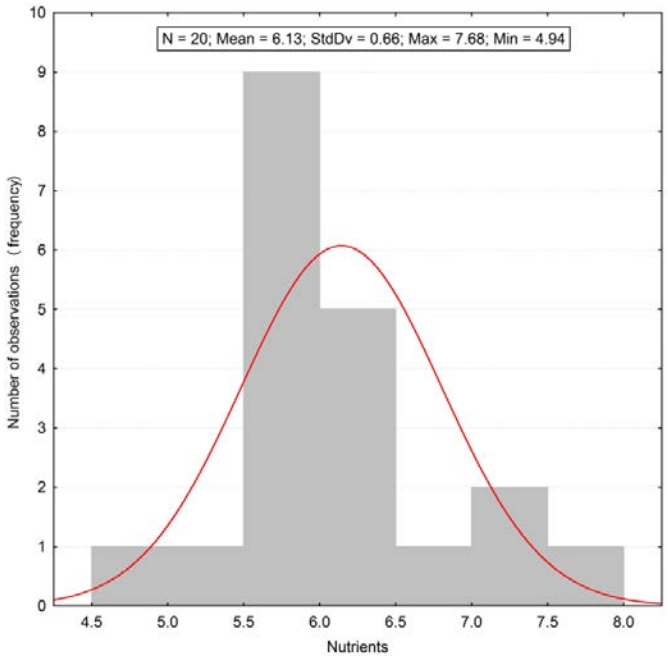

Figure 5. The histogram of the *Xanthium spinosum* ecological requirements for soil nutrients based on Borhidi's 9-grade scale from soils extremely poor to nitrogen to hyper fertilized soils

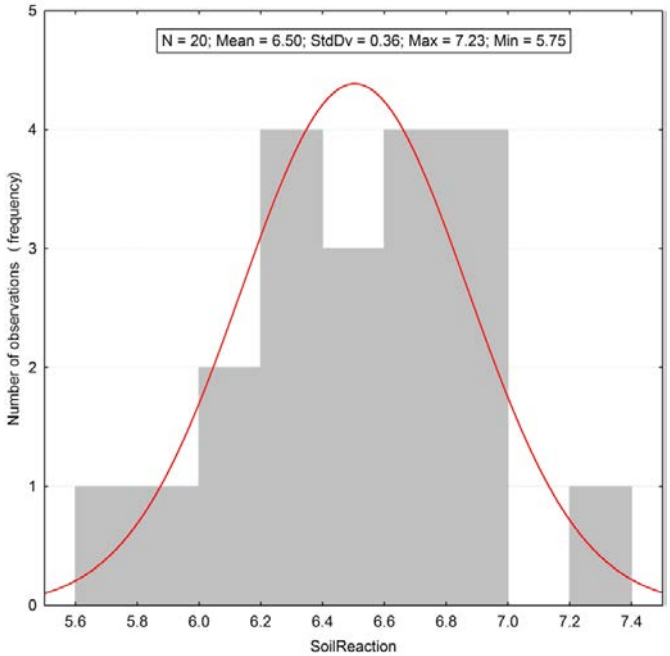

Figure 6. The histogram of the *Xanthium spinosum* ecological requirements for soil reaction (pH) based on Borhidi's 9-grade scale from extremely acidic to explicitly calcareous sites

