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VASCULAR FLORA OF JARUN (ZAGREB, CROATIA)

Nina Vuković[1]*, Igor Boršić[2], Dijana Župan[2], Antun Alegro[1] & Toni Nikolić[1]

[1]Department of Botany, Faculty of Science, University of Zagreb, Marulićev trg 20/II, HR-10000 Zagreb, Croatia
(e-mail: nina.vukovic@biol.pmf.hr; antun.alegro@biol.pmf.hr; toni.nikolic@biol.pmf.hr)

[2]State Institute for Nature Protection, Trg Mažuranića 5, HR-10000 Zagreb, Croatia
(e-mail: igor.borsic@dzzp.hr; dijana.zupan@dzzp.hr)

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A floristic study of Jarun Recreational and Sports Centre in Zagreb was conducted during the vegetation season of 2006 and partially in 2008. In total, 323 plant taxa from 70 families are presented in the list, out of which 156 are newly found, while the presence of 49 previously reported taxa was not confirmed. The most abundant family is Poaceae (11.76%), followed by Asteraceae (9.94%), Fabaceae (6.81%) and Lamiaceae (6.81%). The life form spectrum shows that hemicryptophytes are the most common life form (42.41%), followed by therophytes (24.77%). The phytogeographical spectrum shows the strong prevalence of Euro-Asiatic plants (44.10%), and a high number of adventive (9.94%) and Mediterranean plants (9.63%), while the Illyrian-Balkan chorotype is almost absent (0.31%). Only six taxa are found on the National Red List (*Ophrys apifera*, *Alopecurus geniculatus*, *Carex panicea*, *Cyperus fuscus*, *Orchis militaris* and *Orchis tridentata*), while 25 taxa are classified as invasive. Finally, we conclude that the flora of Jarun is greatly anthropogenically influenced, but still relatively rich.

Key words: biodiversity, urban flora, Jarun Recreational and Sports Centre, life forms, chorotypes

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Floristička istraživanja Rekreacijsko-sportskog centra Jarun u Zagrebu provedena su tijekom vegetacijske sezone 2006. i djelomično 2008. godine. U rezultatima su navedene ukupno 323 biljne svojte iz 70 porodica, od čega je 156 svojti navedeno prvi put, dok 49 prethodno zabilježenih svojti nije potvrđeno u ovom istraživanju. Od porodica su najbrojnije trave (Poaceae, 11,76%), zatim slijede glavočike cjevnjače (Asteraceae, 9,94%), mahunarke (Fabaceae, 6,81%) i usnače (Lamiaceae, 6,81%). Spektar životnih oblika pokazuje da su hemikriptofiti najčešći životni oblik (42,41%), iza čega slijede terofiti (24,77%). U spektru flornih elemenata prevladavaju euroazijske biljke (44,10%), te je zabilježen relativno veliki broj adventivnih (9,94%) i mediteranskih biljaka (9,63%), dok je udio ilirsko-balkanskog flornog elementa vrlo malen (0,31%). Svega šest vrsta se nalazi na Crvenom popisu (*Ophrys apifera*, *Alopecurus geniculatus*, *Carex panicea*, *Cyperus fuscus*, *Orchis militaris* i *Orchis tridentata*), dok je invazivnih vrsta zabilježeno ukupno 25. Naposljetku možemo zaključiti da je floristička raznolikost Jaruna relativno velika, iako se područje nalazi pod jakim utjecajem čovjeka.

Ključne riječi: bioraznolikost, urbana flora, Rekreacijsko-sportski centar Jarun, životni oblici, florni elementi

INTRODUCTION

Threats to biodiversity are nowadays a global issue, mainly related to long-term human influence on nature. Strong negative trends in biodiversity have been observed in modern human history, as recently pointed out by many global organizations. Accor-

dingly, the United Nations declared 2010 the International Year of Biodiversity (Anonymous, 2007) and 2011-2020 the United Nations Decade on Biodiversity (Anonymous, 2011).

Numerous studies of biodiversity in urban environments exist (e.g. Celesti-Grapow & Blasi, 2002; Moraczewski & Sudnik-Wójcikowska, 2007; Williams *et al*., 2009; Ricotta *et al*., 2012), but compared to natural ecosystems, urban diversity is relatively less studied. Urban environments are distinctive as they include specific habitats exposed to human pressure, often characterized with higher disturbance and nitrogen availability, preferred by 'special' groups of plants such as weeds, ruderal plants, and invasive plants (Kojić & Šinžar, 1985; Pyšek *et al*., 2010). On the other hand, maintaining biological diversity in urban areas is extremely important, as natural wildlife provides valuable functions to the city itself.

