

## The vascular flora of Kopački rit Nature Park (Croatia)

### Vaskularne rastline Naravnega parka Kopački rit (Hrvaška)

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**Abstract:** Kopački rit Nature Park is a large fluvial-marshy floodplain, situated in the northeastern Croatia, between courses of the Danube and the Drava Rivers. Due to exceptional biological and ecological values of this floodplain area in the middle course of the Danube River, it had been protected since 1967; proclaimed as Nature Park in 1999 and from 2012 is a part of the UNESCO Transboundary Biosphere Reserve Mura-Drava-Danube. This paper lists a total of 522 vascular plant taxa, classified in 295 genera and 96 families, recorded for Kopački rit Nature Park. The list is completed according to checked literature records and data for 114 new taxa, found during the floristic investigation carried out from 2010 to 2018. Taxonomic, ecological and phytogeographical analyses are presented. Hemicryptophytes dominate (39.3%) in the biological spectrum, followed by therophytes (23.8%), geophytes (12.6%) and hydrophytes (12.5%). In the chorological spectrum, the most numerous are plants of Eurasian floral element (32.8%), followed by Cosmopolites (27.4%), and European floral element (10.7%). Out of 53 recorded allochthonous plants, 26 are invasive alien plant species. According to protection and conservation status at the national level, 55 taxa are listed in the Red Book of Vascular Plants of Croatia and 53 taxa are strictly protected. One species, *Marsilea quadrifolia*, is listed in Annex II of the Habitat Directive.

**Key words:** Kopački rit, Danube, flora, biodiversity

**Povzetek:** Naravni park Kopački rit je obsežna poplavna ravnica, ki se nahaja na severovzhodu Hrvaške, med rekama Donavo in Dravo. Zaradi izjemne biološke in ekološke vrednosti tega poplavnega območja v srednjem toku reke Donave je območje od leta 1967 zaščiteno. Naravni park je bil razglašen leta 1999 in od leta 2012 je območje del prekomejnega biosfernega rezervata UNESCO Mura-Drava-Donava. V Naravnem parku Kopački rit je bilo zabeleženih 522 vaskularnih rastlinskih taksonov, ki sodijo v 295 rodov in 96 družin. Seznam temelji na podatkih v literaturi, katerim smo dodali 114 novih taksonov, ki so bili popisani med florističnimi raziskavami, opravljenimi od leta 2010 do leta 2018. V prispevku so predstavljene taksonomske, ekološke in fitogeografske analize. Med taksoni prevladujejo hemikritopiti (39,3 %),

sledijo jim terofiti (23,8 %), geofiti (12,6 %) in hidrofiti (12,5 %). Najštevilčnejši so evrazijski florni elementi (32,8 %), sledijo kozmopolitske vrste (27,4 %) in evropski florni elementi (10,7 %). Od 53 zabeleženih alohtonih rastlin je 26 invazivnih tujerodnih rastlinskih vrst.

**Ključne besede:** Kopački rit, Donava, flora, biotska raznolikost

## Introduction

Floristic studies in the area of Kopački rit Nature Park were only occasional in the past. Numerous records, sometimes with a description of geographically uncertain localities, are included in publications related to the wider area of the Slavonia and Baranja regions.

The earliest report about plants in the present-day Kopački rit area dates back to the 18<sup>th</sup> century. Count Luigi Ferdinando Marsigli collected information on the indigenous plants of the Danube region and presented it in the sixth volume of the monograph: *Danubius Pannonico-Mysicus* (Marsigli 1726). Among the listed plants and localities along the Danube course, the mouth of the Drava River (“circa influxum Fluvii Dravii”) was recognised as the collection hot spot of several plants. Paul Kitaibel made field excursions in Baranja region in the period 1799 – 1808 (Purger and Csiky 2008), and some of his records were published by Neilreich (1866). Ádám Boros made a field visit in Kopački rit from 24 to 27 June 1944 and reported findings of *Urtica kioviensis* (Boros 1944a), *Veronica peregrina* (Boros 1944b) and *Marsilea quadrifolia* (Boros 1946).

Floristic studies have been renewed and intensified in the period from the 1960s up to the end of 1980s (Jovanović 1965, Ilijanić 1968, Balátová-Tuláčková and Knežević 1975, Rauš et al. 1980, 1985). Trinajstić and Pavletić (1978) investigated the aquatic vegetation and made the first record of a neophyte *Azolla filiculoides* in Kopački rit. In the review of vegetation diversity in Kopački rit Special Zoological Reserve, Topić (1989) described structure of 37 associations, arranged into ten classes of aquatic, marshland, ruderal, meadow and forest vegetation. During the botanical surveys in the period 1986 – 1988, Panjković (1990) recorded 723 taxa for the flora of the Baranja region, including several taxa found in Kopački rit.

Topić (1999) summarised all available literature data about flora and vegetation in Kopački rit and made a list of 368 taxa for the flora of Kopački rit. Zahirović (2000) carried out from 1997 to 1999 an extensive field investigation of the rare and endangered plant species in northeastern Croatia, including the area of Kopački rit. Among 467 recorded taxa, 37 had been new for the flora of the Baranja region. Distribution and ecology of two rare aquatic plants in Kopački rit, *Azolla filiculoides* and *Wolffia arrhiza*, was described in details. Topić and Ozimec (2001) reported the first finding of *Typha laxmannii* as a new to the Croatian flora.

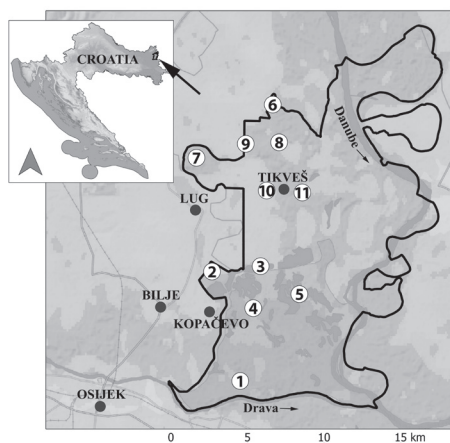
Latest discoveries treated two new taxa to the flora. An invasive aquatic species *Elodea nuttallii* was found in 2006 in the drainage channels in Kopački rit (Kočić et al. 2014). *Scirpus pendulus*, a neophyte originating from North America, was discovered in July 2011 on the muddy bottom in a wet ditch in the area between Kozjak and Tikveš (Ozimec and Topić 2018).

Public Institution Kopački rit Nature Park initiated and supported intensive floristic investigations in the period 2010 – 2018, combined with monitoring of rare and threatened plants and habitats. An important achievement of these activities is a complete list of the vascular flora, presented for the first time in this paper.

## Material and methods

### Study area

Kopački rit Nature Park is located in north-eastern Croatia, in the angular area formed by the confluence of the Danube and the Drava River (Fig. 1). The Park covers an area of 231 km<sup>2</sup> with an altitudinal range from 78 to 86 m a.s.l. This is a large fluvial-marshy floodplain formed during the late Quaternary (Bognar 1990).



**Figure 1:** The area of Kopački rit Nature Park with position of localities where new taxa had been found.

**Slika 1:** Območje Naravnega parka Kopački rit z lokacijami, kjer smo našli nove taksone.

Data from the climatological station in Tikveš for the period 2004 – 2013 confirms that the climate is moderately warm and rainy (Cvitan 2014). Mean annual air temperature is 11.0 °C, the absolute minimum is –25.1 °C, and the absolute maximum is 39.4 °C. The coldest month is January (0.4 °C) and warmest is July (21.9 °C). Mean annual precipitation amounts to 696 mm, the highest in June (89 mm), and lowest in January (44 mm). Mean relative humidity is 85%, highest in December and January (91% each), and lowest in July (79%). Mean annual number of days with frost is 53, and with dew is 142 days.

Floodwater enters the area from both the northern and southern parts when the Danube water level exceeds the value of 81.50 m a.s.l. (at Apatin gauging station), and at water level above 83.00 m a.s.l. the entire area is filled with water. The largest water body is the Kopačko Lake with the surface of 200–250 ha in the period out of flooding. The deepest one is the Sakadaš Lake with a mean depth of 7 m. The lakes are interconnected with rivers through a network of natural channels (Tadić 1999).

The inflow of the Danube floodwaters towards the Kopačko Lake is distributed by the 6 km long Hulovo Channel, which is connected with the Danube course near river km 1,388. In

the northern part, floodwaters are distributed by the Vemeljski Dunavac, a Danube sidearm with upper end at river km 1,407 and lower end at river km 1,392 (Ozimec and Topić 2018).

Danube flooding and water stagnation are major pedogenetic factors of specific soil type characterised by fine texture and low hydraulic conductivity. The most prevalent are hydromorphic soils, particularly gleysols. Excessive wetting by floods and high subsurface water enables the evolution of hydromorphic soils (Tadić et al. 2014).

Regarding the phytogeographical position, the area belongs to the Eurosiberian – North American region and the Pannonian sector of the Central European province. This is a transitory region between the vegetation of the *Carpinion betuli* alliance and forest-steppe zone of the *Aceri tatarici* – *Quercion* alliance (Topić and Šegulja 2005). In the land use structure, freshwaters and marshland covers 40% of the total Park area, forests 30%, and the agricultural land 20% (Anonymous 2006).