Coenotic affinity

Only 20 phytosociological relevés (12 relevés from CDF and 8 own relevés) sampled in Slovakia were available for the analysis of *Xanthium spinosum* vegetation types. The results showed that the species can be found in ruderal vegetation of four classes in Slovakia: *Artemisietea vulgaris*, *Polygono arenastri-Poetea annuae*, *Stellarietea mediae* and *Bidentetea tripartiti* (Tab. 1, 2). It has been most common in annual vegetation of arable land and in ruderal habitats of the class *Stellarietea mediae*, mainly in the alliance *Malvion neglectae* representing annual nitrophilous ruderal stands of low prostrate herbs where five associations with presence of *X. spinosum* were identified (Tab. 1, 2). Of these, stands of the association *Xanthietum spinosi* were only confirmed recently in Slovakia (rels. 14 – 16 in Tab. 1). The association is species poor and dominance of *X. spinosum* is characteristic. It was moderately distributed in southern regions of Slovakia at the end of the 20th century where it spread from Hungary (Eliáš, 1978, 1981, 1986; Krippelová, 1981; Jarolímek et al., 1997). After the collapse of communism, the weed community has become rare and disappeared from many sites (e.g. Eliáš, 2017) due to the reduction of animal production (and cattle grazing) in southern Slovakia (Vězík et al., 2017; Némethová and Civáň, 2017). In Hungary, the community remained more common and it occupied especially overgrazed and trampled sites (Borhidi et al., 2012). Solomacha et al. (1986) reported it as a common in NE Ukraine.

Except for the alliance *Malvion*, *X. spinosum* was also recorded in communities of three other alliances of this class (*Atriplicion nitentis*, *Eragrostio-Polygonion arenastri*, *Eragrostion*). In most cases the previously mentioned data of several authors were confirmed (e.g. Eliáš, 1978, 1981, 1986; Krippelová, 1981; Mucina, 1987; Jarolímek et al., 1997), however, the occurrence of *Xanthium spinosum* in alliance with *Eragrostion* is new to Slovakia. The species were recorded here in the association *Setario pumilae-Hibiscetum trioni* Lososová in Chytrý 2013 (relevé 11 in Tab. 1). For this weed community, the dominant occurrence of *Hibiscus trionum* is characteristic.

Table 1. Plant communities with presence of *Xanthium spinosum* in Slovakia

Relevé No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Relevé plot size [m²]	30	30	6	10	3	10	10	7	9	-	150	16	16	16	9	10	16	16	16	16
Number of species	44	26	9	14	30	34	30	29	11	20	19	10	10	8	12	12	19	23	4	4
Coverage E1 [%]	100	100	100	95	90	100	100	90	90	-	65	80	100	90	70	80	85	100	5	25
Xanthium spinosum	+	1	1	+	1	+	r	3	+	+	+	2	2	5	2	3	2	2	+	+
Diagnostic and constant species of class *Artemisietea vulgaris*																				
Artemisia vulgaris	+	+	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	2	.	.
Ballota nigra	1	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Carduus acanthoides	+	.	.	.	1	1	1	1	.	+	.	.	r	.	.	.	+	.	.	.
Convolvulus arvensis	+	+	.	.	.	+	+	.	.	.	1	.	.	.	.	.	+	.	.	.
Plantago lanceolata	1	.	+	+	.	1	1	1	.	.	.	2	.	.	.	.	.	.		
Reseda lutea		.	.	.	.	+	+	+	+	.	+	.	.	.	.	.	.	.	.	.
Tripleurospermum inodorum	.	.	1	2	.			.	.	.	.	.	+	.	.	.	.	1		
Urtica dioica	+	.	.	.	.	.	+	+	.	.	.	2	3	2	2	+	.	.	.	.
Diagnostic and constant species of class *Bidentetea tripartiti*																				
Echinochloa crus-galli	.	.	.	.	.	.	.	.	.	.	2	.	.	+	+	1	.	.	.	.
Plantago major	.	+	.	+	.	.	.	.	.	.	.	.	.	.	+	.	2	.		
Diagnostic and constant species of class *Stellarietea mediae*																				
Polygonum aviculare agg.	.	.	+	3	+	1	1	1	3	1	1	.	.	.	2	.	2	2	.	2
Amaranthus retroflexus	.	.	+	1	+	r	r	r	+	.	.	.	.	.	2	3	.	.+		
Anagallis arvensis	+	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Atriplex patula	+	.	2	1	+	+	+	.	.	.	.	.	.	.	.	.	+	2		
Capsella bursa-pastoris	.	.	.	.	+	+	+	+	.	3	.	.	.	+	.	.	.	.	.	.
Cirsium arvense	.	+	.	.	.	.	.	.	.	.	1	.	.	r	.	.	.	.		
Geranium pusillum	+	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.