Urban landscapes in Croatia have been considerably less floristically studied than those in nature. Comprehensive floristic data exist, but only for few Dalmatian towns: Šibenik and its surroundings (Milović, 2002), Split (Ruščić, 2003), Zadar (Milović & Mitić, 2012) and Omiš (Tafra *et al*., 2012). The wider area of Zagreb has been frequently explored since the second part of the 19th century (Schlosser & Vukotinović, 1869; Gjurašin, 1923; Horvatić, 1931; Gospodarić 1958; Marković, 1970, 1973, 1975, 1978; Randić *et al*., 1981; Lukač, 1988; Ilijanić *et al*., 1989; Smital *et al*., 1998; Mitić *et al*., 2007); however, the absence of systematic research into the city accounts for the ultimately poor knowledge on the urban flora of Zagreb.

Prior to systematic floristic studies of the city, the biodiversity of Zagreb was presented only in a descriptive manner in popular publications (Černicki, 2006; Tvrtković, 2010). Recently Hudina *et al*. (2012) performed a floristic study of Konopljenka and Piškorovo, the area on the right bank of the River Sava in the western part of the city of Zagreb, and found 351 species and subspecies of vascular plants. Also, certain urban zones of Zagreb (Jarun, Maksimir and Savica) have been floristically surveyed and mapped within the project Countdown towards 2010 in Zagreb (Anonymous, 2008; Alegro *et al*., 2013).

MATERIAL AND METHODS

Study area

We conducted our study in the Jarun Recreational and Sports Centre, situated in the south-western part of the city of Zagreb. The area is 235 ha in area and comprises artificial lakes, islands and land, with different types of cover (natural and artificial). Water surfaces comprise around 30% of the total area and consist of two lakes (Veliko jezero and Malo jezero) connected by a 2550 m long regatta course. There are six islands in the area, four of them connected with the rest of the Centre: Otok Trešnjevka (bridge), Otok Univerzijade (bridge), Otok divljine, Otok hrvatske mladeži (bridge), Otok ljubavi and Otok veslača (bridge) (Sabolić, 2003).

The complex is surrounded with residential districts, except from the south, where the main flow of the River Sava with its embankment represents the border toward the area of Konopljenka and Piškorovo in Novi Zagreb (Fig. 1). In the past, Jarun was a backwater of the River Sava, traditionally used for gravel excavation which resulted in a formation of a lake. The complex in its present form was constructed to host the 14th World University Games held in 1987, and since that time it has been used by citizens

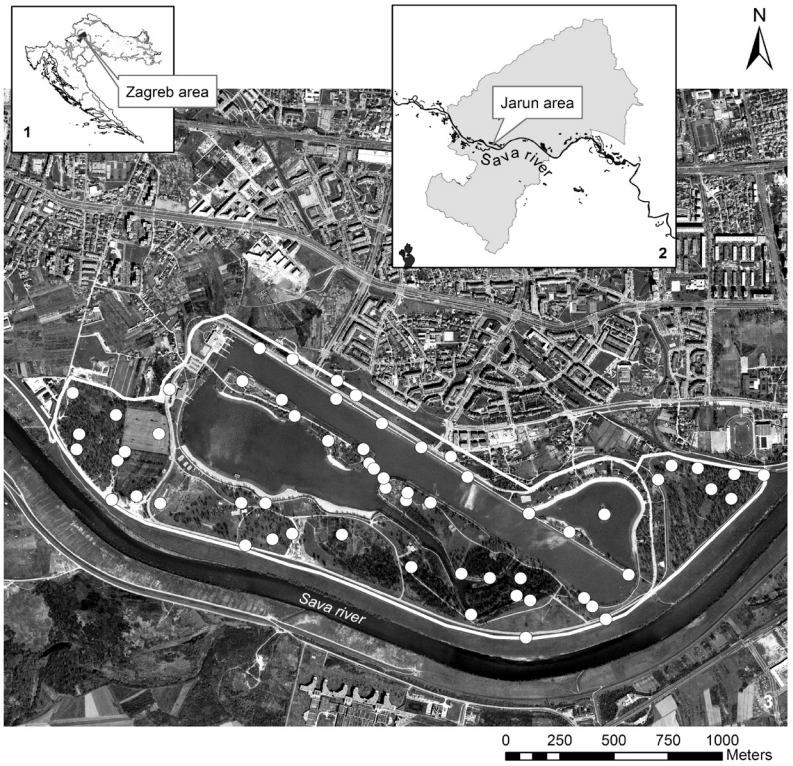

Fig. 1. Geographical position of the researched area. 1 – City of Zagreb in Croatia, 2 – Jarun area inside Zagreb. The main map shows the researched area with localities corresponding to check-lists (white dots). Check-lists associated with centroids of MTB 1/64 fields which are located outside the area border are not shown.

