

## FLORA OF THE SEMINATURAL MARSHLAND SAVICA, PART OF THE (SUB)URBAN FLORA OF THE CITY OF ZAGREB (CROATIA)

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The flora of Savica, a suburban part of the town Zagreb with remnants of alluvial forests and vegetation of still waters, was surveyed mainly during 2006 with some later additions. In total 289 vascular plant species and subspecies were recorded. Regarding the spectrum of chorological types the flora of Savica is similar to other areas of NW Croatia, but with higher ratio of Euro-Asiatic chorotypes (48.3%), adventive species (13.2%) and Mediterranean chorotypes (9.7%) as consequence of anthropogenic influence and the ruderalisation of habitats. The same process is reflected in its relatively high ratio of therophytes (19.1%). Indicators of anthropogenic changes show that the flora of Savica is more influenced by archaeophytes than by neophytes. Among them, 25 species (8.6%) are invasive alien species. The life-form spectrum is almost the same as for other areas of NW Croatia, suggesting that the flora has a structure well adapted to general climate of North-Western Croatia. A special value of the flora of Savica consists of stands of tree species representing the last remnants of alluvial forests along the Sava River, as well as hydrophytes and helophytes in and around small lakes.

**Key words:** biodiversity, urban flora, life-forms, chorological types, alien species

Alegro, A., Bogdanović, S., Rešetnik, I., Boršić, I., Cigić, P. & Nikolić, T.: Flora poluprirodne močvare Savica, suburbanog dijela grada Zagreba (Hrvatska). *Nat. Croat.*, Vol. 22, No. 1., 111–134, 2013, Zagreb.

Flora Savice, suburbanog dijela grada Zagreba s ostacima poplavnih šuma i vegetacijom stajačica, istraživana je mahom 2006. s nekoliko kasnijih dodataka. Ukupno je zabilježeno 289 vrsta i podvrsta vaskularnog bilja. S obzirom na spektar horoloških tipova, flora Savice slična je nekim drugim područjima SZ Hrvatske s time da se s većom učestalošću ističu biljke eurazijskog elementa (48,3%), adventivne vrste (13,2%) i biljke mediteranskog elementa (9,7%), što je posljedica antropogenog utjecaja i posljedice ruderalizacije staništa. Taj proces se ogleda i u razmjerno visokom udjelu terofita (19,1%). Pokazatelji antropogene promjene pokazuju da je flora Savice više utjecana arheofitima nego neofitima. Među njima nalazi se 25 vrsta (8,6%) invazivnih stranih vrsta. Spektar životnih oblika gotovo je isti kao za druga područja SZ Hrvatske, što upućuje da je flora dobro prilagođena općoj klimi SZ Hrvatske. Osobita vrijednost flore Savice su sastojine drvenastih vrsta koje predstavljaju posljednje ostatke poplavne vegetacije uz rijeku Savu, kao i hidrofiti i helofiti prisutni u jezercima i oko njih.

**Ključne riječi:** biološka raznolikost, urbana flora, životni oblici, horološki tipovi, strane vrste

## INTRODUCTION

Savica, a seminatural marshland area inside the administrative boundaries of the town of Zagreb, is an ideal test field to study the influence of urbanization on the changes in the composition of flora as consequence of habitat modification. Throughout habitat fragmentation, degradation and creation of new habitats with new ecological conditions the process of anthropization has strong influence on natural biodiversity resulting, at species level, in changes in species compositions and abundances. Anthropogenic pressure leads to changes in geographical-historical structure of the urban flora resulting in: (1) a flora with a structure divergent from that originally present (disturbance of natural floristic continuity in time), (2) a flora with a structure different from that present in extra-urban areas (disturbance of floristic continuity in space) and (3) in taxonomic, ecological and geographical uniformisation of floras in different urban areas (WITOSŁAWSKI & BOMANOVSKA, 2009).

The floras of the urban areas in Croatia are very poorly known. Comprehensive data exists only for some towns in Dalmatia: Šibenik (MILOVIĆ, 2000), Split (RUŠČIĆ, 2003; JASPRICA *et al.*, 2010), Zadar (MILOVIĆ, 2008; MILOVIĆ & MITIĆ, 2012), Omiš (TAFRA, 2009; TAFRA *et al.*, 2012) and Dubrovnik (JASPRICA *et al.*, 2010), but for inland parts of Croatia they are very scarce and partial. Reports on the flora and vegetation of Zagreb and its surroundings are relatively numerous compared to the other cities in Croatia. The area along the Sava River near Zagreb has been extensively researched since the second half of the 19<sup>th</sup> century (SCHLOSSER & VUKOTINOVIĆ, 1857, 1869; GJURAŠIN, 1923; HORVATIĆ, 1931; GOSPODARIĆ, 1958; HORVATIĆ & GOSPODARIĆ, 1959-60; MARKOVIĆ-GOSPODARIĆ, 1965; MARKOVIĆ, 1970, 1973, 1975, 1978; TOPIĆ & ŠEGULJA, 1978; LUKAČ, 1988; ILIJANIĆ *et al.*, 1989; SMITAL *et al.*, 1998; NIKOLIĆ & FADLJEVIĆ, 1999; HRŠAK, 2002; MILOVIĆ, 2004 and MITIĆ *et al.*, 2007), and the most recent study deals with the flora on the right bank of the Sava river in the area of Piškorovo and Konopljenka (HUDINA *et al.*, 2012).

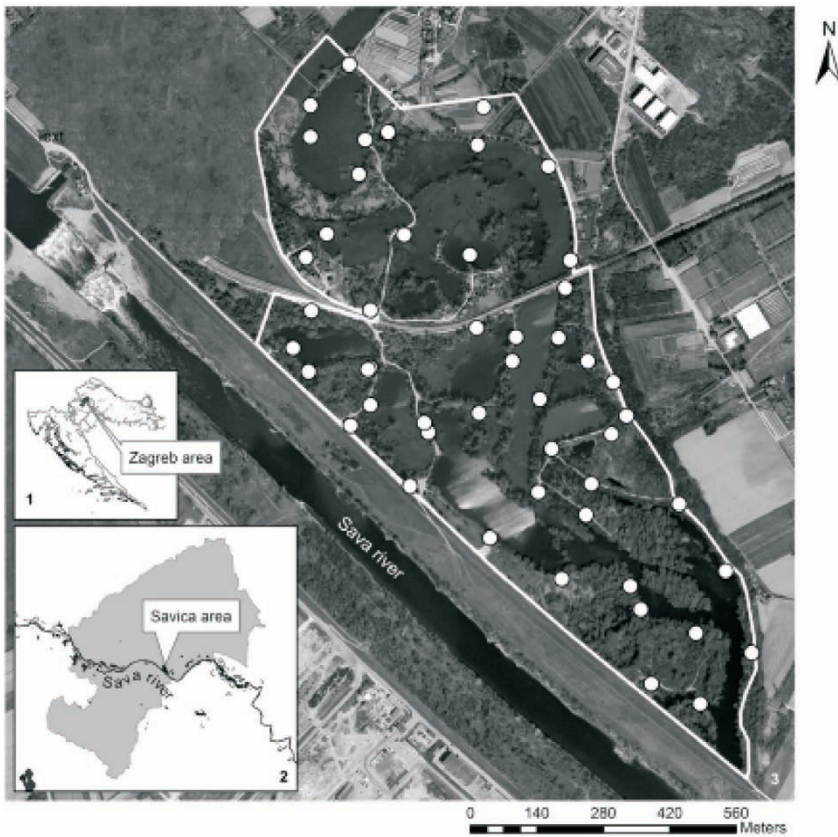
On the other hand floristic data of the urban part of Zagreb are almost non-existent (an exception is a popular field guide ČERNICKI (2006). Mapping of certain urban zones (Jarun, Maksimir, Savica) was conducted during 2006 within the frames of the project Countdown 2010 Zagreb (NIKOLIĆ *et al.*, 2007; ANONYMOUS, 2008).