Continued																					
Chenopodium album agg.	.	+	.	.	.	.	.	.	+	.	1	.	.	.	2	+	+	+			
Chenopodium opulifolium	+	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	
Veronica polita	+	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.			
Other species																					
Lolium perenne	+	.	.	+	+	+	+	.	.	1	.	2	.	.	.	.	.	2	.	.	
Matricaria discoidea	1	.	.	.	3	2	1	1	.	.	.	.	.	.	+	.	.	.			
Anthemis cotula	2	.	.	.	3	4	4	3	.	.	.	.	.	.	.	.	.	.	.	.	
Achillea millefolium agg.	1	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	1	.	.	
Trifolium repens	.	.	.	.	+	.	.	.	.	.	.	2	2	.	.	.	.	.	.	1	
Marrubium peregrinum	4	.	.	.	+	+	.	1	.	.	.	.	.	.	.	.	.	.			
Medicago lupulina	+	.	.	.	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	
Potentilla anserina	.	.	.	.	+	+	.	.	.	.	.	2	2	.	.	.	.	.			
Salvia nemorosa	+	.	.	.	1	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	
Conyza canadensis		.	.	.	.	+	+	+	+	.	.	.	.	.	+.	.	.	.	.	.	
Onopordum acanthium	r	r	.	.	.	r	.	+	.	+	.	.	.	.	.	.	.	.			
Verbascum densiflorum	+	.	.	.	r	+	+	+	.	+	.	.	.	.	.	.	.	.			
Malva neglecta	.	.	.	.	+	.	1	.	.	2	.	.	.	.	2	.	.	.			
Hyoscyamus niger	.	.	.	.	.	.	+	+	.	2	.	.	.	.	.	1.	.	.			
Rumex obtusifolius	+	.	.	.	+	+	.	.	.	.	.	.	r	.	.	.	.	.	.	.	
Malva pusilla	.	.	5	4	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	
Solanum nigrum										1					+	2			.	.	
Atriplex tatarica	.	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	
Arctium sp.	.	.	+	1	.	r	.	.	.	.	.	.	.	.	.	.	.	.			
Potentilla argentea	+	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	
Leonurus cardiaca	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.			
Rorippa sylvestris	.	+	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	

Continued

Poa annua	.	.	.	.	.	+	.	+	.	1	.	.	.	.	.	.	.	.			
Verbena officinalis	1	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.			
Galinsoga parviflora	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	
Lepidium ruderale	.	.	.	+	.	.	.	.	r	.	+	.	.	.	.	.	.	.	.	.	

Species recorded in two relevés only: *Acosta rhenana s. lat.* r (1), r (2); *Ambrosia artemisiifolia* 2 (17), 2 (18); *Anagallis foemina* + (8), 2 (10); *Anchusa officinalis* + (2), + (10); *Arctium minus* r (7), r (8); *Atriplex prostrata* ssp. *latifolia* + (11), 2 (18); *Berteroa incana* + (1), + (7); *Cichorium intybus* + (2), + (18); *Diplotaxis muralis* + (5), + (7); *Erodium cicutarium* r (5), + (7); *Eryngium campestre* 1 (1), + (6); *Glechoma hederacea* 1 (1), 2 (13); *Chenopodium hybridum* r (1), + (11); *Ch. vulvaria* r (1), r (7); *Lactuca serriola* r (17), r (18); *Lycopus europaeus* + (2), r (14); *Medicago falcata* + (1), + (8); *Mercurialis annua* + (1), + (8); *Persicaria hydropiper* 2 (17), r (18); *P. lapathifolia* r (5), r (6); *Potentilla reptans* r (7), r (8); *Sonchus oleraceus* 1 (2), r (17); *Urtica urens* + (10), + (15); *Xanthium albinum* agg. + (17), + (18);