The area of Kopački rit was firstly protected in 1967 under the category of Managed Natural Reserve. Its boundaries and protection categories had been changed during the fifty-year period. Existing protection status was established in 1999 by the Act of Kopački rit Nature Park (Anonymous 1999) at total area of 231 km<sup>2</sup> including 71 km<sup>2</sup> of Kopački rit Special Zoological Reserve and the Danube course between river km 1,412 and 1,382. In 1993, Kopački rit was designated on the List of Wetlands of International Importance under the Ramsar Convention. It is included in the ecological network Natura 2000 in Croatia, with a site code HR2000394 Kopački rit (Anonymous 2013a, 2015). The latest achievement in nature protection is the establishment of UNESCO Transboundary Biosphere Reserve Mura-Drava-Danube, proclaimed in July 2012, with Kopački rit Nature Park as the best-preserved natural floodplain of the entire Reserve.

#### Floristic study

Field investigations were carried out in the period from 2010 to 2018, with an approval for research and collection issued by the competent state authority for the nature protection.

Investigated localities (Fig. 1) where new taxa had been found are described as it follows:

1. Wet meadows near the left bank of the Drava River (19 May 2010, 26 May 2011, 25 May 2012, 29 August 2017), size about 83 ha, degraded meadow association *Veronico longifoliae* – *Euphorbietum lucidae*;
2. Fishponds “Podunavlje”, basins A, D, and E and surrounding area (2 July 2010, 1 July 2011, 11 August 2011), size about 217 ha, channels and standing water with aquatic and marshland vegetation from classes *Lemnetea*, *Potamogetonetea* and *Phragmito-Magnocaricetea*;
3. Fishponds “Podunavlje”, basins B and C and surrounding area (15 September 2010, 2 June 2014), size about 300 ha, standing water with aquatic and marshland vegetation from classes *Lemnetea*, *Potamogetonetea* and *Phragmito-Magnocaricetea*; periodically developed amphibious alliance *Nanocyperion*; meadow association *Arrhenatheretum elatioris* along the flood protection dyke;
4. Čonakut Channel and surrounding area (1 July 2011), size about 35 ha, channels and banks with vegetation from classes *Lemnetea*, *Potamogetonetea* and *Phragmito-Magnocaricetea*; periodically developed amphibious alliance *Nanocyperion*;
5. Kopačko Lake and surrounding area (12 July 2013, 24 August 2018), size about 200 ha, standing water with aquatic and marshland vegetation from classes *Lemnetea*, *Potamogetonetea* and *Phragmito-Magnocaricetea*; periodically developed amphibious alliance *Nanocyperion*;
6. Čarna Channel by the road bridge (15 September 2011), size about 1 ha, ruderal vegetation developed by the road;
7. Siget forest complex (10 June 2010, 7 April 2011, 30 September 2011), size about 443 ha, forest communities of pedunculate oak and common hornbeam, association *Carpino betuli-Quercetum roboris*;
8. Tikveš Castle complex and surrounding area (18 April 2011, 16 May 2011, 8 July 2011, 8 May 2012, 25 May 2012, 4 May 2017, 8 May 2018, 1 June 2018), size about 140 ha, forest communities of pedunculate oak and common hornbeam, association *Carpino betuli-Quercetum roboris*, Black walnut (*Juglans nigra*) plantation, meadow association *Arrhenatheretum elatioris*;
9. Melioration canals between settlement Kozjak and Tikveš Castle complex (23 July 2010, 18 August 2010, 18 August 2011, 15 September 2011), size about 8 ha, channels and banks with vegetation from classes *Lemnetea*, *Potamogetonetea* and *Phragmito-Magnocaricetea*;
10. Area between settlements Tikveš and Kozjak (13 July 2010, 1 July 2011, 10 August 2012, 20 August 2014), size about 40 ha, channels with vegetation from classes *Lemnetea*, *Potamogetonetea* and *Phragmito-Magnocaricetea*; shrubs from the class *Rhamno-Prunetea* at site of the former pasture;
11. Settlement Tikveš and Čarna Channel (10 August 2012, 23 September 2018), size about 16 ha, channels with vegetation from classes *Lemnetea*, *Potamogetonetea* and *Phragmito-Magnocaricetea* ruderal vegetation developed by the road.

The plant taxa were determined using the standard determination keys and iconographies (Domac 2002, Javorka and Csapody 1991, Knežević 2006, Pignatti 2002, Preston 1995, Rothmaler 2009). Agricultural and strictly ornamental plants have not been part of this research and are not presented in the results. Taxonomy and nomenclature had been adjusted according to the Flora Croatica Database (Nikolić 2018). Literature data on the presence of taxa were taken from the previously published papers and other printed sources.

A complete list of the flora of Kopački rit Nature Park contains taxa arranged in systematic order with families, genera, species and infraspecific taxa arranged alphabetically. Newly recorded taxa are marked with \*, and invasive alien plant species with <sup>1)</sup>.

*Ecological and phytogeographical analyses*

The plant life-forms are interpreted according to Raunkier (1937) and Pignatti (2002). The following abbreviations were used to define life forms: Ch – Chamaephyta, G – Geophyta, H – Hemicryptophyta, Hy – Hydrophyta, P – Phanerophyta, T – Therophyta. Chorological elements follow Horvatić (1963), Horvatić et al. (1967-1968) and Pignatti (2002). Floristic elements were described with the following abbreviations: Ce – Central European; Cir-H – Circum-Holarctic; Cosm – Cosmopolites; Cul-ad – Cultivated and adventive; E – European; E-As – Eurasian; Ee-P – East European-Pontic, Med –Mediterranean; S-Eur – South European; Se-E – Southeast European.

Taxa included in the Red Book of Vascular Flora of Croatia (Nikolić and Topić 2005) are indicated by an abbreviation of the IUCN risk category: CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened and DD – Data Deficient.

Taxa assigned as strictly protected species in Croatia under the Ordinance on Strictly Protected Species (Anonymous 2013b, 2016), are abbreviated as SP.

Allochthonous flora was determined and analysed according to Mitić et al. (2008), Nikolić et al. (2014) and Flora Croatica Database (Nikolić 2018). Invasive alien plant species and their areas of origin were attributed from Boršić et al. (2008) with abbreviations: AmS – South America, AmN – North America, As – Asia, EA – Eurasia, Am – Americas, M – Mediterranean, C – in culture.

**Results**

A total of 522 taxa (504 species and 18 subspecies) representing 295 genera and 96 families have been recorded for the vascular flora of Kopački rit Nature Park (Tab. 1). As an achievement of the field investigations, carried out from 2010 to 2018, the floristic diversity increased for additional 114 newly recorded taxa.

**Table 1:** Floristic list of Kopački rit Nature Park.**Tabela 1:** Seznam flore Naravnega park Kopački rit.

List of taxa	Investigated locality	Life form	Floral element	Risk category / Protection statusw
<b>PTERIDOPHYTA</b>				
<b>Azollaceae</b>				
<i>Azolla filiculoides</i> Lam.		Hy	Cul-ad	
<b>Equisetaceae</b>				
<i>Equisetum arvense</i> L.		G	Cir-H	
<i>Equisetum x moorei</i> Newman		G	Cir-H	
<i>Equisetum palustre</i> L.		G	Cir-H	
<i>Equisetum telmateia</i> Ehrh.*	3	G	Cir-H	
<b>Marsileaceae</b>				
<i>Marsilea quadrifolia</i> L.		Hy	Cir-H	EN SP
<b>Ophioglossaceae</b>				
<i>Ophioglossum vulgatum</i> L.		G	Cir-H	NT
<b>Salviniaceae</b>				
<i>Salvinia natans</i> (L.) All.		Hy	E	NT SP
<b>Woodsiaceae</b>				
<i>Athyrium filix-femina</i> (L.) Roth*	8	H	Cosm	