The aim of this paper is to present the recent flora of Savica, to investigate the participation of archaeophytes and kenophytes in it, and their connection to historical, causal and functional factors.

## MATERIAL AND METHODS

### Study area

Savica (Fig. 1) is a complex of 12 small interconnected eutrophic lakes and surrounding habitats situated on the left river bank in the Sava plain (elevation between 110 and 125 m a. s. l.) on Neogene alluvial deposits. It is in the SE part of town Zagreb, ca 4 km from the town centre. The lakes are remnants of backwaters of the River Sava. They are spread on 30 ha, while the whole area has a surface of 75 ha. Habitats surrounding the lakes are strongly changed and degraded stands of previous floodplain forests. The lakes are now at a higher elevation than the Sava River and therefore without any communication with flowing water. They are fed with water only by precipitation and by cooling water from neighbouring thermal power plant/station.



**Fig. 1.** Geographic position of the investigated area: 1/ area of the city of Zagreb in Croatia, 2/ Savica area inside Zagreb, 3/ Savica area – sampling localities are represented by white dots.

Historically, the area was part of huge lowland forests zone of pedunculate oak (ass. *Genisto elatae-Quercetum roboris* Horvat 1938 and *Carpino betuli-Quercetum roboris* (Anić 1959) Rauš 1971). Alongside the river and backwaters and on other habitats more strongly influenced by floods, with high groundwater and surface water remaining for longer periods, different types of forest communities with willows, alders and poplars (alliances *Salicion albae* Soó 1930 and *Alnion glutinosae* Malcuit 1929) developed (VUKELIĆ, 2012).

Nowadays the area of Savica is without closed forest stands. It is characterised by a mosaic of more or less disturbed habitats around the lakes with single or small groups of trees and dense scrub between them. The most abundant tree species are white willow (*Salix alba*), black and white poplar (*Populus nigra* and *P. alba*), common alder (*Alnus glutinosa*) and black locust (*Robinia pseudoacacia*). The scrub consists mostly of *Cornus sanguinea*, *Prunus spinosa*, *Rosa canina*, *Crataegus monogyna*, *Corylus avellana*, *Sambucus nigra*, *Salix purpurea*, *Ligustrum vulgare* and some other species, all densely interwoven by *Rubus* spp., *Clematis vitalba* and in spots by *Thladiantha dubia*, discovered here for the first time in Croatia outside the Botanical Garden in Zagreb (ILJANIĆ *et al.*, 1985; ALEGRO *et al.*, 2010). This scrub belongs to the alliance *Carpino betuli-Prunion spinosae* (R. Tx. 1952)

H. E. Weber 1974 and to ass. *Cornetum sanguinei* Kaiser 1930. Loose stands of scrub, paths, open habitats and banks of lakes are overgrown by herbaceous species belonging mostly to the alliance *Senecion fluviatilis* R. Tx. 1950 (syn. *Convolvulion sepii* R. Tx. 1947). The most abundant species in this vegetation type are *Epilobium hirsutum*, *E. tetragonum*, *Urtica dioica*, *Calystegia sepium*, *Solidago gigantea*, *Bidens frondosa*, *Helianthus tuberosus*, *Impatiens glandulifera*, *Lysimachia vulgaris* and *L. punctata*. Regarding the water vegetation the most widespread is a community of spiked water milfoil and yellow water lily (ass. *Myriophyllo-Nupharetum luteae* (W. Koch 1926) Hueck 1931). Beside the spiked water milfoil in this community hornwort (*Ceratophyllum demersum*) is very abundant indicating eutrophy in the lakes. Near the banks, in shallow and still water, a community of duckweed has developed (ass. *Lemno-Spirodeletum polyrhizae* W. Koch 1954) with both of the two species abundantly present. In similar habitats there are sporadic occurrences of a community of floating heart (ass. *Nymphoidetum peltatae* Bellot 1951). Very important is the community of periodically flooded banks (*Nanocyperion* W. Koch 1926) encompassing several *Cyperus* and *Carex* species. On the edges and banks of lakes, small patches of reed vegetation belonging to ass. *Phragmitetum australis* (Gams 1927) Schmale 1939 and ass. *Typhetum latifoliae* (Soó 1927) Now. 1930 are developed.

Nevertheless, the area of Savica is one of the last marshland habitats in the town Zagreb, and therefore protected as significant landscape (IUCN category V) with zoological reserve since 1991. In total, 174 bird species (data of Croatian Ornithological Society), 16 mammal species, six reptile species and four amphibian species have been recorded here (TVRTKOVIĆ *et al.*, 2007).

## METHODS

The area of Savica was floristically studied in 2006, during the vegetation period. The specimens were identified directly in the field, or herbarized for subsequent identification, in 46 geocoded sampling spots (Fig. 1/3). Geocoding was done by GPS devices (Garmin eTrex Vista HCx). The historical records from literature were added to the field observation data.

*Flora Europea* (TUTIN *et al.*, 1964-1980, 1993) was mainly used to identify plant material, but some other floras were also employed (OBERDORFER, 2001; MARTINČIČ *et al.*, 2007; FISCHER *et al.*, 2008). The nomenclature used follows *Flora Croatica Database* (NIKOLIĆ 2012). Life-form, chorological type and origin (type and time of immigration) were attributed to each taxon of the check-list.

*Raunkier's* system of life-forms as presented by ELLENBERG *et al.* (1991), OBERDORFER (2001), LANDOLT *et al.* (2010) was accepted:

- p – Phanerophytes,
- ch – Chamaephytes,
- h – Hemicryptophytes,
- t – Therophytes,
- g – Geophytes,
- hy – Hydrophytes.

Chorological types follow the system proposed by HORVATIĆ (1963) and HORVATIĆ *et al.* (1967-1968), but the affiliation of species to particular groups was revised and accorded to newer point of view (SIMON *et al.*, 1992; OBERDORFER, 2001; CIOCĂRLAN, 2009 and especially LANDOLT *et al.*, 2010). The chorological groups used in this paper are:

1. mediterranean – Mediterranean (in broadest sense),
2. illyr-balkan – Illyrian-Balkan,
3. S-europ – South-European,
4. atl – Atlantic,
5. E-europ-pont – East-European-Pontic,
6. SE-europ – Southern-East-European
7. C-europ – Central-European,
8. europ – European,
9. euro-asiat – Eurasiatic,
10. circ-holoart – Circumholarctic,
11. cosmop – Cosmopolites,
12. adv – Adventive species.