Species recorded in one relevé only: *Abutilon theophrasti* r (17); *Althaea officinalis* 2 (12); *Amaranthus blitoides* 1 (9); *Anthemis arvensis* + (10); *Arctium lappa* r (18); *Arenaria serpyllifolia* + (10); *Artemisia absinthium* + (10); *Atriplex sagittata* r (18); *Bassia scoparia* ssp. *scoparia* + (11); *Bidens frondosus* (17); *Brassica napus* + (18); *Bromus hordeaceus* + (1); *B. sterilis* + (1); *B. tectorum* + (1); *Calamagrostis epigejos* r (2); *Calystegia sepium* r (12); *Cardaria draba* 1 (1); *Conium maculatum* r (4); *Cuscuta epithymum* + (11); *Cynodon dactylon* + (9); *Cynoglossum officinale* 2 (10); *Dactylis glomerata* + (19); *Datura stramonium* 1 (11); *Daucus carota* 1 (2); *Descurainia sophia* + (10); *Echinocystis lobata* + (17); *Echium vulgare* 2 (2); *Elytrigia repens* + (2); *Eragrostis minor* + (9); *Galium aparine* r (6); *Heleochloa schoenoides* + (11); *Helianthus annuus* + (11); *Hibiscus trionum* 3 (11); *Chenopodium ficifolium* 1 (17); *Ch. glaucum* 1 (16); *Ch. urbicum* 1 (11); *Iva xanthiifolia* r (18); *Lamium purpureum* + (1); *Lappula squarrosa* 2 (10); *Lathyrus tuberosus* r (2); *Lycopersicum esculentum* + (16); *Matricaria chamomilla* + (2); *Melilotus officinalis* 4 (2); *Nepeta nuda* + (10); *Oenothera* sp. + (2); *Pastinaca sativa* 1 (2); *Persicaria maculosa* r (1); *Phalaris arundinacea* r (17); *Poa bulbosa* 2 (10); *P. compressa* + (2); *P. pratensis* 2 (1); *Populus alba* r (12); *Portulaca oleracea* 3 (9); *Raphanus sativus* + (6); *Reseda phyteuma* + (5); *Rubus caesius* 2 (15); *Rumex crispus* + (7); *R. stenophyllus* 1 (11); *Securigera varia* + (1); *Setaria pumila* + (18); *Silene latifolia* ssp. *alba* + (1); *Sisymbrium loeselii* + (2); *S. officinale* r (13); *Sonchus arvensis* + (2); *Stachys annua* + (1); *S. germanica* + (10); *Taraxacum* sect. *Ruderalia* + (4); *Tithymalus helioscopia* r (7); *T. peplus* + (10); *Tragus racemosus* + (9); *Trifolium hybridum* r (18); *Verbascum phlomoides* 2 (2); *Veronica persica* r (1); *Viola arvensis* + (5); *Xanthium strumarium* 2 (2); *Zea mays* 2 (11);

Localities of original relevés and unpublished relevés / references to published relevés in Tab. 1