List of taxa	Investigated locality	Life form	Floral element	Risk category / Protection statusw
<b>SPERMATOPHYTA</b>				
<b>MAGNOLIOPHYTINA</b>				
<b>MAGNOLIOPSIDA</b>				
<b>(DICOTYLEDONAE)</b>				
<b>Aceraceae</b>				
<i>Acer campestre</i> L.		P	E	
<i>Acer negundo</i> L. <sup>1)</sup>		P	Cul-ad	
<i>Acer tataricum</i> L.		P	Se-E	
<b>Amaranthaceae</b>				
<i>Amaranthus retroflexus</i> L. <sup>1)</sup>		T	Cosm	
<b>Apiaceae</b>				
<i>Aegopodium podagraria</i> L.		G	E-As	
<i>Anthriscus sylvestris</i> (L.) Hoffm.		H	E-As	
<i>Chaerophyllum temulum</i> L.		T	E-As	
<i>Conium maculatum</i> L.		H	Cosm	
<i>Daucus carota</i> L.		H	E-As	
<i>Oenanthe aquatica</i> (L.) Poir.		H	E-As	
<i>Orlaya grandiflora</i> (L.) Hoffm.*	8	T	S-Eur	
<i>Pastinaca sativa</i> L.		H	Cosm	
<i>Pimpinella saxifraga</i> L.		H	E-As	
<i>Sanicula europaea</i> L.*	8	H	Cosm	
<i>Sium latifolium</i> L.		Hy	Ce	
<i>Torilis japonica</i> (Houtt.) DC.		T	Cosm	
<i>Trinia glauca</i> (L.) Dumort.		H	Med	
<b>Araliaceae</b>				
<i>Hedera helix</i> L.*	7	P	E	
<b>Aristolochiaceae</b>				
<i>Aristolochia clematitis</i> L.		G	S-Eur	
<b>Asclepiadaceae</b>				
<i>Asclepias syriaca</i> L. <sup>1)</sup>		G	Cul-ad	
<b>Asteraceae</b>				
<i>Achillea millefolium</i> L.		H	Cosm	
<i>Achillea pannonica</i> Scheele		H	Se-E	
<i>Ambrosia artemisiifolia</i> L. <sup>1)</sup>		T	Cul-ad	
<i>Anthemis cotula</i> L.		T	Cosm	
<i>Arctium lappa</i> L.		H	E-As	
<i>Artemisia annua</i> L.		T	E-As	
<i>Artemisia campestris</i> L.		Ch	Cir-H	
<i>Artemisia vulgaris</i> L.		H	Cosm	
<i>Aster novi-belgii</i> L.		H	Cul-ad	
<i>Bellis perennis</i> L.		H	Ce	
<i>Bidens cernuaw</i> L.		T	E-As	
<i>Bidens frondosa</i> L.* <sup>1)</sup>	5	T	Cul-ad	
<i>Bidens tripartita</i> L.		T	E-As	
<i>Carduus acanthoides</i> L.		H	S-Eur	
<i>Carpesium abrotanoides</i> L.		H	E-As	
<i>Carpesium cernuum</i> L.		T	S-Eur	
<i>Centaurea jacea</i> L.		H	Cosm	
<i>Centaurea micranthos</i> S. G. Gmel.		H	Ee-P	
<i>Centaurea rhenana</i> Boreau		H	E	
<i>Chamomilla recutita</i> (L.) Rauschert		T	Cosm	
<i>Chamomilla suaveolens</i> (Pursh) Rydb. <sup>1)</sup>		T	Cosm	

List of taxa	Investigated locality	Life form	Floral element	Risk category / Protection statusw
<i>Cirsium arvense</i> (L.) Scop.		G	E-As	
<i>Cirsium canum</i> (L.) All.		G	Se-E	
<i>Conyza canadensis</i> (L.) Cronquist <sup>1)</sup>		T	Cul-ad	
<i>Erigeron annuus</i> (L.) Pers. <sup>1)</sup>		T	Cul-ad	
<i>Eupatorium cannabinum</i> L.		H	E-As	
<i>Filaginella uliginosa</i> (L.) Opiz		T	E-As	
<i>Galinsoga parviflora</i> Cav. <sup>1)</sup>		T	Cul-ad	
<i>Inula britannica</i> L.		H	E-As	
<i>Inula ensifolia</i> L.		H	Se-E	
<i>Inula salicina</i> L.		H	E-As	
<i>Leucanthemum vulgare</i> Lam.*	8	H	E-As	
<i>Matricaria perforata</i> Mérat*	8	T	E-As	
<i>Pulicaria dysenterica</i> (L.) Bernh.		H	S-Eur	
<i>Pulicaria vulgaris</i> Gaertn.		T	E-As	
<i>Senecio aquaticus</i> Hill		H	E	
<i>Senecio paludosus</i> L.		H	Cir-H	
<i>Serratula tinctoria</i> L.		H	E-As	
<i>Solidago gigantea</i> Aiton <sup>1)</sup>		H	Cul-ad	
<i>Tanacetum vulgare</i> L.		H	E-As	
<i>Tussilago farfara</i> L.		G	E-As	
<i>Xanthium strumarium</i> L.		T	Med	
ssp. <i>italicum</i> (Moretti) D.Löve* <sup>1)</sup>	2	T	Med	
<i>Xanthium strumarium</i> L.		T	Cul-ad	
ssp. <i>strumarium</i>				
<b>Balsaminaceae</b>				
<i>Impatiens glandulifera</i> Royle* <sup>1)</sup>	8	T	Cul-ad	
<i>Impatiens noli-tangere</i> L.		T	E-As	
<i>Impatiens parviflora</i> DC. <sup>1)</sup>		T	Cul-ad	
<b>Betulaceae</b>				
<i>Alnus glutinosa</i> (L.) Gaertner		P	E-As	
<i>Alnus incana</i> (L.) Moench.		P	Cul-ad	
<i>Betula pendula</i> Roth *	7	P	E-As	
<b>Boraginaceae</b>				
<i>Anchusa arvensis</i> (L.) M.Bieb.		T	E-As	
<i>Anchusa officinalis</i> L.		H	E	
<i>Cerinth minor</i> L.*	10	T	S-Eur	
<i>Cynoglossum officinale</i> L.		H	E-As	
<i>Echium vulgare</i> L.*	10	H	E	
<i>Heliotropium europaeum</i> L.*	11	T	Med	
<i>Lithospermum arvense</i> L.*	10	T	E-As	
<i>Lithospermum officinale</i> L.*	8	H	E-As	
<i>Myosotis arvensis</i> (L.) Hill.		T	E-As	
<i>Myosotis laxa</i> Lehm. ssp.		T	Cir-H	
<i>Caespitosa</i> (C. F. Schultz) Nordh.		T	E-As	
<i>Myosotis ramosissima</i> Rochel		T	E-As	
<i>Myosotis scorpioides</i> L.		H	Cir-H	
<i>Pulmonaria officinalis</i> L.*	8	H	E	
<i>Symphytum officinale</i> L.		H	E	
<i>Symphytum tuberosum</i> L.		G	Ce	
<b>Brassicaceae</b>				
<i>Alliaria petiolata</i> (M. Bieb.) Cavara et Grande*	8	H	E-As	

List of taxa	Investigated locality	Life form	Floral element	Risk category / Protection statusw
<i>Alyssum alyssoides</i> (L.) L.		T	S-Eur	
<i>Arabidopsis thaliana</i> (L.) Heynh.		T	Cosm	
<i>Arabis glabra</i> (L.) Bernhardt		H	Cosm	
<i>Arabis hirsuta</i> (L.) Scop.*	8	H	Cosm	
<i>Brassica napus</i> L.		T	Cul-ad	
<i>Calepina irregularis</i> (Asso) Thell.*	8	T	E	
<i>Capsella bursa-pastoris</i> (L.) Med.		H	Cosm	
<i>Cardamine bulbifera</i> (L.) Crantz*	8	G	E	
<i>Cardamine pratensis</i> L.		H	Cir-H	
ssp. <i>dentata</i> (Schult.) Čelak		G	Cosm	
<i>Cardaria draba</i> (L.) Desv		T	Cosm	
<i>Coronopus squamatus</i> (Forssk.) Asch.		T	Cosm	
<i>Descurainia sophia</i> (L.) Webb ex Parntl		T	E-As	
<i>Diplotaxis muralis</i> (L.) DC.		T	Cosm	
<i>Diplotaxis tenuifolia</i> (L.) DC.		H	Cosm	
<i>Lepidium ruderales</i> L.		T	E-As	
<i>Rorippa amphibia</i> (L.) Besser		Hy	E-As	
<i>Rorippa sylvestris</i> (L.) Besser		H	E-As	
<i>Sinapis arvensis</i> L.		T	Cosm	
<i>Sisymbrium officinale</i> (L.) Scop.		T	Cosm	
<i>Thlaspi alliaceum</i> L.*	8	T	S-Eur	
<b>Callitrichaceae</b>				
<i>Callitriche palustris</i> L.		Hy	Cir-H	SP
<b>Campanulaceae</b>				
<i>Campanula patula</i> L. *	8	H	E-As	
<i>Campanula sibirica</i> L.*	11	H	Se-E	
<i>Campanula trachelium</i> L.		H	E-As	DD
ssp. <i>trachelium</i> *	7	H	E-As	
<b>Cannabaceae</b>				
<i>Humulus lupulus</i> L.*	2	P	E-As	
<b>Caprifoliaceae</b>				
<i>Sambucus nigra</i> L.		P	Cosm	
<i>Viburnum opulus</i> L.		P	E-As	
<b>Caryophyllaceae</b>				
<i>Agrostemma githago</i> L.*	2	T	Cosm	
<i>Arenaria serpyllifolia</i> L.		T	Cosm	
<i>Cerastium brachypetalum</i> Pers.		T	S-Eur	
<i>Cerastium glomeratum</i> Thuill.		T	Cosm	
<i>Cerastium semidecandrum</i> L.		T	S-Eur	
<i>Lychnis flos-cuculi</i> L.*	8	H	E-As	
<i>Lychnis viscaria</i> L.		H	E-As	
<i>Myosoton aquaticum</i> (L.) Moench.		H	E-As	
<i>Petrorhagia prolifera</i> (L.) P. W. Ball et Heywood		T	E-As	
<i>Silene latifolia</i> Poir. ssp. <i>alba</i> (Mill.) Greuter et Bourdet		H	E-As	
<i>Silene otites</i> (L.) Wibel		H	E-As	
<i>Silene vulgaris</i> (Moench) Garcke		H	E-As	
<i>Stellaria media</i> (L.) Vill.		T	Cosm	
<b>Celastraceae</b>				
<i>Euonymus europaeus</i> L.		P	E-As	