Spectra of life-forms and chorological types were compared with some other areas in North-Western Croatia characterized by mosaic, seminatural landscapes: Martinci in Hrvatsko zagorje (MARTINKO, 2009); Stupnik, a suburban area 10 km southwest from Zagreb (MITIĆ *et al.*, 2007); Konjščina in Hrvatsko zagorje (STANČIĆ, 1994), Piškorovo and Konopljenka in suburban area on the south of Zagreb (HUDINA *et al.*, 2012) and Vukova Gorica on the edge of the Gorski kotar Region (ALEGRO *et al.*, 2006).

Origin, i.e. type and time of immigration, was mainly accepted after LANDOLT *et al.* (2010), PYŠEK *et al.* (2002) and LAUBER & WAGNER (1996), but with consideration of the specific circumstances of inland parts of Croatia. The terminology follows KORNAŠ (1981), MIREK (1981) and JACKOWIAK (1990). In brackets are quoted categories proposed by MITIĆ *et al.* (2008) as standards for national flora used in further text. The groups are:

- Sp – spontaneophytes (native plants),
- Ar – archaeophytes, established alien species introduced intentionally or unintentionally before 1500,
- Kn – kenophytes (neophytes), alien species introduced intentionally or unintentionally after 1500, and
- Df – diaphytes (non native casual plants), alien species not permanently established.

Indicators of anthropogenic changes in the flora were calculated after JACKOWIAK (1990, 2006) as follows:

### 1. Indicators of anthropization

- 1.1.  $IAN_t$  – indicator of total anthropization,  $IAN_t = (An / (Sp + An)) * 100$ ;
- 1.2.  $IAN_p$  – indicator of permanent anthropization,  $IAN_p = (Mt / (Sp + Mt)) * 100$ ;

### 2. Indicators of archaeophytization

- 2.1.  $IAR_t$  – indicator of total archaeophytization,  $IAR_t = (Ar / (Sp + An)) * 100$ ;
- 2.2.  $IAR_p$  – indicator of permanent archaeophytization,  $IAR_p = (Ar / (Sp + Mt)) * 100$ ;

### 3. Indicators of kenophytization

- 3.1.  $IKN_t$  – indicator of total kenophytization,  $IKN_t = (Kn / (Sp + An)) * 100$ ;
- 3.2.  $IKN_p$  – indicator of permanent kenophytization,  $IKN_p = (Kn / (Sp + Mt)) * 100$

### 4. IM – indicator of modernization, $IM = (Kn / Mt) * 100$ ;

### 5. IF – indicator of fluctuation changes, $IF = (Df / (Sp + An)) * 100$ ;

where An is number of anthropophytes (alien species i.e.  $An = Ar + Kn + Df$ ) and Mt is number of metaphytes (permanently established alien species, i.e.  $Mt = Ar + Kn$ ).

Threat categories according to the *Red Book of Vascular Flora of Croatia* (NIKOLIĆ & TOPIĆ, 2005), legal protection statuses (ANONYMOUS, 2009) and invasiveness of species (BORŠIĆ *et al.*, 2008; MIRIĆ *et al.*, 2008) were also listed.

## RESULTS

In the area of Savica 289 vascular plant species and subspecies belonging to 199 genera and 75 families were recorded (Tab 1). The most abundant families (Fig. 2) are Asteraceae (12.5%), Poaceae (11.8%), Lamiaceae (5.9%), Fabaceae (5.2%), Cyperaceae

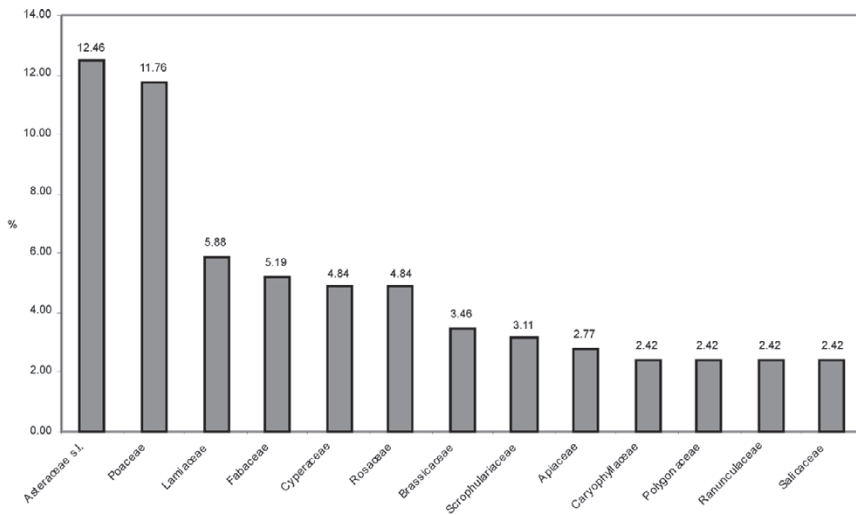


Fig. 2. The most abundant families in the flora of Savica.

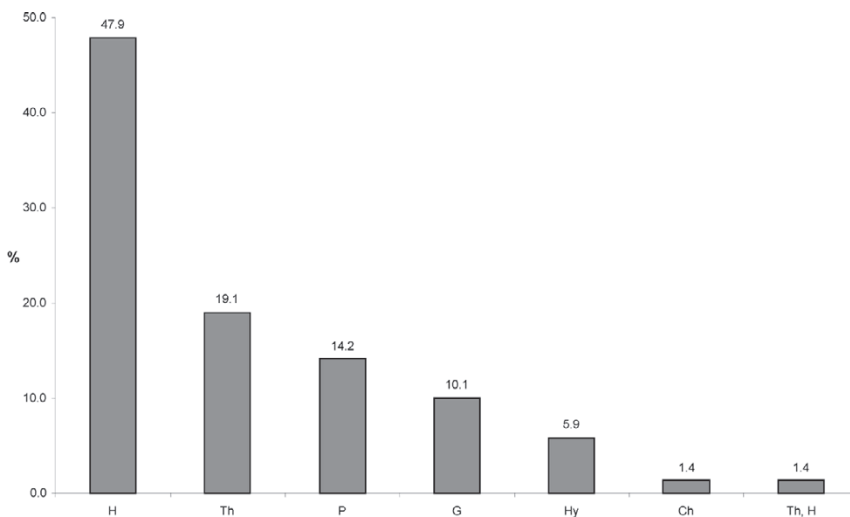


Fig. 3. Spectrum of life-forms for the flora of Savica.



**Tab. 1.** Vascular flora of Savica. O – origin (Sp- native plants, Ar- archaeophytes, Kn- neophytes, Df- non native casual plants), Ch – chorological types, LF – life forms, P – law protection status (P-protected, SP-strictly protected), IAS – invasive alien species.