1. Tab. 8, relevé 1 in Mucina (1981).
2. Považský Inovec Mts., Koplotovce, near the futball playground, area 30 m^2, aspect SE, slope 15°, 145 m a. s. l., 12. 7. 1978, L. Mucina, unpublished.
3. and 4. Tab. 3, relevés 1 and 2 in Mucina (1987).
5. – 8. Tab. 4, relevés 1 – 4 in Mucina (1987).
9. Podunajská nížina Lowland, Marcelová, place near sheepfold, area 9 m^2, aspect S, slope 5°, 120 m a.s.l., 47°47'17.8"N 18°18'42.4"E, 17. 9. 1982, L. Mucina ined.
10. relevé in page 121 in Klika (1935).
11. Podunajská nížina Lowland, Močenok, site Široké ca 2,5 km SW from the village, midden, area 150 m^2, 115 m a. s. l., 48°12'05.0"N 17°54'22.1"E, 12. 9. 2013, P. Eliáš jun.
12. Východoslovenská nížina Lowland, Zemplínske Hradište, edge of pasture on the bank of Ondava River, sheep and goats grazing, clay soil, area 16 m^2, 101 m a.s.l., 48°35'23.8"N 21°47'57.7"E, 7. 7. 2018, M. Dudáš.
13. Východoslovenská nížina Lowland, Zemplínske Hradište, pasture under dam, area 16 m^2, 107 m a.s.l., 48°35'33.7"N 21°47'51.5"E, 7. 7. 2018, M. Dudáš.
14. Východoslovenská nížina Lowland, Zemplínske Hradište, clay soil on bank of Ondava River, area 16 m^2, 103 m a.s.l., 48°35'40.3"N 21°47'50.4"E, 7. 7. 2018, M. Dudáš.
15. and 16. Tab. 19, relevés 1 and 2 in Krippelová (1981).
17. Východoslovenská nížina Lowland, Brehov, clay soil on bank of Ondava River (under bridge), area 16 m^2, 103 m a.s.l., 48°29'11.3"N 21°49'14.2"E, 7. 7. 2018, M. Dudáš.
18. Východoslovenská nížina Lowland, Zemplín, abandoned pasture (grazed by steppe cattle), area 16 m^2, 105 m a.s.l., 48°26'11.9"N 21°48'19.6"E, 8. 7. 2018, M. Dudáš.
19. Východoslovenská nížina Lowland, Streda nad Bodrogom, site Veterné piesky, pasture (sheep) on sand, area 16 m^2, 105 m a.s.l., 48°22'26.2"N 21°46'25.3"E, 8. 7. 2018, M. Dudáš.
20. Východoslovenská nížina Lowland, Zemplínske Hradište, field roadside on pasture, area 16 m^2, 101 m a.s.l., 48°35'39.2"N 21°47'50.2"E, 7. 7. 2018, M. Dudáš.

In addition to this, numerous weed species as well as halophilic and subhalophilic plants are presented (e.g., *Atriplex prostrata*, *Heleochloa schoenoides*). The association is developed on former occasionally flooded saline grasslands and occupies fields with various crops (cereals, sunflower, sugar beet or maize), stubble fields and field margins (Němec et al., 2011; Lososová, 2013). Jarolímek et al. (1997) presented similar, but not identical association *Hibisco trioni-Eragrostietum poaeoidis* in southern Slovakia. This community occupies stands of vegetable crops (pepper, cucumber) and special crops (tobacco) and *X. spinosum* did not occur here.

The species was recorded relatively frequently in stands of class *Artemisietea vulgaris*, alliance *Onopordion acanthii*. Here, it was mentioned in two associations: *Lapullo echinatae-Cynoglossetum* (Klika, 1935) and *Salvio nemorosae-Marrubietum peregrine* (Mucina, 1981). Within this class, *X. spinosum* was recorded also in stands of alliance *Dauco-Melilotion*, association *Odontito-Ambrosietum artemisifoliae* (Tab. 1, relevé 18). The community is developed in gravelly and permeable soils on embankments, soil deposits and along roads (Jarolímek et al., 1997).

Table 2. Survey of plant communities with occurrence of *Xantium spinosum* in Slovakia (numbers of relevés corresponding with Tab. 1)

Class	Aliance	Association	Reference
Artemisietea vulgaris	*Onopordion acanthii*	*Lapullo echinatae-Cynoglossetum*	relevé 10 in Tab. 1 (Klika, 1935)
		Salvio nemorosae-Marrubietum peregrini	relevés 1 and 2 (Mucina, 1981),
	Dauco-Melilotion	*Odontito-Ambrosietum artemisiifoliae*	original data, relevé 18
Bidentetea tripartiti	*Chenopodion rubri*	*Chenopodietum ficifolii*	original data, relevé 17
Molinio-Arrhenatheretea	*Potentillion anserinae*	*Potentilletum anserinae*	original data, relevés 12 and 13
Polygono arenastri-Poetea annuae	*Matricario matricarioidis-Polygonion arenastri*	*Poo annuae-Coronopetum squamati*	Jarolímek et al. (1997)
		Matricario-Polygonetum arenastri	original data, relevé 20
Stellarietea mediae	*Atriplicion nitentis*	*Artemisietum annuae*	Jarolímek et al. (1997)
		Ivaetum xanthiifoliae	Jarolímek et al. (1997)
	Eragrostio-Polygonion arenastri	*Polygono-Portulacetum oleraceae*	Eliáš (1978, 1981, 1986), Jarolímek et al. (1997), relevé 9 (Mucina, 1982 ined.)
	Eragrostion	*Setario pumilae-Hibiscetum trioni Lososová in Chytrý 2013*	original data, relevé 11
	Malvion neglectae	*Hyoscyamo nigri-Malvetum neglectae*	Jarolímek et al. (1997)
		Chenopodio-Xanthietum strumarii	Jarolímek et al. (1997)
		Malvetum pusillae	Jarolímek et al. (1997), relevés 3 and 4 (Mucina, 1987)
		Matricario-Anthemitetum cotulae	relevés 5-8 (Mucina, 1987),
		Xanthietum spinosi	original data, relevé 14, relevés 15, 16 (Krippelová, 1981)