List of taxa	Investigated locality	Life form	Floral element	Risk category / Protection statusw
<b>Ceratophyllaceae</b>				
<i>Ceratophyllum demersum</i> L.		Hy	Cosm	
<b>Chenopodiaceae</b>				
<i>Chenopodium album</i> L.		T	Cosm	
<i>Chenopodium polyspermum</i> L.		T	Cosm	
<i>Chenopodium rubrum</i> L.		T	Cosm	DD SP
<b>Cichoriaceae</b>				
<i>Cichorium intybus</i> L.		H	Cosm	
<i>Crepis foetida</i> L. ssp. <i>rheoadifolia</i> (M. Bieb.) Čelak.		T	Ee-P	
<i>Hieracium caespitosum</i> Dumort.*	8	H	E-As	
<i>Lactuca serriola</i> L.		H	Cosm	
<i>Mycelis muralis</i> (L.) Dumort.		H	E-As	
<i>Picris hieracioides</i> L.		H	E-As	
<i>Sonchus arvensis</i> L.		H	Cosm	
<i>Sonchus asper</i> (L.) Hill		T	E-As	
<i>Taraxacum officinale</i> Weber		H	Cosm	
<i>Tragopogon pratensis</i> L.		H	E-As	
ssp. <i>orientalis</i> (L.) Čelak.				
<i>Tragopogon pratensis</i> L. ssp. <i>pratensis</i>		H	E-As	
<b>Clusiaceae</b>				
<i>Hypericum hirsutum</i> L.		H	Cosm	
<i>Hypericum perforatum</i> L.		H	Cosm	
<b>Convolvulaceae</b>				
<i>Calystegia sepium</i> (L.) R. Br.		H	Cosm	
<i>Convolvulus arvensis</i> L.		G	Cosm	
<b>Cornaceae</b>				
<i>Cornus mas</i> L.		P	S-Eur	
<i>Cornus sanguinea</i> L.		P	E	
<b>Corylaceae</b>				
<i>Carpinus betulus</i> L.		P	Ce	
<i>Corylus avellana</i> L.		P	E	
<b>Cucurbitaceae</b>				
<i>Echinocystis lobata</i> (Michx.) Torr. et Gray <sup>1)</sup>		T	Cul-ad	
<b>Cuscutaceae</b>				
<i>Cuscuta australis</i> R. Br. ssp. <i>cesatiana</i> * (Bertol.) Feinbrun	4	T	S-Eur	
<b>Dipsacaceae</b>				
<i>Dipsacus fullonum</i> L.		H	S-Eur	
<i>Dipsacus laciniatus</i> L.*	2	H	E-As	
<i>Dipsacus pilosus</i> L.		H	E-As	
<i>Scabiosa ochroleuca</i> L.		H	E	
<b>Euphorbiaceae</b>				
<i>Euphorbia amygdaloides</i> L.		Ch	Ce	
<i>Euphorbia cyparissias</i> L.		H	E-As	
<i>Euphorbia lucida</i> Waldst. et Kit.*	1	H	Ce	
<i>Euphorbia palustris</i> L.		G	Cosm	
<i>Euphorbia salicifolia</i> Host		H	Ee-P	
<i>Euphorbia virgata</i> Waldst. et Kit.*	1	H	E-As	
<b>Fabaceae</b>				
<i>Amorpha fruticosa</i> L. <sup>1)</sup>		P	Cul-ad	

List of taxa	Investigated		Floral element	Risk category / Protection statusw
	locality	Life form		
<i>Astragalus glycyphyllos</i> L.		H	E-As	
<i>Coronilla varia</i> L.		H	E	
<i>Galega officinalis</i> L.		H	Ee-P	
<i>Lathyrus hirsutus</i> L.*	2	T	S-Eur	
<i>Lathyrus palustris</i> L.*	2	H	Cir-H	DD SP
<i>Lathyrus pratensis</i> L.		H	E-As	
<i>Lathyrus tuberosus</i> L.		H	E-As	
<i>Lotus corniculatus</i> L.		H	Cosm	
<i>Medicago lupulina</i> L.		T	Cosm	
<i>Melilotus albus</i> Medik.		T	E-As	
<i>Melilotus officinalis</i> (L.) Lam.		H	E-As	
<i>Ononis arvensis</i> L.		Ch	E-As	
<i>Ononis spinosa</i> L.		Ch	E	
<i>Robinia pseudoacacia</i> L. <sup>1)</sup>		P	Cul-ad	
<i>Trifolium campestre</i> Schreber		T	Cosm	
<i>Trifolium hybridum</i> L.		H	S-Eur	
<i>Trifolium patens</i> Schreb.*	8	T	S-Eur	
<i>Trifolium pratense</i> L.		H	E-As	
<i>Trifolium repens</i> L.		H	Cosm	
<i>Vicia angustifolia</i> L.		T	E	
<i>Vicia grandiflora</i> Scop.		H	Ee-P	
<i>Vicia sativa</i> L.		T	Cosm	
<b>Fagaceae</b>				
<i>Quercus cerris</i> L.		P	S-Eur	
<i>Quercus robur</i> L.		P	E	
<b>Fumariaceae</b>				
<i>Corydalis intermedia</i> (L.) Mérat*	8	G	Ce	
<b>Gentianaceae</b>				
<i>Centaurium pulchellum</i> (Sw.) Druce		T	E-As	
<i>Gentiana pneumonanthe</i> L.*	1	H	E-As	EN SP
<b>Geraniaceae</b>				
<i>Erodium cicutarium</i> (L.) L' Her.		T	Cosm	
<i>Geranium dissectum</i> L.*	1	T	Cosm	
<i>Geranium molle</i> L.*	7	T	Cosm	
<i>Geranium robertianum</i> L.		T	Cosm	
<b>Haloragaceae</b>				
<i>Myriophyllum spicatum</i> L.		Hy	Cosm	
<i>Myriophyllum verticillatum</i> L.		Hy	Cir-H	
<b>Hippuridaceae</b>				
<i>Hippuris vulgaris</i> L.		Hy	Cir-H	EN SP
<b>Juglandaceae</b>				
<i>Juglans nigra</i> L.		P	Cul-ad	
<i>Juglans regia</i> L.*	8	P	Cul-ad	
<b>Lamiaceae</b>				
<i>Ajuga genevensis</i> L.*	8	H	E-As	
<i>Ajuga reptans</i> L.		H	E-As	
<i>Ballota nigra</i> L.		H	E	
<i>Calamintha sylvatica</i> Bromf.		H	E	
<i>Clinopodium vulgare</i> L.		H	Cosm	
<i>Galeopsis speciosa</i> Mill.		T	E	
<i>Galeopsis tetrahit</i> L.		T	E-As	

List of taxa	Investigated		Floral element	Risk category / Protection statusw
	locality	Life form		
<i>Glechoma hederacea</i> L.		H	Cir-H	
<i>Glechoma hirsuta</i> Waldst. et Kit.		H	S-Eur	
<i>Lamium amplexicaule</i> L.*	7	T	E-As	
<i>Lamium maculatum</i> L.		H	E-As	
<i>Lamium purpureum</i> L.		T	E-As	
<i>Leonurus cardiaca</i> L.		H	E-As	
<i>Leonurus marrubiastrum</i> L.		H	E-As	
<i>Lycopus europaeus</i> L.		H	E-As	
<i>Mentha aquatica</i> L.		H	Cosm	
<i>Mentha arvensis</i> L.		H	Cir-H	
<i>Mentha longifolia</i> (L.) Huds.		H	Cosm	
<i>Mentha piperita</i> L.		H	Cosm	
<i>Mentha pulegium</i> L.		H	E-As	
<i>Mentha x verticillata</i> L.		H	E	
<i>Nepeta cataria</i> L.*	10	H	Cosm	
<i>Prunella laciniata</i> (L.) L.		H	S-Eur	
<i>Prunella vulgaris</i> L.		H	Cosm	
<i>Salvia glutinosa</i> L.*	7	H	E-As	
<i>Salvia nemorosa</i> L.*	3	H	Ee-P	EN SP
<i>Salvia pratensis</i> L.*	8	H	E	
<i>Scutellaria galericulata</i> L.		G	Cir-H	
<i>Scutellaria hastifolia</i> L.		G	Se-E	
<i>Stachys palustris</i> L.		H	Cir-H	
<i>Stachys recta</i> L.*	8	G	S-Eur	
<i>Stachys sylvatica</i> L.*	7	H	E-As	
<i>Teucrium scordium</i> L.		H	E	
<i>Thymus pulegioides</i> L.		Ch	S-Eur	
<b>Lentibulariaceae</b>				
<i>Utricularia vulgaris</i> L.		Hy	Cir-H	SP
<b>Loranthaceae</b>				
<i>Loranthus europaeus</i> Jacq.		P	E-As	
<b>Lythraceae</b>				
<i>Lythrum hyssopifolia</i> L.		T	Cosm	
<i>Lythrum salicaria</i> L.		H	Cosm	
<b>Malvaceae</b>				
<i>Abutilon theophrasti</i> Medik. <sup>1)</sup>		T	Cosm	
<i>Althaea officinalis</i> L.		H	Cosm	
<i>Hibiscus trionum</i> L.*	6	T	S-Eur	EN SP
<i>Lavatera thuringiaca</i> L.*	6	H	E-As	
<i>Malva sylvestris</i> L.		P	Ce	
<b>Menyanthaceae</b>				
<i>Nymphoides peltata</i> (S. G. Gmelin) Kuntze		Hy	E-As	
<b>Moraceae</b>				
<i>Morus alba</i> L.		P	Cul-ad	
<i>Morus nigra</i> L.		P	Cul-ad	
<b>Nymphaeaceae</b>				
<i>Nuphar lutea</i> Sibth. et Sm.		Hy	E-As	
<i>Nymphaea alba</i> L.		Hy	E-As	
<b>Oleaceae</b>				
<i>Fraxinus americana</i> L.		P	Cul-ad	
<i>Fraxinus angustifolia</i> Vahl		P	S-Eur	