	O	Ch	LF	P	IAS
Subclass Equisetidae					
Equisetaceae					
<i>Equisetum arvense</i> L.	Sp	10	g		
<i>Equisetum pratense</i> Ehrh.	Sp	10	g		
<i>Equisetum ramosissimum</i> Desf.	Sp	11	g		
Subclass Magnoliidae					
Amaranthaceae					
<i>Amaranthus retroflexus</i> L.	Kn	12	t		I
Apiaceae					
<i>Aegopodium podagraria</i> L.	Sp	9	h		
<i>Angelica sylvestris</i> L.	Sp	9	h		
<i>Anthriscus sylvestris</i> (L.) Hoffm.	Sp	9	h		
<i>Berula erecta</i> (Huds.) Coville	Sp	10	hy		
<i>Daucus carota</i> L.	Ar	1	h		
<i>Hacquetia epipactis</i> (Scop.) DC.	Sp	2	h		
<i>Heracleum sphondylium</i> L.	Sp	9	h		
<i>Torilis arvensis</i> (Huds.) Link	Ar	1	t		
Araliaceae					
<i>Hedera helix</i> L.	Sp	7	p		
Aristolochiaceae					
<i>Aristolochia clematitis</i> L.	Ar	1	h	P	
Asclepiadaceae					
<i>Asclepias syriaca</i> L.	Kn	12	g		I
Asteraceae					
<i>Achillea millefolium</i> L.	Sp	9	h		
<i>Ambrosia artemisiifolia</i> L.	Kn	12	t		I
<i>Arctium lappa</i> L.	Sp	9	h		
<i>Arctium minus</i> Bernh.	Sp	8	h		
<i>Artemisia verlotiorum</i> Lamotte	Kn	12	h		I
<i>Artemisia vulgaris</i> L.	Sp	9	h		
<i>Bellis perennis</i> L.	Sp	9	h		

<i>Bidens frondosa</i> L.	Kn	12	t		I
<i>Centaurea jacea</i> L.	Sp	9	h		
<i>Centaurea nigrescens</i> Willd.	Sp	5	h		
<i>Centaurea rhenana</i> Boreau	Sp	9	h		
<i>Cichorium intybus</i> L.	Ar	9	h		
<i>Cirsium arvense</i> (L.) Scop.	Sp	9	g		
<i>Cirsium vulgare</i> (Savi) Ten.	Sp	9	h		
<i>Conyza canadensis</i> (L.) Cronquist	Kn	12	t		I
<i>Crepis biennis</i> L.	Sp	7	h		
<i>Erigeron annuus</i> (L.) Pers.	Kn	12	h		I
<i>Eupatorium cannabinum</i> L.	Sp	9	h		
<i>Galinsoga ciliata</i> (Raf.) S.F.Blake	Kn	12	t		I
<i>Galinsoga parviflora</i> Cav.	Kn	12	t		I
<i>Helianthus tuberosus</i> L.	Kn	12	g		I
<i>Lactuca serriola</i> L.	Sp	9	h		
<i>Lapsana communis</i> L.	Sp	9	h		
<i>Petasites hybridus</i> (L.) P.Gaertn., B.Mey. et Schreb.	Sp	9	g		
<i>Picris hieracioides</i> L.	Sp	9	h		
<i>Pulicaria dysenterica</i> (L.) Bernh.	Ar	1	h	P	
<i>Rudbeckia laciniata</i> L.	Kn	12	h		I
<i>Senecio erraticus</i> Bertol.	Sp	3	h		
<i>Senecio vulgaris</i> L.	Ar	1	t		
<i>Solidago gigantea</i> Aiton	Kn	12	h	P	I
<i>Sonchus asper</i> (L.) Hill	Ar	9	t		
<i>Sonchus oleraceus</i> L.	Ar	9	t		
<i>Tanacetum vulgare</i> L.	Sp	9	h		
<i>Taraxacum officinale</i> Weber	Sp	10	h	P	
<i>Tripleurospermum inodorum</i> (L.) Sch. Bip.	Ar	9	t,h		
<i>Tussilago farfara</i> L.	Sp	9	h		
<b>Balsaminaceae</b>					
<i>Impatiens glandulifera</i> Royle	Kn	12	t		I
<i>Impatiens parviflora</i> DC.	Kn	12	t		I
<b>Berberidaceae</b>					
<i>Berberis vulgaris</i> L.	Sp	7	p	P	
<b>Betulaceae</b>					
<i>Alnus glutinosa</i> (L.) Gaertner	Sp	9	p		
<b>Boraginaceae</b>					
<i>Myosotis scorpioides</i> L.	Sp	9	h		
<i>Pulmonaria officinalis</i> L.	Sp	6	h		



<i>Symphytum officinale</i> L.	Sp	9	h	
<b>Brassicaceae</b>				
<i>Alliaria petiolata</i> (M. Bieb.) Cavara et Grande	Sp	9	h	P
<i>Capsella bursa-pastoris</i> (L.) Medik.	Ar	1	t	
<i>Cardamine impatiens</i> L.	Sp	9	h	
<i>Diplotaxis muralis</i> (L.) DC	Ar	1	t	
<i>Erophila verna</i> (L.) DC	Sp	9	t	
<i>Lepidium ruderales</i> L.	Ar	9	t	
<i>Nasturtium officinale</i> R. Br.	Sp	10	hy	P
<i>Rorippa amphibia</i> (L.) Besser	Sp	9	hy	
<i>Rorippa sylvestris</i> (L.) Besser	Sp	7	h	
<i>Sinapis arvensis</i> L.	Ar	1	t	
<b>Cannabidaceae</b>				
<i>Humulus lupulus</i> L.	Sp	9	h	
<b>Caprifoliaceae</b>				
<i>Lonicera xylosteum</i> L.	Sp	9	p	
<i>Sambucus ebulus</i> L.	Sp	1	h	
<i>Sambucus nigra</i> L.	Sp	8	p	
<i>Viburnum lantana</i> L.	Sp	9	p	
<i>Viburnum opulus</i> L.	Sp	9	p	
<b>Caryophyllaceae</b>				
<i>Cerastium sylvaticum</i> Waldst. et Kit.	Sp	5	h	
<i>Cucubalus baccifer</i> L.	Sp	9	h	
<i>Saponaria officinalis</i> L.	Sp	9	h	P
<i>Silene dioica</i> (L.) Clairv.	Sp	8	h	
<i>Silene latifolia</i> Poir. subsp. <i>alba</i> (Mill.) Greuter et Bourdet	Sp	1	h	
<i>Silene vulgaris</i> (Moench.) Garcke	Sp	7	h	
<i>Stellaria media</i> (L.) Vill.	Ar	1	t	
<b>Celastraceae</b>				
<i>Euonymus europaeus</i> L.	Sp	9	p	P
<b>Ceratophyllaceae</b>				
<i>Ceratophyllum demersum</i> L.	Sp	11	hy	
<b>Chenopodiaceae</b>				
<i>Chenopodium album</i> L.	Ar	9	t	
<b>Convolvulaceae</b>				