Xanthium spinosum was sporadically recorded in vegetation of class *Polygono arenastri-Poetea annuae* developing in habitats exposed to trampling. Jarolímek et al. (1997) mentioned it in alliance *Matricario matricarioidis-Polygonion arenastri* and association *Poo annuae-Coronopetum squamati*. *X. spinosum* was found also in another association – *Matricario-Polygonetum arenastri* (relevé 20 in Tab. 1). The community is very species-poor with the dominant occurrence of *Polygonum aviculare* tolerates frequent and very intense mechanical disturbances (Jarolímek et al., 1997; Láníková, 2009). The resistance of *X. spinosum* to mechanical disturbance of the habitat is also confirmed by relevé 19 (Table 1) sampled in open sandy dunes near Streda nad Bodrogom (SE Slovakia). This extremely species-poor pioneer vegetation in the initial stage of succession cannot be accurately classified.

During the research, *Xanthium spinosum* was also found in stands of two classes where it was previously not reported from Slovakia. The species was recorded in stand of the class *Bidentetea tripartiti* representing vegetation of annual nitrophilous wetland herbs belonging to alliance *Chenopodion rubri* and association *Chenopodietum ficifolii* (Table 1, relevé 17). According to Lososová (2011), this association has a marginal position within the alliance of *Chenopodion rubri*, and forms a transition to the annual ruderal vegetation of the *Atriplicion* in class *Stellarietea mediae*. For the first time in Slovakia, a rare occurrence of the species was recorded in the meadow vegetation of class *Molinio-Arrhenatheretea*. Those stands represent degraded vegetation of alliance *Potentillion anserinae*, association *Potentilletum anserinae* (Table 1, relevés 12 and 13). The penetration of *X. spinosum* into communities where it has not yet been recorded is related to grazing. It is very likely that it will occur there only temporarily. Similarly, P. Eliáš sen. (2019 ined.) observed *X. spinosum* in the salt steppe communities of the *Artemisio-Festucetum pseudovinae* alliance in the locality of Močenok (SW Slovakia). It was present in areas where sheep grazing was quite intensive in the past and trampled open areas were created. At present, the number of animals has been reduced and the species does not grow in this grassland vegetation.

CONCLUSIONS

Xanthium spinosum mostly occupies open, sunny to semi-shadow habitats developed in mesotrophic and moderately nutrient rich soils. In terms of moisture, temperature and continentality, the species prefers semidry, sub-montane as well as thermophilous sites in a wide range of climatic conditions from oceanic and sub-oceanic to subcontinental. It was mainly recorded in ruderal vegetation units of class *Stellarietea mediae*, however, it was also recorded in the stands of classes *Bidentetea* and *Molinio-Arrhenatheretea* for the first time in Slovakia. A relatively wide ecological valence allows the species to be used in different phytocoenoses and it will be recorded in other communities in the future.

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REFERENCES

Auld, B. A., Say, M. M. (1999) Comparison of isolates of *Colletotrichum orbiculare* from Argentina and Australia as potential bioherbicides for *Xanthium spinosum* in Australia. Agriculture, Ecosystems & Environment, 72 (1), 53-58. DOI: https://doi.org/10.1016/S0167-8809(98)00161-3

Borhidi, A. (1995) Social behaviour types, the naturalness and relative ecological indicator values of the higher plants in the Hungarian flora. Acta Botanica Hungarica, 39, 97-181.