List of taxa	Investigated locality	Life form	Floral element	Risk category / Protection statusw
<i>Fraxinus pennsylvanica</i> Marshall		P	Cul-ad	
<i>Ligustrum vulgare</i> L.		P	Ce	
<b>Onagraceae</b>				
<i>Circaea lutetiana</i> L.		H	Cosm	
<i>Epilobium parviflorum</i> Schreber*	3	H	E-As	
<b>Oxalidaceae</b>				
<i>Oxalis acetosella</i> L.		G	Cosm	
<i>Oxalis fontana</i> Bunge		H	Cul-ad	
<b>Papaveraceae</b>				
<i>Chelidonium majus</i> L.		Hy	Cosm	
<i>Papaver dubium</i> L.*	2	T	Cosm	
<i>Papaver rhoeas</i> L.		T	Cosm	
<b>Phytolaccaceae</b>				
<i>Phytolacca americana</i> L. <sup>1)</sup>		G	Cul-ad	
<b>Plantaginaceae</b>				
<i>Littorella uniflora</i> (L.) Asch.*	5	Hy	E-As	DD SP
<i>Plantago altissima</i> L.		H	S-Eur	
<i>Plantago lanceolata</i> L.		H	Cosm	
<i>Plantago major</i> L.		H	E-As	
ssp. <i>intermedia</i> (Gilib.) Lange		H	E-As	
<i>Plantago major</i> L. ssp. <i>major</i>		H	Cosm	
<b>Polygalaceae</b>				
<i>Polygala comosa</i> Schkuhr*	8	H	E-As	
<b>Polygonaceae</b>				
<i>Polygonum amphibium</i> L.		G	Cosm	
<i>Polygonum arenastrum</i> Boreau*	6	T	Cosm	
<i>Polygonum aviculare</i> L.*	9	T	Cosm	
<i>Polygonum hydropiper</i> L.		T	Cir-H	
<i>Polygonum lapathifolium</i> L.*	2	T	Cosm	
<i>Polygonum minus</i> Hudson		T	Cosm	
<i>Polygonum mite</i> Schrank		T	E	
<i>Polygonum persicaria</i> L.		T	Cosm	
<i>Reynoutria japonica</i> Houtt. <sup>1)</sup>		G	Cul-ad	
<i>Rumex conglomeratus</i> Murray		H	Cosm	
<i>Rumex crispus</i> L.		H	Cosm	
<i>Rumex hydrolapathum</i> Hudson		Hy	E	
<i>Rumex maritimus</i> L.		T	E-As	DD SP
<i>Rumex obtusifolius</i> L.		H	Cosm	
<i>Rumex palustris</i> Sm.		T	E-As	
<b>Portulacaceae</b>				
<i>Portulaca oleracea</i> L.*	6	T	Cosm	
<b>Primulaceae</b>				
<i>Anagallis arvensis</i> L.*	8	T	Cosm	
<i>Hottonia palustris</i> L.		Hy	E-As	EN SP
<i>Lysimachia nummularia</i> L.		H	E	
<i>Lysimachia vulgaris</i> L.		H	E-As	
<i>Primula vulgaris</i> Huds.		H	S-Eur	
<b>Ranunculaceae</b>				
<i>Caltha palustris</i> L.*	8	H	Cosm	
<i>Clematis vitalba</i> L.		P	E	
<i>Consolida regalis</i> S. F. Gray*	9	T	S-Eur	

List of taxa	Investigated		Floral element	Risk category / Protection statusw
	locality	Life form		
<i>Ranunculus acris</i> L.		H	Cosm	
<i>Ranunculus aquatilis</i> L.		Hy	Cosm	
<i>Ranunculus auricomus</i> L.		H	E-As	
<i>Ranunculus circinatus</i> Sibth.		Hy	E-As	
<i>Ranunculus ficaria</i> L.		G	E	
<i>Ranunculus flammula</i> L.		H	E-As	
<i>Ranunculus repens</i> L.		H	Cosm	
<i>Ranunculus sardous</i> Crantz*	9	T	Cosm	
<i>Ranunculus sceleratus</i> L.		T	E-As	
<i>Ranunculus trichophyllus</i> Chaix in Vill.		Hy	E	
<i>Thalictrum lucidum</i> L.		H	E	
<b>Resedaceae</b>				
<i>Reseda lutea</i> L.		H	Cosm	
<b>Rhamnaceae</b>				
<i>Frangula alnus</i> Mill.		P	Ce	
<i>Rhamnus catharticus</i> L.*	7	P	E-As	
<b>Rosaceae</b>				
<i>Agrimonia eupatoria</i> L.		H	Cir-H	
<i>Crataegus monogyna</i> Jacq.		P	Ce	
<i>Crataegus nigra</i> Waldst. et Kit.		P	Ee-P	
<i>Crataegus pentagyna</i> Waldst. et Kit. ex Willd.		P	Ee-P	
<i>Fragaria vesca</i> L.		H	Cosm	
<i>Geum urbanum</i> L.*	7	H	Cosm	
<i>Malus sylvestris</i> Mill.*	7	P	Ce	
<i>Potentilla anserina</i> L.		H	Cosm	
<i>Potentilla reptans</i> L.		H	Med	
<i>Potentilla supina</i> L.		T	Cosm	
<i>Prunus avium</i> L.		P	E-As	
<i>Pyrus pyraster</i> (L.) Burgsd.*	10	P	E-As	
<i>Rosa canina</i> L.*	2	P	Cosm	
<i>Rubus caesius</i> L.		P	E-As	
<i>Rubus plicatus</i> Weihe et Nees		P	Ce	
<b>Rubiaceae</b>				
<i>Cruciata glabra</i> (L.) Ehrend.		H	E-As	
<i>Cruciata laevipes</i> Opiz		H	E-As	
<i>Galium album</i> Mill.		H	E-As	
<i>Galium aparine</i> L.*	2	T	Cosm	
<i>Galium mollugo</i> L.		H	E-As	
<i>Galium odoratum</i> (L.) Scop.*	7	G	E-As	
<i>Galium palustre</i> L.		H	E-As	
<i>Galium verum</i> L.		H	Cosm	
<b>Salicaceae</b>				
<i>Populus alba</i> L.		P	E-As	
<i>Populus x canadensis</i> Moench*	6	P	Cul-ad	
<i>Populus nigra</i> L.		P	E-As	
<i>Salix alba</i> L.		P	E-As	
<i>Salix caprea</i> L.		P	E-As	
<i>Salix fragilis</i> L.		P	E-As	
<i>Salix purpurea</i> L.		P	E-As	
<i>Salix triandra</i> L.		P	E-As	