<i>Calystegia sepium</i> (L.) R. Br.	Sp	9	h	
<i>Convolvulus arvensis</i> L.	Ar	9	h	
<b>Cornaceae</b>				
<i>Cornus sanguinea</i> L.	Sp	8	p	
<b>Corylaceae</b>				
<i>Corylus avellana</i> L.	Sp	8	p	
<b>Cucurbitaceae</b>				
<i>Echinocystis lobata</i> (Michx.) Torr. et Gray	Kn	12	t	I
<i>Thladiantha dubia</i> Bunge	Kn	12	g	
<b>Dipsacaceae</b>				
<i>Dipsacus fullonum</i> L.	Ar	1	h	
<i>Knautia arvensis</i> (L.) Coult.	Sp	9	h	
<i>Scabiosa columbaria</i> L.	Sp	7	h	
<b>Euphorbiaceae</b>				
<i>Euphorbia cyparissias</i> L.	Sp	9	h	
<i>Euphorbia esula</i> L.	Sp	9	h	
<i>Euphorbia helioscopia</i> L.	Ar	1	t	
<b>Fabaceae</b>				
<i>Coronilla varia</i> L.	Sp	8	h	
<i>Galega officinalis</i> L.	Ar	1	h	P
<i>Lathyrus latifolius</i> L.	Sp	3	h	
<i>Lathyrus pratensis</i> L.	Sp	9	h	
<i>Lotus corniculatus</i> L.	Sp	9	h	
<i>Medicago falcata</i> L.	Sp	9	h	
<i>Medicago lupulina</i> L.	Ar	1	t	
<i>Medicago sativa</i> L.	Ar	1	h	
<i>Melilotus albus</i> Medik.	Ar	9	h	
<i>Melilotus officinalis</i> (L.) Lam.	Ar	9	h	
<i>Robinia pseudoacacia</i> L.	Kn	12	p	I
<i>Trifolium arvense</i> L.	Ar	3	t	
<i>Trifolium pratense</i> L.	Sp	9	h	
<i>Trifolium repens</i> L.	Sp	9	h	
<i>Vicia cracca</i> L.	Sp	9	h	
<b>Gentianaceae</b>				
<i>Nymphoides peltata</i> (S. G. Gmelin) O. Kuntze	Sp	9	hy	

Geraniaceae				
<i>Geranium robertianum</i> L.	Sp	10	h	P
Haloragaceae				
<i>Myriophyllum spicatum</i> L.	Sp	10	hy	
Hypericaceae				
<i>Hypericum perforatum</i> L.	Sp	9	h	P
Juglandaceae				
<i>Juglans regia</i> L.	Ar	12	p	
Lamiaceae				
<i>Ajuga reptans</i> L.	Sp	9	h	
<i>Ballota nigra</i> L.	Ar	1	h	P
<i>Galeopsis speciosa</i> Mill.	Sp	5	t	
<i>Glechoma hederacea</i> L.	Sp	9	h	
<i>Lamium maculatum</i> L.	Sp	7	h	
<i>Lamium orvala</i> L.	Sp	2	h	
<i>Lamium purpureum</i> L.	Ar	1	t	
<i>Lycopus europaeus</i> L.	Sp	9	h	P
<i>Mentha aquatica</i> L.	Sp	9	hy	P
<i>Mentha arvensis</i> L.	Sp	10	h	
<i>Mentha longifolia</i> (L.) Huds.	Sp	9	h	
<i>Prunella vulgaris</i> L.	Sp	10	h	
<i>Salvia pratensis</i> L.	Sp	1	h	
<i>Scutellaria galericulata</i> L.	Sp	10	h	
<i>Stachys palustris</i> L.	Sp	10	g	
<i>Thymus longicaulis</i> C.Presl	Sp	6	ch	
<i>Thymus pulegioides</i> L.	Sp	9	ch	
Linaceae				
<i>Linum bienne</i> Mill.	Sp	1	h	
Lythraceae				
<i>Lythrum salicaria</i> L.	Sp	9	h	P
Malvaceae				
<i>Althaea officinalis</i> L.	Ar	12	h	P
<i>Malva sylvestris</i> L.	Ar	9	h	
Moraceae				
<i>Morus alba</i> L.	Ar	12	p	

Nymphaeaceae				
<i>Nuphar lutea</i> (L.) Sm. in Sibith. et Sm.	Sp	9	hy	P
Onagraceae				
<i>Circaea lutetiana</i> L.	Sp	9	h	
<i>Epilobium hirsutum</i> L.	Sp	9	h	
<i>Epilobium palustre</i> L.	Sp	10	h	
<i>Epilobium tetragonum</i> L.	Sp	7	h	
<i>Oenothera biennis</i> L.	Kn	12	t	I
Oleaceae				
<i>Ligustrum vulgare</i> L.	Sp	9	p	
Oxalidaceae				
<i>Oxalis corniculata</i> L.	Kn	12	t	
<i>Oxalis stricta</i> L.	Kn	12	t	
Papaveraceae				
<i>Chelidonium majus</i> L.	Sp	9	h	
Plantaginaceae				
<i>Plantago lanceolata</i> L.	Sp	9	h	
<i>Plantago major</i> L.	Sp	9	h	
<i>Plantago media</i> L.	Sp	9	h	
Polygonaceae				
<i>Fallopia convolvulus</i> (L.) Á.Löve	Ar	1	t	
<i>Polygonum aviculare</i> L.	Sp	9	t	
<i>Polygonum mite</i> Schrank	Sp	7	t	
<i>Polygonum persicaria</i> L.	Sp	11	t	
<i>Rumex crispus</i> L.	Sp	9	h	
<i>Rumex hydrolapathum</i> Hudson	Sp	7	hy	
<i>Rumex palustris</i> Sm.	Sp	9	t,h	
Portulacaceae				
<i>Portulaca oleracea</i> L.	Ar	1	t	
Primulaceae				
<i>Anagallis arvensis</i> L.	Ar	1	t	
<i>Lysimachia nummularia</i> L.	Sp	8	h	
<i>Lysimachia punctata</i> L.	Sp	5	h	
<i>Lysimachia vulgaris</i> L.	Sp	9	h	

<i>Primula vulgaris</i> Huds.	Sp	10	h		
<b>Ranunculaceae</b>					
<i>Clematis vitalba</i> L.	Sp	7	p		
<i>Ranunculus acris</i> L.	Sp	9	h	P	
<i>Ranunculus ficaria</i> L.	Sp	7	h	P	
<i>Ranunculus repens</i> L.	Sp	9	h	P	
<i>Ranunculus sardous</i> Crantz	Ar	1	h	P	
<i>Thalictrum lucidum</i> L.	Sp	5	h	P	
<i>Thalictrum minus</i> L.	Sp	9	h	P	
<b>Rhamnaceae</b>					
<i>Frangula alnus</i> Mill.	Sp	9	p		
<b>Rosaceae</b>					
<i>Agrimonia eupatoria</i> L.	Sp	9	h	P	
<i>Crataegus monogyna</i> Jacq.	Sp	9	p	P	
<i>Duchesnea indica</i> (Andrews) Focke	Kn	12	h		I
<i>Filipendula ulmaria</i> (L.) Maxim.	Sp	9	h	P	
<i>Malus domestica</i> Borkh.	Df	12	p		
<i>Potentilla reptans</i> L.	Sp	9	h		
<i>Prunus avium</i> L.	Sp	9	p	P	
<i>Prunus persica</i> (L.) Batsch	Ar	12	p		
<i>Prunus spinosa</i> L.	Sp	9	p		
<i>Rosa canina</i> L.	Sp	9	p	P	
<i>Rubus bifrons</i> Vest ex Tratt.	Sp	7	p		
<i>Rubus caesius</i> L.	Sp	9	p		
<i>Rubus idaeus</i> L.	Sp	9	p		
<i>Sanguisorba minor</i> Scop.	Sp	7	h	P	
<b>Rubiaceae</b>					
<i>Cruciata laevipes</i> Opiz	Sp	7	h		
<i>Galium aparine</i> L.	Sp	9	t		
<i>Galium mollugo</i> L.	Sp	9	h		
<i>Galium palustre</i> L.	Sp	9	h		
<i>Galium verum</i> L.	Sp	9	h	P	
<b>Salicaceae</b>					
<i>Populus alba</i> L.	Sp	9	p		
<i>Populus nigra</i> L.	Sp	9	p		
<i>Populus tremula</i> L.	Sp	9	p	P	
<i>Salix alba</i> L.	Sp	9	p		
<i>Salix cinerea</i> L.	Sp	9	p		