for sport and recreation (Sabolić, 2003). It is a very popular recreational area, visited daily by hundreds (sometimes thousands) of citizens of Zagreb. On weekends with nice weather, there are more than 10 000 visitors, and during some special events (like festivals) even more than 20 000 visitors.

Apart from rainfall, Jarun is fed with underground water from the Sava alluvium. Average depth of the lakes is 5 m (maximum 13 m), but the water level varies depending on the relative levels of the Sava and the groundwater (Sabolić, 2003; Vršek *et al*., 2004). Average annual temperature of the water is 14 °C, and average summer temperature is 24 °C (Sabolić, 2003).

Although the researched area is climazonally situated in the zone of oak-hornbeam forests, the main determinant of its natural vegetation is the level of underground and flood water. Accordingly, the main vegetation of the Sava River floodplain before intensive human influence were pedunculate oak forests, together with willow, alder and poplar forests (alliances *Alnion incanae* Pawl. in Pawl et al. 1928, *Salicion albae* Soó 1930, *Alnion glutinosae* Malciut 1929) (Horvatić, 1967; Vukelić, 2012) as paraclimatic vegetation cover related to the significant amounts of surface and underground water in the

habitat (Horvat, 1938, 1949; Horvatić, 1967; Bertović, 1975). Today, the river plain is considerably modified due to urbanisation. As for Jarun, northern parts of the complex are more urban, gradually turning into more natural forms towards the south. The most authentic area, 'the ecological core', is the south-eastern part around Otok divljine ('Wilderness Island'), where no human intervention is allowed. Elsewhere, regular management includes periodic mowing of grasslands, cutting of woody vegetation/forestation, removing of macrophytes and mud from the lakes, periodic introduction of fish etc. (Sabolić, 2003).

The only existing checklist of Jarun flora (Randić *et al*., 1981) provides 103 plant taxa. When completed with sporadic data from other authors (Marković, 1970, 1973, 1975, 1978; Lukač, 1988; Ilijanić *et al*., 1989; Smital *et al*., 1998; Milović, 2004), and herbarium data (Herbarium Croaticum – ZA), the total number of previously recorded taxa reaches 167. The purpose of this paper was to present a comprehensive list of plant taxa for Jarun Recreational and Sports Centre and to perform basic analyses of its flora.

Fieldwork

Jarun was systematically surveyed during the vegetation season of 2006, and several more field observations were obtained in spring of 2008. We searched the area with the intention of exploring all habitats. Accordingly, we recorded the coordinates of 51 point localities with a Garmin eTrex GPS device and made check-lists of the adjacent flora. Additionally, on separate check-lists, we recorded all species not present at specific points, but in MTB 1/64 fields with codes 0261.124, 0261.213, 0261.214. Ultimately, we collected 56 check-lists (Fig. 1).

Plants were mostly identified in the field, although in some cases plants were herbarised and identified subsequently. The following determination keys were used: Tutin *et al*. (1968-1980), Pignatti (1982), Jávorka & Csapody (1991), Tutin *et al*. (1993), Domac (1994), Rothmaler (2000). All nomenclature is given according to Flora Croatica Database (Nikolić, 2013).

Data analysis

Grouping of the taxa into chorological types follows the system of Horvatić (1963) and Horvatić *et al*. (1967/1968). For the taxa not listed there, Simon *et al*. (1992), Milović (2002), Pignatti *et al*. (2005), Alegro *et al*. (2006), and Mitić *et al*. (2007) were used, although the affiliation of taxa to particular groups was reviewed according to a newer approach by Landolt *et al*. (2010). The taxa were classified into the following groups (with abbreviations):

1. Mediterranean (med)
2. Illyrian-Balkan (illyr-balk)
3. South-Europaean (S-europ)
4. East European-Pontic (E-europ-pont)
5. Central-Europaean (C-europ)
6. Europaean (europ)
7. Euro-Asiatic (euro-asiat)
8. Circum-Holarctic (circ-holarct)
9. Cosmopolites (cosmop)
10. Adventive (advent)