List of taxa	Investigated locality	Life form	Floral element	Risk category / Protection statusw
<b>Santalaceae</b>				
<i>Viscum album</i> L.		P	E-As	
<b>Scrophulariaceae</b>				
<i>Gratiola officinalis</i> L.		H	Cosm	
<i>Kickxia elatine</i> (L.) Dumort. ssp. <i>elatine</i>		T	S-Eur	DD
<i>Lathraea squamaria</i> L.*	8	G	E-As	
<i>Limosella aquatica</i> L.		T	Cir-H	CR SP
<i>Linaria genistifolia</i> (L.) Mill.		H	E-As	
<i>Linaria vulgaris</i> Mill.		H	E-As	
<i>Lindernia procumbens</i> (Krock.) Philcox		T	E-As	VU SP
<i>Odontites vernus</i> (Bellardi) Dumort.*	10	T	E-As	
<i>Pseudolysimachion longifolium</i> (L.) Opiz		H	E-As	EN SP
<i>Scrophularia nodosa</i> L.		H	Cir-H	
<i>Verbascum blattaria</i> L.		H	Cosm	
<i>Verbascum nigrum</i> L.		H	E	
<i>Verbascum phlomoides</i> L.		H	E	
<i>Veronica anagallis-aquatica</i> L.		H	E	
<i>Veronica austriaca</i> L.		H	Ee-P	
<i>Veronica catenata</i> Pennell*	5	Hy	Cir-H	
<i>Veronica chamaedrys</i> L.		H	E-As	
<i>Veronica hederifolia</i> L.		T	E-As	
<i>Veronica peregrina</i> L.		T	Cul-ad	
<i>Veronica persica</i> Poir. <sup>1)</sup>		T	Cosm	
<i>Veronica scutellata</i> L.		H	E	
<i>Veronica serpyllifolia</i> L.*	8	H	Cosm	
<i>Veronica teucrium</i> L.		H	E-As	
<b>Simaroubaceae</b>				
<i>Ailanthus altissima</i> (Mill.) Swingle*. <sup>1)</sup>	2	P	Cul-ad	
<b>Solanaceae</b>				
<i>Datura stramonium</i> L. <sup>1)</sup>		T	Cosm	
<i>Physalis alkekengi</i> L.		H	E	
<i>Solanum dulcamara</i> L.		P	Cosm	
<i>Solanum nigrum</i> L.		T	Cosm	
<b>Tiliaceae</b>				
<i>Tilia cordata</i> Mill.*	7	P	E	
<i>Tilia platyphyllos</i> Scop.*	7	P	E	
<b>Trapaceae</b>				
<i>Trapa natans</i> L.		Hy	Cosm	NT SP
<b>Ulmaceae</b>				
<i>Ulmus laevis</i> Pall.		P	Ce	
<i>Ulmus minor</i> Miller		P	E	
<b>Urticaceae</b>				
<i>Parietaria officinalis</i> L.		H	S-Eur	
<i>Urtica dioica</i> L.		H	Cosm	
<i>Urtica kioviensis</i> Rogow.		H	E	
<b>Valerianaceae</b>				
<i>Valeriana officinalis</i> L.*	3	H	E-As	
<i>Valerianella locusta</i> (L.) Laterrade		T	Med	
<b>Verbenaceae</b>				
<i>Verbena officinalis</i> L.		H	Cosm	
<b>Violaceae</b>				
<i>Viola alba</i> Besser		H	S-Eur	

List of taxa	Investigated		Floral element	Risk category / Protection statusw
	locality	Life form		
<i>Viola arvensis</i> Murray*	7	T	Cosm	
<i>Viola elatior</i> Fr.*	8	H	E-As	
<i>Viola hirta</i> L.		H	E-As	
<i>Viola odorata</i> L.		H	E	
<i>Viola reichenbachiana</i> Jord. ex Boreau		H	E-As	
<i>Viola tricolor</i> L.		T	Cul-ad	
<b>Vitaceae</b>				
<i>Vitis vinifera</i> L.				
ssp. <i>sylvestris</i> (C. C. Gmel) Hegi*	2	P	Cul-ad	
<b>LILIOPSIDA (MONOCOTYLEDONAE)</b>				
<b>Acoraceae</b>				
<i>Acorus calamus</i> L.		Hy	Cul-ad	
<b>Alismataceae</b>				
<i>Alisma gramineum</i> Lej.		Hy	E-As	EN SP
<i>Alisma lanceolatum</i> With.		Hy	Cosm	
<i>Alisma plantago-aquatica</i> L.		Hy	Cosm	
<i>Sagittaria sagittifolia</i> L.		Hy	E-As	
<b>Amaryllidaceae</b>				
<i>Allium angulosum</i> L.*	1	G	E-As	EN SP
<i>Allium scorodoprasum</i> L.		G	Ee-P	
<i>Allium vineale</i> L.*	8	G	Cosm	
<i>Leucojum aestivum</i> L.		G	E	
<b>Asparagaceae</b>				
<i>Asparagus officinalis</i> L.*	8	G	Cul-ad	
<i>Convallaria majalis</i> L.		G	Cir-H	
<i>Muscari botryoides</i> (L.) Mill.*	8	G	S-Eur	
<i>Scilla bifolia</i> L.		G	S-Eur	
<b>Butomaceae</b>				
<i>Butomus umbellatus</i> L.		Hy	E-As	NT
<b>Colchicaceae</b>				
<i>Colchicum autumnale</i> L.*	8	G	Ce	
<b>Cyperaceae</b>				
<i>Bolboschoenus maritimus</i> (L.) Palla*	9	Hy	Cosm	NT
<i>Carex acuta</i> L.		Hy	E-As	
<i>Carex acutiformis</i> Ehrh.		Hy	E-As	NT
<i>Carex bohemica</i> Schreb.		H	Cir-H	CR SP
<i>Carex digitata</i> L.		H	E-As	
<i>Carex distans</i> L.		H	E	
<i>Carex divulsa</i> Stokes		H	Cosm	
<i>Carex elata</i> All.		Hy	E	
<i>Carex flacca</i> Schreb.*	9	G	Cosm	
<i>Carex hirta</i> L.		G	E-As	
<i>Carex nigra</i> (L.) Reichard		G	Cosm	EN SP
<i>Carex pendula</i> Huds.		H	E-As	
<i>Carex remota</i> L.		H	E	
<i>Carex riparia</i> Curt.		G	E-As	VU SP
<i>Carex spicata</i> Huds.		H	E-As	
<i>Carex sylvatica</i> Huds.		H	E	
<i>Carex vesicaria</i> L.		G	Cir-H	VU SP
<i>Carex vulpina</i> L.		H	E	

List of taxa	Investigated		Floral element	Risk category / Protection statusw
	locality	Life form		
<i>Cyperus flavescens</i> L.		T	Cosm	VU SP
<i>Cyperus fuscus</i> L.		T	E-As	VU SP
<i>Cyperus glomeratus</i> L.*	3	T	E-As	VU SP
<i>Cyperus longus</i> L.		Hy	Cosm	VU SP
<i>Cyperus michelianus</i> (L.) Link		T	E-As	VU SP
<i>Eleocharis acicularis</i> (L.) Roem. et Schult.		G	Cosm	
<i>Eleocharis ovata</i> (Roth) Roem. et Schult.		T	Cir-H	EN SP
<i>Eleocharis palustris</i> (L.) Roem. et Schult.		G	Cosm	
<i>Scirpus lacustris</i> L. ssp. <i>lacustris</i>		Hy	Cosm	
<i>Scirpus mucronatus</i> L.*	2	Hy	Cosm	CR SP
<i>Scirpus pendulus</i> Muhl.*	10	Hy	Cul-ad	
<i>Scirpus supinus</i> L.		T	Cosm	CR SP
<b>Hydrocharitaceae</b>				
<i>Elodea canadensis</i> Michx.* <sup>1)</sup>	9	Hy	Cul-ad	
<i>Elodea nuttallii</i> (Planch.) H.St.John		Hy	Cul-ad	
<i>Hydrocharis morsus-ranae</i> L.		Hy	E-As	
<i>Stratiotes aloides</i> L.*	2	Hy	E-As	VU SP
<b>Iridaceae</b>				
<i>Iris pseudacorus</i> L.		G	E-As	SP
<i>Iris sibirica</i> L. ssp. <i>sibirica</i> *	1	G	E-As	VU SP
<b>Juncaceae</b>				
<i>Juncus articulatus</i> L.		G	Cir-H	
<i>Juncus bufonius</i> L.		T	Cosm	
<i>Juncus compressus</i> Jacq.		G	Cosm	
<i>Juncus effusus</i> L.w		H	E-As	
<i>Juncus inflexus</i> L.		H	E-As	
<i>Juncus tenuis</i> Willd. <sup>1)</sup>		H	Cosm	
<b>Lemnaceae</b>				
<i>Lemna gibba</i> L.	11	Hy	Cosm	EN SP
<i>Lemna minor</i> L.		Hy	Cosm	
<i>Lemna minuta</i> Kunth*	11	Hy	Cosm	
<i>Lemna trisulca</i> L.		Hy	Cosm	
<i>Spirodela polyrhiza</i> (L.) Schleiden		Hy	Cosm	
<i>Wolffia arrhiza</i> (L.) Horkel ex Wimm.		Hy	Cosm	VU SP
<b>Liliaceae</b>				
<i>Fritillaria meleagris</i> L.*	8	G	Med	VU SP
<b>Najadaceae</b>				
<i>Najas marina</i> L.		Hy	Cosm	
<i>Najas minor</i> All.		Hy	E-As	
<b>Orchidaceae</b>				
<i>Anacamptis pyramidalis</i> (L.) Rich.*	3	G	E	NT SP
<i>Cephalanthera damasonium</i> (Mill.) Druce		G	S-Eur	NT SP
<i>Dactylorhiza incarnata</i> (L.) Soó*	10	G	E-As	EN SP
ssp. <i>incarnata</i>		G	E-As	
<i>Epipactis helleborine</i> (L.) Crantz*	8	G	E-As	SP
<i>Listera ovata</i> (L.) R.Br.*	7	G	E-As	SP
<i>Orchis laxiflora</i> Lam. ssp. <i>palustris</i> (Jacq.) Bonnier et Layens		G	E	DD SP
<i>Orchis purpurea</i> Huds.*	8	G	E-As	VU SP