<i>Salix fragilis</i> L.	Sp	9	p	
<i>Salix purpurea</i> L.	Sp	9	p	
Sapindaceae				
<i>Acer campestre</i> L.	Sp	9	p	
<i>Acer negundo</i> L.	Kn	12	p	I
<i>Acer platanoides</i> L.	Sp	7	p	
<i>Acer pseudoplatanus</i> L.	Sp	6	p	
<i>Aesculus hippocastanum</i> L.	Df	12	p	
Saxifragaceae				
<i>Bergenia crassifolia</i> (L.) Fritsch	Df	12	h	
Scrophulariaceae				
<i>Chaenorhinum minus</i> (L.) Lange	Ar	1	t	
<i>Linaria vulgaris</i> Mill.	Sp	9	g	P
<i>Odontites vulgaris</i> Moench	Sp	9	t	
<i>Rhinanthus minor</i> L.	Sp	9	t	
<i>Scrophularia nodosa</i> L.	Sp	10	h	P
<i>Verbascum thapsus</i> L.	Sp	9	t,h	
<i>Veronica chamaedrys</i> L.	Sp	9	ch	
<i>Veronica persica</i> Poir.	Kn	12	t	I
<i>Veronica serpyllifolia</i> L.	Sp	9	h	
Simaroubaceae				
<i>Ailanthus altissima</i> (Mill.) Swingle	Kn	12	p	I
Solanaceae				
<i>Solanum dulcamara</i> L.	Sp	9	ch	P
<i>Solanum nigrum</i> L.	Sp	10	t	P
Staphyleaceae				
<i>Staphylea pinnata</i> L.	Sp	9	p	
Ulmaceae				
<i>Ulmus laevis</i> Pall.	Sp	5	p	
<i>Ulmus minor</i> Miller	Sp	3	p	
Urticaceae				
<i>Parietaria officinalis</i> L.	Sp	3	h	
<i>Urtica dioica</i> L.	Sp	9	h	
Verbenaceae				

<i>Verbena officinalis</i> L.	Ar	1	t,h	
Violaceae				
<i>Viola reichenbachiana</i> Jord. ex Boreau	Sp	7	h	
Vitaceae				
<i>Parthenocissus quinquefolia</i> (L.) Planchon	Kn	12	p	I
Superorder Lilianae				
Alliaceae				
<i>Allium carinatum</i> L.	Sp	3	g	
<i>Allium schoenoprasum</i> L.	Sp	10	g	
Amaryllidaceae				
<i>Galanthus nivalis</i> L.	Sp	3	g	P
Asparagaceae				
<i>Asparagus tenuifolius</i> Lam.	Sp	3	g	P
Araceae				
<i>Arum maculatum</i> L.	Sp	7	g	P
Alismataceae				
<i>Alisma plantago-aquatica</i> L.	Sp	9	hy	
Cyperaceae				
<i>Carex elata</i> All.	Sp	8	h	
<i>Carex hirta</i> L.	Sp	9	h	
<i>Carex otrubae</i> Podp.	Sp	9	h	
<i>Carex pendula</i> Huds.	Sp	9	h	
<i>Carex pseudocyperus</i> L.	Sp	10	hy	
<i>Carex remota</i> L.	Sp	10	h	
<i>Carex spicata</i> Huds.	Sp	9	h	
<i>Carex sylvatica</i> Huds.	Sp	9	h	
<i>Carex vulpina</i> L.	Sp	9	h	
<i>Cyperus fuscus</i> L.	Sp	9	t	
<i>Cyperus glomeratus</i> L.	Sp	9	hy	SP
<i>Cyperus serotinus</i> Rottb.	Sp	9	g	SP
<i>Eleocharis palustris</i> (L.) Roem. et Schult.	Sp	10	hy	
<i>Scirpus sylvaticus</i> L.	Sp	9	g	
Dioscoreaceae				



<i>Tamus communis</i> L.	Sp	3	g	P
Iridaceae				
<i>Iris pseudacorus</i> L.	Sp	8	g	SP
Juncaceae				
<i>Juncus compressus</i> Jacq.	Sp	9	g	
<i>Juncus effusus</i> L.	Sp	9	h	
<i>Juncus inflexus</i> L.	Sp	9	h	
Lemnaceae				
<i>Lemna minor</i> L.	Sp	10	hy	
<i>Spirodela polyrhiza</i> (L.) Schleiden	Sp	11	hy	
Orchidaceae				
<i>Epipactis palustris</i> (L.) Crantz	Sp	9	g	SP
Poaceae				
<i>Agrostis capillaris</i> L.	Sp	9	h	
<i>Agrostis stolonifera</i> L.	Sp	9	h	
<i>Brachypodium pinnatum</i> (L.) P. Beauv.	Sp	9	h	
<i>Brachypodium sylvaticum</i> (Huds.) P. Beauv.	Sp	9	h	
<i>Bromus hordeaceus</i> L.	Ar	9	t	
<i>Bromus sterilis</i> L.	Ar	9	t	
<i>Calamagrostis epigejos</i> (L.) Roth	Sp	8	g	
<i>Cynodon dactylon</i> (L.) Pers.	Ar	11	g	
<i>Dactylis glomerata</i> L.	Sp	9	h	
<i>Digitaria sanguinalis</i> (L.) Scop.	Ar	9	t	
<i>Echinochloa crus-galli</i> (L.) P. Beauv.	Ar	12	t	
<i>Eleusine indica</i> (L.) Gaertn.	Kn	12	t	I
<i>Elymus repens</i> (L.) Gould	Sp	10	g	
<i>Eragrostis minor</i> Host	Ar	9	t	
<i>Festuca pratensis</i> Huds.	Sp	9	h	
<i>Holcus lanatus</i> L.	Sp	9	h	
<i>Hordeum murinum</i> L.	Ar	1	t	
<i>Leersia oryzoides</i> (L.) Sw.	Sp	9	g	P
<i>Lolium perenne</i> L.	Sp	8	h	
<i>Panicum capillare</i> L.	Kn	12	t	I
<i>Panicum miliaceum</i> L.	Ar	9	t	
<i>Phalaris arundinacea</i> L.	Sp	11	g	
<i>Phleum pratense</i> L.	Sp	9	h	
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	Sp	11	hy	
<i>Poa annua</i> L.	Sp	9	t	