Borhidi, A., Kevey, B., Lendvai, G. (2012) Plant communities of Hungary. Budapest: Academic Press.

Braun-Blanquet, J. (1964) Pfanzensoziologie. Grundzüge der Vegetationskunde. Ed. 3. Wien, New York: Springer-Verlag.

Danihelka, J., Chrtek, J. Jr., Kaplan, Z. (2012) Checklist of vascular plants of the Czech Republic. Preslia, 84, 647-811. [Online] Available at: http://www.preslia.cz/P123Danihelka.pdf [Accessed 20. December 2020].

Dudáš, M., Eliáš, P. Jr. (2021) Alien weed *Xanthium spinosum* in Slovakia I: distribution and habitats. Journal of Central European Agriculture, 22, 305-316.

Eliáš, P. (1978) Ruderálne spoločenstvá v hornom Požitaví. Acta Ecologica, Bratislava, 16, 31-90. (in Slovak)

Eliáš, P. (1981) A short survey of the ruderal plant communities in western Slovakia. Acta Botanica Academiae Scientiarum Hungaricae, Budapest, 27, 335-349.

Eliáš, P. (1986) A survey of the ruderal plant communities of Western Slovakia. II. Feddes Repertorium, Berlin, 97, 197-221.

Eliáš P. (2017) Komentovaný prehľad rastlinných spoločenstiev: mikroregión Tribečsko. Nitra: Slovenská poľnohospodárska univerzita. (in Slovak with an English summary)

Greuter, W. (2006) *Xanthium* L.. In: Greuter, W., Raab-Straube, E. von, ed. Compositae. Euro+Med Plantbase - the information resource for Euro-Mediterranean plant diversity. [Online] Available at: http://ww2.bgbm.org/EuroPlusMed/PTaxonDetail.asp?NameCache=Xanthium&PTRefFk=7000000 [Accessed 2 December 2020].

Hegedüšová, K. (2007) Centrálna databáza fytocenologických zápisov (CDF) na Slovensku (stav k januáru 2007). Bulletin Slovenskej botanickej spoločnosti, 29, 124-129. (in Slovak with an English summary)

Hilbe, J.M. (2007) STATISTICA 7: An Overview. The American Statistician, 61, 91-94.

Holm, L.R.G, Plucknett, D.L., Pancho, J.V., Herberger, J.P. (1977) The world's worst weeds. Distribution and biology. Honolulu, Hawaii, USA: University Press of Hawaii.

Jarolímek, I., Zaliberová, M., Mucina, L., Mochnacký, S. (1997) Rastlinné spoločenstvá Slovenska 2. Synantropná vegetácia, Bratislava: Veda. (in Slovak)

Jarolímek, I., Šibík, J., eds. (2008) Diagnostic, constant and dominant species of the higher vegetation units of Slovakia. Bratislava: Veda.

Klika, J. (1935) Příspěvek k poznání našich ruderálních společenstev. Věda Přírodní, 16, 119-122. (in Czech)

Krippelová, T. (1981) Synanthrope Vegetation des Beckens Košická kotlina. Vegetácia ČSSR, B4. Bratislava: Veda.

Láníková, D. (2009) *Polygonetum arenastri* Gams 1927 corr. Láníková in Chytrý 2009. In: Chytrý, M., ed. Vegetace České republiky. 2. Ruderální, plevelová, skalní a suťová vegetace, p. 47-50, Praha: Academia. (in Czech)

Lososová, Z. (2011) *Chenopodietum ficifolii* Hejný in Hejný et al. 1979. In: Chytrý M., ed., Vegetace České republiky. 3. Vodní a mokřadní vegetace, p. 379-381, Praha: Academia. (in Czech)

Lososová, Z. (2013) *Setario pumilae-Hibiscetum trioni* Lososová in Chytrý 2013 ass. nova hoc loco. In: Chytrý M., ed. Vegetace České republiky. 4. Lesní a křovinná vegetace, p. 433–436, Praha: Academia. (in Czech)

Löve, D., Dansereau, P. (1959) Biosystematic studies on *Xanthium*: Taxonomic appraisal and ecological status. Canadian Journal of Botany, 37, 173-208. DOI: https://doi.org/10.1139/b59-016

Marhold, K., Hindák, F., eds. (1998) Checklist of non-vascular and vascular plants of Slovakia. Bratislava: Veda.