List of taxa	Investigated		Floral element	Risk category / Protection statusw
	locality	Life form		
<i>Platanthera bifolia</i> (L.) Rich.*	8	G	E-As	VU SP
<i>Platanthera chlorantha</i> (Custer) Rchb.*	8	G	E-As	NT SP
<b>Poaceae</b>				
<i>Agrostis stolonifera</i> L.		H	Cir-H	
<i>Alopecurus aequalis</i> Sobol.		H	E	VU SP
<i>Alopecurus geniculatus</i> L.*	3	H	Cosm	VU SP
<i>Alopecurus pratensis</i> L.		H	E-As	
<i>Dichanthium ischaemum</i> (L.) Roberty		H	S-Eur	SP
<i>Brachypodium sylvaticum</i> (Huds.) P. Beauv.		H	E-As	
<i>Bromus japonicus</i> Thunb.		T	E-As	
<i>Bromus squarossus</i> L.		T	S-Eur	
<i>Bromus sterillis</i> L.		T	Cosm	
<i>Calamagrostis epigejos</i> (L.) Roth.		H	E	
<i>Cynodon dactylon</i> (L.) Pers.		G	Cosm	
<i>Cynosurus cristatus</i> L.		H	E	
<i>Dactylis glomerata</i> L.		H	E-As	
<i>Echinochloa crus-galli</i> (L.) P. Beauv.		T	Cosm	
<i>Eleusine indica</i> (L.) Gaertn.* <sup>1)</sup>	11	T	Cul-ad	
<i>Elymus caninus</i> (L.) L.		G	E-As	
<i>Elymus hispidus</i> (Opiz) Melderis		G	S-Eur	
<i>Elymus repens</i> (L.) Gould*	10	G	Cosm	
<i>Festuca ovina</i> L.		H	E	
<i>Festuca pratensis</i> Huds.*	8	H	Cosm	
<i>Festuca rubra</i> L.		H	Cir-H	
<i>Glyceria fluitans</i> (L.) R.Br.		Hy	Cosm	VU SP
<i>Glyceria maxima</i> (Hartm.) Holmb.		Hy	E-As	
<i>Holcus lanatus</i> L.		H	E-As	
<i>Hordeum murinum</i> L.		T	Cir-H	
<i>Koeleria macrantha</i> (Ledeb.) Schult.		H	E-As	
<i>Koeleria pyramidata</i> (Lam.) P. Beauv.		H	E	
<i>Lolium perenne</i> L.*	8	H	E	
<i>Panicum capillare</i> L.* <sup>1)</sup>	3	T	Cul-ad	
<i>Phalaris arundinacea</i> L.		G	Cir-H	
<i>Phleum paniculatum</i> Huds.		T	Med	SP
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.		Hy	Cosm	
<i>Poa annua</i> L.		T	Cosm	
<i>Poa bulbosa</i> L.		H	E-As	
<i>Poa palustris</i> L.		H	Cir-H	NT
<i>Poa pratensis</i> L.		H	Cosm	
<i>Poa trivialis</i> L.		H	E-As	
<i>Sclerochloa dura</i> (L.) P.Beauv		T	Med	
<i>Setaria pumila</i> (Poir.) Schult.		T	Cosm	
<i>Setaria viridis</i> (L.) P.Beauv.		T	E-As	
<b>Potamogetonaceae</b>				
<i>Potamogeton coloratus</i> Hornem.*	5	Hy	E	
<i>Potamogeton crispus</i> L.		Hy	Cosm	
<i>Potamogeton gramineus</i> L.		Hy	Cir-H	
<i>Potamogeton lucens</i> L.		Hy	Cir-H	
<i>Potamogeton natans</i> L.*	2	Hy	Cosm	
<i>Potamogeton nodosus</i> Poir.*	10	Hy	Cosm	

List of taxa	Investigated		Floral element	Risk category / Protection statusw
	locality	Life form		
<i>Potamogeton perfoliatus</i> L.		Hy	Cosm	
<i>Potamogeton pusillus</i> L.		Hy	Cosm	
<i>Potamogeton trichoides</i> Cham. et Schldl.		Hy	E-As	
<i>Stuckenia pectinata</i> (L.) Börner*	5	Hy	Cosm	
<b>Sparganiaceae</b>				
<i>Sparganium erectum</i> L.		Hy	E-As	
<i>Sparganium erectum</i> L. ssp. <i>neglectum</i> (Beeby) Schinz et Thell.		Hy	E-As	
<i>Sparganium minimum</i> Wallr.		Hy	E-As	DD
<b>Typhaceae</b>				
<i>Typha angustifolia</i> L.		G	Cir-H	
<i>Typha latifolia</i> L.		G	Cosm	
<i>Typha laxmannii</i> Lepech.		G	E-As	CR SP
<i>Typha minima</i> Funck		G	E-As	CR SP

From the taxonomic viewpoint, nine taxa (1.7%) belonged to ferns, while angiosperms were represented by 513 taxa: 381 (72.9%) belongs to dicotyledons and 132 (25.3%) to monocotyledons (Tab. 2).

**Table 2:** Taxonomic analyses of the flora of Kopački rit Nature Park.

**Tabela 2:** Taksonomske analize flore Naravnega parka Kopački rit.

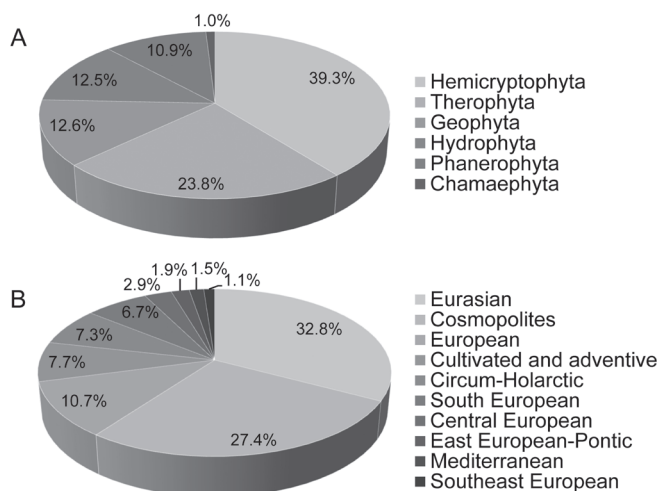
Taxonomic category	Species and subspecies	Genus	Family
Pteridophyta	9	6	6
Magnoliopsida (Dicotyledonae)	381	226	72
Liliopsida (Monocotyledonae)	132	63	18
Total	522	295	96

The most diverse genera were: *Carex* (17 taxa), *Ranunculus* and *Veronica* (10 taxa each), *Potamogeton* (9), *Polygonum* (8) and *Viola* (7 taxa). The most frequent families were: Asteraceae (43 taxa), Poaceae (40), Lamiaceae (34), Cyperaceae (30), Fabaceae and Scrophulariaceae (23 taxa each).

Life-form analysis (Fig. 2a) showed that hemicryptophytes (39.3%) were dominant, followed by therophytes (23.8%), geophytes (12.6%), hydrophytes (12.5%) and phanerophytes (10.9%).

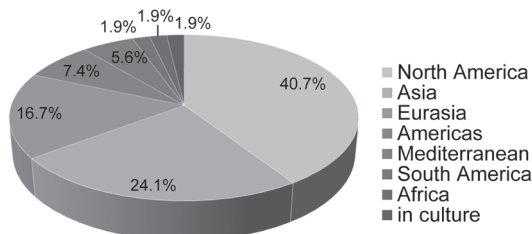
Phytogeographical analysis (Fig. 2b), showed the prevalence of Eurasian floral element (32.8%), followed by Cosmopolites (27.4%) and European floral element (10.7%).

Allochthonous flora was represented with 53 taxa (10.2% of the total flora) of which 12 (22.6%) were archaeophytes and 41 (77.4%) neophytes. The most of these taxa (22) have the North American origin, followed by 12 taxa of Asian origin (Fig. 3). Invasive alien plant species are represented by 26 taxa, which makes about 5% of the total flora.



**Figure 2:** Life-form (A) and chorological spectrum (B) of the flora of Kopački rit Nature Park.

**Slika 2:** Življenjska oblika (A) in horološki spekter (B) flore Naravnega parka Kopački rit.



**Figure 3:** The ratio of geographical origin of allochthonous plants of Kopački rit Nature Park.

**Slika 3:** Delež geografskega izvora alohtonih rastlin Naravnega parka Kopački rit.

According to risk status assigned in the Red Book of Vascular Flora of Croatia (Nikolić and Topić 2005), 55 taxa (10.5% of the total flora) belongs to the following categories: critically endangered (6 taxa), endangered (13), vulnerable (17), near threatened (10), and 9 taxa as data deficient. Status of strictly protected species at the national level (Anonymous 2013b, 2016) was assigned to 53 taxa (10.2% of the total flora).