<i>Poa compressa</i> L.	Sp	9	h	
<i>Poa nemoralis</i> L.	Sp	10	h	
<i>Poa pratensis</i> L.	Sp	10	h	
<i>Poa trivialis</i> L.	Sp	10	h	
<i>Setaria pumila</i> (Poir.) Schult.	Ar	12	t	
<i>Setaria verticillata</i> (L.) P.Beauv.	Ar	11	t	
<i>Setaria viridis</i> (L.) P.Beauv.	Ar	1	t	
<i>Sorghum halepense</i> (L.) Pers.	Kn	12	g	I
<i>Zea mays</i> L.	Df	12	t	
<b>Potamogetonaceae</b>				
<i>Potamogeton natans</i> L.	Sp	11	hy	
<b>Sparganiaceae</b>				
<i>Sparganium erectum</i> L.	Sp	9	g	
<b>Typhaceae</b>				
<i>Typha latifolia</i> L.	Sp	10	g	

(4.8%) and Rosaceae (4.8%). The biggest genus is *Carex* with nine species, followed by *Poa* (5), then by *Acer*, *Galium* and *Salix* with four species each.

Regarding life-form spectrum (Fig. 3) almost the half of the recorded taxa (47.9%) are hemicryptophytes. Very significant is the relatively high ratio of therophytes (19.1%).

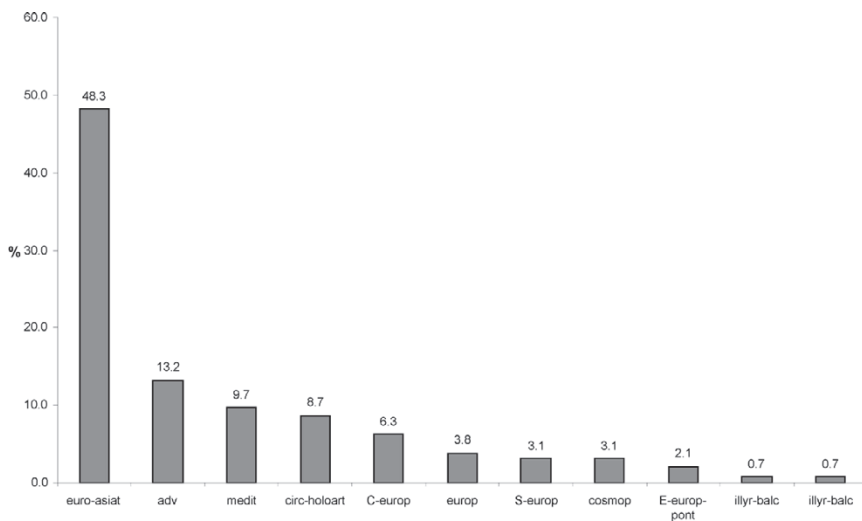


Fig. 4. Spectrum of chorological types for the flora of Savica.

**Tab. 2.** Comparative spectra of life-forms for some areas in NW Croatia with seminatural landscapes.

Life-forms (%)	Savica	Marinci	Stupnik	Konjšćina	Piškorovo and Konopljenka	Vukova Gorica
p	14.2	15.1	10.9	8.9	14.5	11.4
ch	1.4	2.7	3.1	5.0	3.1	4.0
h	47.9	52.1	49.6	45.0	48.1	52.3
g	10.1	13.7	10.0	13.9	10.8	13.5
th	19.1	16.1	24.0	24.0	22.2	13.5
hy	5.9	0.3	2.4	3.3	1.1	1.3
th, h	1.4	–	–	–	–	–

**Tab. 3.** Comparative spectra of chorological types for some areas in NW Croatia with seminatural landscapes. Some specific values for the flora of Savica are bolded.

chorotype (%)	Savica	Marinci	Stupnik	Konjšćina	Piškorovo and Konopljenka	Vukova Gorica
medit	<b>9.7</b>	1.0	2.0	1.0	1.4	1.5
illyr-balk	0.7	-	0.2	0.7	-	1.2
S-europ	<b>3.1</b>	7.6	9.0	9.4	9.1	11.3
atlantic	-	-	0.4	0.2	-	0.2
E-europ-pont	2.1	1.0	0.9	0.9	1.1	1.2
SE-europ	1.0	1.0	0.4	0.5	0.6	0.6
C-europ	6.3	3.8	4.2	2.9	3.1	4.8
europ	<b>3.8</b>	11.0	11.5	11.5	11.1	12.6
euro-asiat	<b>48.3</b>	34.8	32.5	33.2	30.1	31.9
circ-holoart	8.7	6.6	7.3	7.9	6.3	8.4
cosmop	3.1	25.2	27.7	26.4	27.0	23.1
adv	<b>13.2</b>	7.9	3.7	5.5	10.2	3.4

Water habitats enable the occurrence of 5.9% of hydrophytes. A small proportion of taxa (1.4%) can behave as therophytes or hemicryptophytes depending on local ecological conditions, first of all on the duration and severity of winters.

The phytogeographical spectrum is presented in Fig. 4. Almost the half of the recorded taxa (48.3%) belong to the Euro-Asiatic chorotype. A peculiar feature is that the second place belongs to adventive species, with a relatively high ratio of 13.2%. All other

**Tab. 4.** Indicators of anthropogenic changes in the flora of Savica.

Indicators of anthropization	%
IAN <sub>t</sub>	27,78
IAN <sub>p</sub>	26,76
Indicators of archaeophytization	
IAR <sub>t</sub>	16,67
IAR <sub>p</sub>	16,90
Indicators of kenophytization	
IKn <sub>t</sub>	9,72
IKn <sub>p</sub>	9,86
Indicator of modernization	
IM	36,84
Indicator of fluctuation changes	
IF	1,39

chorotypes are represented with less than 10% each. It is important to stress that Illyrian-Balkan chorotype is represented with only 0.7% i.e. with two species (*Hacquetia epipactis* and *Lamium orvala*). The Mediterranean chorotype has accounts for 9.7%, the circumholarctic 8.7% and the Central-European for 6.3%, which all reflect different aspects of origin of the researched flora. Comparative spectra (Tab. 2) show that the flora of Savica is similar to other localities in North-Western Croatia regarding life-forms. In comparison to some other places in North-Western Croatia (Tab. 3) it is obvious that the flora of Savica has specific composition with higher ratios of Euro-Asiatic, adventive, and Mediterranean plants.

Indicators of anthropogenic changes (Tab. 4) show that the flora of Savica is more influenced by archaeophytes than by neophytes. Very similar values of total and permanent values of indices indicate that alien flora is well established, i.e. with only a small proportion of not-permanently-established species. This is confirmed by the low value of the indicator of fluctuating changes. The relatively high indicator of modernization (36.8%) is in accordance with the high proportion of adventive species (13.2%), both showing the vigorous anthropogenic influence on the flora of Savica.