Medvecká, J., Kliment, J., Májeková, J., Halada, Ľ., Zaliberová, M., Gojdičová, E., Feráková, V., Jarolímek I. (2012) Inventory of the alien flora of Slovakia. Preslia, 84, 257-309. [Online] Available at: http://www.preslia.cz/P122Medvecka.pdf [Accessed 14 October 2019].

Mucina, L. (1981) Die Ruderalvegetation des nôrdlichen Teils der Donau-Tiefebene, 1. *Onopordion acanthii*-Verband. Folia Geobotanica et Phytotaxonomica, 16, 225-263. DOI: https://doi.org/10.1007/BF02851895

Mucina, L. (1987) The ruderal vegetation of the northwestern part of the Podunajská Nížina Lowland. 5. *Malvion neglectae*. Folia Geobotanica et Phytotaxonomica, 22, 1-23. DOI: https://doi.org/10.1007/BF02853211

Némethová, J., Civáň, M. (2017) Regional differences in agriculture in Slovakia after its accession to the European union, 2017. Quaestiones Geographicae, 36, 9-21. DOI: https://doi.org/10.1515/quageo–2017–0011

Němec, R., Lososová, Z., Dřevojan, P., Žáková, K. (2011) Synanthropic vegetation of the *Eragrostion cilianensi-minoris* alliance in the Czech Republic. Biologia, 66, 1019-1026. DOI: http://dx.doi.org/10.2478/s11756-011-0108-0

Parsons, W.T., Cuthbertson, E.G. (1992) Noxious Weeds of Australia. Melbourne, Australia: Inkata Press.

Pitcher D, 1989. *Xanthium spinosum*, Spiny Cocklebur. Element Stewardship Abstract. Arlington, USA: The Nature Conservancy.

Solomacha T. D., Solomacha B. A., Šeljag-Sosonko J. R. (1986) Osnovny asociacii ruderalnoi roslinnostii livoberežnovo lisostepu Ukrajiny. Ukrainskiy Botananitcheskiy Zhurnal 43(3), 70-75. (in Ukrainian with an English summary)

Song, Z. Z., Tan D.Y., Zhou, G. L. (2012) Distribution and community characteristics of invasive *Xanthium spinosum* in Xinjiang. Acta Botanica Boreali-Occidentalia Sinica, 32, 1448-1453. DOI: http://xbzwxb.nwsuaf.edu.cn

Strother, J. L. (2006) *Xanthium*. In: Flora of North America Editorial Committee, eds. Flora of North America, vol. 21. New York-Oxford: Oxford University Press, pp. 19-20. [Online] Available at: http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=135017 [Accessed 2 October 2020].

Terpó, A., Zając M., Zając A. (1999) Provisional list of Hungarian archeophytes. Thaiszia – Journal of Botany, 9, 41-47.

Tóth, Š, Sikora, V. (2016) Nebezpečné voškovníky *Xanthium* spp. a cukrová repa. Listy Cukrovarnické a Řepařské, 132(4), 138-142. [Online] Available at: http://www.cukr-listy.cz/on_line/2016/PDF/138-142.pdf [Accessed 12 October 2020]. (in Slovak)

Věžník, A., Svobodová, H., Némethová, J., Hradický, J. (2017) Livestock production in Czechia and Slovakia, ten years beyond EU accession, 2017. Human Geographies: Journal of Studies and Research in Human Geography, 11, 77-94. DOI: http://dx.doi.org/10.5719/hgeo.2017.111.5