One species, *Marsilea quadrifolia* is listed in Annex II of the European Union Habitat Directive (Anonymous 1992, 2013c).

## Discussion

The vascular plant diversity of Kopački rit Nature Park makes 10.4% of the total 5,034 taxa (species and subspecies) recorded for the vascular flora of Croatia (Nikolić 2018).

The floristic diversity of Kopački rit Nature Park is compared to that reported for selected protected areas in the Danube River basin (Tab. 3).

Biological spectrum confirms the phytogeographical position in the Pannonian sector of Central European Province, with hemicryptophytes indicating high plant resistance to the winter cold and adaptation to the moderate climate (Ellenberg 1988). For the comparison, therophytes (38.0%)

and hemicryptophytes (33.0%) are dominant in the Danube Delta, due to transitional position of this region, eastern of the Danubial Province and western of the Pontic Province (Ciocârlan 2011). A higher portion of therophytes (23.8%) indicates warm, and periodically dry climate conditions, as well as an impact of the human disturbance, because this life-form is usual in anthropogenic habitats (Dobrović et al. 2006). The agricultural land under intensive crop production (oilseed rape, wheat, barley, corn, sugar beet, sunflower and soybean) dominates in Baranja region (Kovačić et al. 2016) and cropland surrounds the western border of the Park. Percentage of hydrophytes (12.5%) is higher than 4% confirmed for the Baranja region (Panjković 1990).

This reflects the ecological features of Kopački rit as a large fluvial-marshy floodplain where an occurrence and spatial distribution of terrestrial, wetland and aquatic vegetation depends on the frequency, intensity and duration of floods, and drought periods.

The dominance of Eurasian floral element (32.8%) corresponds to 31.0% for the Baranja region (Panjković 1990) and 28.0% for the Danube Delta (Ciocârlan 2011).

The percentage of cosmopolites (27.4%) is much higher than in the Baranja region (6.2%), and the Danube Delta (8.3%). Oppositely, the percentage of the Central European floral element

is much higher in the Baranja region (20.9%) than in Kopački rit Nature Park (2.9%). Percentage of European floral element is higher in the Danube Delta (14.0%).

The allochthonous flora includes 53 taxa, which makes 8.5% of 624 taxa registered for the allochthonous flora of Croatia. Invasive alien plants count 26 taxa or 34.7% of 75 taxa registered in the Croatian flora (Nikolić 2018). The presence of alien plants is higher (13.4%) in Donau-Auen National Park (Drescher and Magnes 2002), and lower (3.1%) in Special Nature Reserve Gornje Podunavlje (Panjković and Stojšić 2001), and Danube Delta Biosphere Reserve with 5.4% (Mihai et al. 2011). The richer allochthonous flora shows disturbance intensity caused by anthropogenic activities.

Wet meadows from the vegetation alliance *Cnidion dubii* are still present in the area of Kopački rit Nature Park, but under the high risk of extinction. This was confirmed by recording the presence of taxa: *Allium angulosum*, *Euphorbia lucida*, *Gentiana pneumonanthe*, *Iris sibirica* ssp. *sibirica* and *Pseudolysimachion longifolium*, as diagnostic species for this habitat type listed in Annex I of the EU Habitats Directive under the code: 6440 Alluvial meadows of river valleys of the *Cnidion dubii* (Anonymous 1992, 2013c).

Knowledge on the diversity of orchid family (*Orchidaceae*) expands from two previously re-

**Table 3:** A comparison of the floristic diversity between Kopački rit Nature Park and selected protected areas in the Danube catchment area.

**Tabela 3:** Primerjava flore raznovrstnosti Naravnega parka Kopački rit z izbranimi zavarovanimi območji v Donavskem porečju.

Protected area (Country)	Number of taxa	Reference
Kopački rit Nature Park (Croatia)	522	
Lonjsko Polje Nature Park (Croatia)	550	Gugić (2008)
Donau-Auen National Park (Croatia)	838	Drescher and Magnes (2002)
Gornje Podunavlje Special Nature Reserve (Serbia)	1,000	Panjković et al. (2000)
Đerdap National Park (Serbia)	1,013	Petrić et al. (2010)
Rusenski Lom Nature Park (Bulgaria)	877	Stoyanov (2005)
Danube Delta (Romania)	985	Ciocârlan (2011)
Danube Delta Biosphere Reserve (Romania)	1,215	Mihai et al. (2011)

ported taxa (*Cephalanthera damasonium*, *Orchis laxiflora* ssp. *palustris*) to currently known nine taxa. During the field surveys, following seven taxa were discovered: *Anacamptys pyramidalis*, *Dactylorhiza incarnata* ssp. *incarnata*, *Epipactis helleborine*, *Listera ovata*, *Orchis purpurea*, *Platanthera bifolia* and *Platanthera chlorantha*. All taxa of the *Orchidaceae* are strictly protected species in Croatia.

The macrophyte diversity in Kopački rit Nature Park comprises 158 taxa (30.3% of the total flora), which exceeds the number of only seven taxa recorded in the Danube main channel, and 37 taxa recorded in water bodies along the right bank in the Croatian reach of the Danube River (Ozimec and Topić 2018).

Stressors and threats to the flora of Kopački rit Nature Park are natural and anthropogenic. In recent decades, more frequent fluctuations in flooding intensity of the Danube River, and extension of a dry season affects to reduction in size of the inundated area. Accumulation of suspended solids and sediment in sidearms and channels disrupt hydrological connection and initiate the natural succession processes. Abandoned land, as well as habitats overgrown with shrubs or herbaceous ruderal vegetation under the natural succession, supports the colonisation and dispersal of the invasive alien plant species, which can threaten the native flora. Stressors such as air, soil and water pollutants, pests and pathogens, invasive species, fire, storms, land management and visitor use have a harmful impact at some point on plants and their habitats.

## Conclusions

1. The diversity of vascular plants in Kopački rit Nature Park, with 522 currently known taxa, confirms significant ecological values of this floodplain area situated in the middle course of the Danube River.
2. The flora is characterised by high percentage of hemicryptophytes and therophytes, as well as of Eurasian floral element and Cosmopolites.
3. Regarding the plant conservation, 53 taxa have a status of strictly protected species, and 55 taxa are included in the Red Book of Vascular Flora of Croatia.
4. Allochthonous flora is represented with 53 taxa, among which 26 are invasive alien plant species.
5. Comprehensive knowledge on plant diversity is an important tool for planning and implementation of activities in conservation of rare and threatened plants and their habitats in Kopački rit Nature Park.

## Povzetek

Naravni park Kopački rit se nahaja v severovzhodni Hrvaški, na območju sotočja Donave in reke Drave. Park pokriva območje 231 km<sup>2</sup> in se nahaja na nadmorski višino od 78 do 86 m. Glede na fitogeografsko razdelitev sodi območje v evrosibirsko-severnoameriško regijo, panonski sektor srednjeevropske province. Zaradi izjemne biološke in ekološke vrednosti tega poplavnega območja v srednjem toku reke Donave, je območje od leta 1967 zaščiteno. Floristične študije na območju Naravnega parka Kopački rit so bile v preteklosti razdrobljene. V prispevku so zbrani literaturni podatki in rezultati terenskih raziskav, ki so bile izvedene v obdobju od leta 2010 do leta 2018. V Naravnem parku Kopački rit je bilo ugotovljenih 522 taksonov vaskularnih rastlin, kar potrjuje ekološko vrednost tega poplavnega območja, ki se nahaja v srednjem toku reke Donave. Za floro je značilen visok odstotek hemikriptofitov in terofitov, ter evrazijskih flornih elementov in kozmopolitov. Kar 53 taksonov ima status strogo zaščitene vrste, 55 pa jih je vključenih na Rdeči seznam flore Hrvaške. Tujerodne rastline so zastopane s 53 taksoni, med katerimi je 26 invazivnih tujerodnih rastlinskih vrst. V Naravnem parku Kopački rit so prisotni številni naravni in antropogeni pritiski. V zadnjih desetletjih so pogoste spemembe vodostajev reka Donave in podaljševanje suhe sezone kar vpliva na zmanjšanje obsega poplavljenе površine. Kopičenje usedlin v stranskih rokavih in kanalih moti hidrološko povezavo med različnimi predeli kar pospešuje sukcesijske procese. Opuščena

zemljišča ter habitati poraščeni z grmovjem ali zeliščno ruderalno vegetacijo, podpirajo kolonizacijo in razširjanje invazivnih tujerodnih rastlinskih vrst, ki lahko ogrozijo domačo floro. Predstavljeni izsledki predstavljajo pomembno izhodišče za načrtovanje in izvajanje dejavnosti ohranjanja redkih in ogroženih rastlin ter njihovih habitatov v Naravnem parku Kopački rit in drugih podobnih območjih.

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