Four species are quoted on the Red list: *Asparagus tenuifolius* (NT), *Cyperus glomeratus* (VU), *Cyperus serotinus* (VU) and *Leersia oryzoides* (NT). According to the Ordinance on Designating Wild Taxa Protected and Strictly Protected (ANONYMOUS 2009) 44 taxa (15.2%) are legally protected and four of them (1.4%) are strictly protected. According to Boršić *et al.* (2008) and Mrrić *et al.* (2008), 25 species (8.6%) are invasive alien species (IAS).

## DISCUSSION

The flora of Savica counts 289 taxa, and the species-richest families are: Asteraceae and Poaceae with more than 10% of taxa; Lamiaceae, Fabaceae, Rosaceae and Cype-

raceae with more than 5%; Scrophulariaceae and Brassicaceae with more than 3%; and Apiaceae, Ranunculaceae and Salicaceae with more than 2%. This order of families in general reflects the order for entire national flora according to NIKOLIĆ (2012), with some exceptions as consequences of some specific characteristics of habitats of the area.

The first notes about Savica flora go back to 1954 and come from the ZA herbarium samples of *Zannichellia palustris* L. and *Potamogeton pectinatus* L. Neither of these taxa were confirmed recently. Only 25 taxa were mentioned previously in literature (ALEGRO et al. 2010).

The higher share of grasses indicates the presence of intensively influenced ruderal habitats, whereas the more abundant Cyperaceae and Salicaceae reflect the presence of water and alluvial habitats. A relatively high share of the Mediterranean element (9.7%) is also a consequence of the presence of highly disturbed habitats which support the occurrence of thermophilous but annual species. So, 16 of 28 Mediterranean species are therophytes, and even more important is that 24 of them are archaeophytes, which are not part of stable plant communities, but are pioneers on open habitats, where co-occurrence of other species is low (bare soil, edges of paths and gardens etc.). All these facts are reflected in high indicators of archaeophytization. A very similar trend is reflected in the composition of neophytes, where 15 of 28 species are also therophytes. However, the total number of archaeophytes is almost twice as high as number of neophytes (48 vs. 28). This is also visible from indicators of archaeophytization (16.7 and 16.9) and kenophytization (9.7 and 9.9). Similar values of total and permanent indicators suggest that both archaeophytes and neophytes are permanently established in local flora, with only a few occasional species. In general, therophytes are the dominant life-form among archaeophytes and neophytes, followed by hemicryptophytes, with only a few intentionally introduced phanerophytes (Ar: *Juglans regia* and Kn: *Robinia pseudoacacia*, *Acer negundo* and *Ailanthus altissima*). On the other hand, all the described facts can be seen in the high total share of adventive species (13.2 %), which is significantly higher than in other areas of NW Croatia, varying from 3.4-7.9 %.

The high ratio of Mediterranean species compared to other areas of NW Croatia (STANČIĆ, 1994; ALEGRO et al., 2006; MITIĆ et al., 2007; MARTINKO, 2009; HUDINA et al., 2012) is significant. This can be explained not only by the presence of the described suitable habitats, but also by the slightly different definition of the Mediterranean geoelement accepted here. As Mediterranean plants are treated also well established species in the local flora, historically originating from Mediterranean area, up to day not present in natural and seminatural plant communities, but only as ruderal and weed species.

Also significant in the researched flora is the higher share of Euro-Asiatic species (48.3%) (31.9-34.8%) and the lower share of European species (38% vs. 11.0-12.6%) in comparison to other areas. From all these facts it can be concluded that the flora of Savica very weakly reflects the phytogeographical position of the area, but it has more general character as a consequence of the great human impact and changed habitats. The peri-Pannonian position of the researched area is indicated only in the relatively high share of Central-European species (6.3%). However, the general, non-specific character of the flora is naturally supported by the presence of water habitats, i.e. hydrophytes, which mainly have broad areas of distribution without being restricted to narrowly defined phytogeographical areas. Disturbance of the area is also indicated by the no fewer than 25 invasive species, all kenophytes originating mainly from North America. On the other hand, the life-form spectrum is almost the same as for other areas compa-

red, suggesting that the flora of Savica has a structure well adapted to the general climate of North-Western Croatia.

A special value of the vegetation of Savica inheres in the stands of tree species (*Salix alba*, *Populus nigra*, *Alnus glutinosa*) representing the last remnants of alluvial vegetation along the Sava River and hydrophytes and helophytes in and around the lakes (i.e. *Nuphar lutea*, *Myriophyllum spicatum*, *Nymphoides peltata*, *Nasturtium officinale*, *Berula erecta*, *Rorippa amphibia*, *Lemna minor*, *Spirodella polyrhiza*, *Cyperus* spp. and some others) forming several communities.

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## SAŽETAK

### Flora poluprirodne močvare Savica, suburbanog dijela grada Zagreba (Hrvatska)

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Flora Savice, suburbanog dijela grada Zagreba s ostacima poplavnih šuma i vegetacijom stajačica, istraživana je tokom vegetacijske sezone 2006. s nekoliko kasnijih dodataka. Istraživano područje čini sustav od 12 jezeraca s okolnim staništima. Ukupno je zabilježeno 289 vrsta i podvrsta vaskularnog bilja. Najzastupljenije porodice su Asteraceae (12.5 %), Poaceae (11.8 %), Lamiaceae (5.9 %), Fabaceae (5.2 %), Cyperaceae (4.8 %) i Rosaceae (4.8 %), a rodovi zastupljeni s najviše vrsta su: *Carex* (9), *Poa* (5), a zatim *Acer*, *Galium* i *Salix* svaki s po četiri vrste. S obzirom na spektar horoloških tipova, flora Savice slična je nekim drugim područjima SZ Hrvatske s time da se s većom učestalošću ističu biljke eurazijskog elementa (48.3%), adventivne vrste (13.2%) i biljke mediteranskog elementa (9.7%), što je posljedica antropogenog utjecaja i posljedične ruderalizacije staništa. Taj proces se ogleda i u razmjerno visokom udjelu terofita (19.1%). Pokazatelji

antropogene promjene pokazuju da je flora Savice više utjecana arheofitima nego neofitima. Među njima nalazi se 25 vrsta (8.6%) invazivnih stranih vrsta. Spekter životnih oblika gotovo je isti kao za druga područja SZ Hrvatske, što upućuje da je flora dobro prilagođena općoj klimi SZ Hrvatske. Osobita vrijednost flore Savice su sastojine drvenastih vrsta (*Salix alba*, *Populus nigra*, *Alnus glutinosa*), koje predstavljaju posljednje ostatke poplavne vegetacije uz rijeku Savu, kao i hidrofiti i helofiti prisutni u jezercima i oko njih (npr. *Nuphar lutea*, *Myriophyllum spicatum*, *Nymphoides peltata*, *Nasturtium officinale*, *Berula erecta*, *Rorippa amphibia*, *Lemna minor*, *Spirodella polyrhiza*, *Cyperus* spp. i dr.). Četiri vrste navedene su Crvenom popisu: *Asparagus tenuifolius* (NT), *Cyperus glomeratus* (VU), *Cyperus serotinus* (VU) and *Leersia oryzoides* (NT). Zakonom su zaštićene 44 vrste (15.2 %), a četiri od njih (1.4 %) su strogo zaštićene.