Regarding life-forms, data from Pignatti *et al*. (2005) and Landolt *et al.* (2010) following *Raunkier's* system were used in the preparation of the corresponding spectrum,

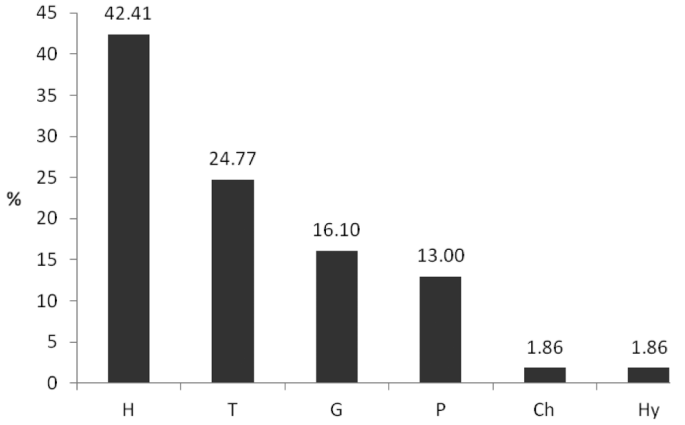

Fig. 2. Life form spectrum for the flora of Jarun.

with the following abbreviations: P – phanaerophytes, Ch – chamaephytes, H – hemicryptophytes, T – therophytes, G – geophytes, Hy – hydrophytes.

Chorotypes and life-forms of the flora of Jarun were compared with some other floras: Konjščina (Stančić, 1994) and Martinci (Martinko, 2009) in Hrvatsko Zagorje, Vukova Gorica (Alegro *et al*., 2006) on the edge of Gorski kotar, Stupnik (Mitić *et al*., 2007) in the suburbs of Zagreb, Konopljenka and Piškorovo (Hudina *et al*., 2012) and Savica (Alegro *et al.* 2013) in the city of Zagreb.

The Red Book of Vascular Flora of Croatia (Nikolić & Topić, 2005) was used to determine the threat level according to IUCN criteria, while the Ordinance on Designating Wild Taxa Protected and Strictly Protected (Anonymous, 2009) was the source of data on legal protection. The data on invasive status of the taxa originate from the preliminary check-list of Croatian invasive flora (Boršić *et al*., 2008).

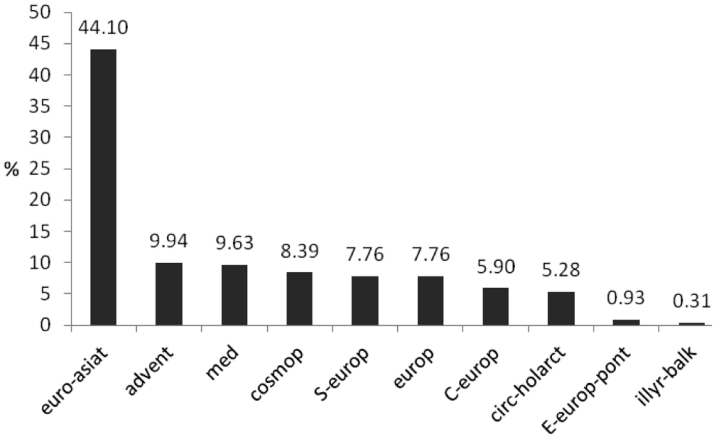

Fig. 3. Phytogeographical spectrum for the flora of Jarun.

RESULTS

Altogether 323 taxa have been recorded in the flora of Jarun (Tab. 1), belonging to 70 plant families. The most abundant family is Poaceae (11.76%), followed by Asteraceae (9.94%), Fabaceae (6.81%) and Lamiaceae (6.81%), while other families contribute less than 5% each. Two species belong to pteridophytes (subclass Equisetidae), while 321 taxa are classified as spermatophytes. Dicotyledons (subclass Magnoliidae) consist of 258 taxa, while monocotyledons (subclass Liliidae) comprise 63 taxa. Previous records of 49 taxa were not confirmed during our study, and 156 taxa were recorded for the first time.

The life form spectrum (Fig. 2) shows the prevalence of hemicryptophytes (over 40%), followed by a relatively high portion of therophytes (almost 25%). The composition of life forms is similar to that of some other areas in NW Croatia (Tab. 2).

The phytogeographical spectrum of the flora of Jarun is presented on Fig. 3. The largest proportion of taxa belongs to Euro-Asiatic plants (around 45%), followed by a relatively high number of adventive plants (around 10%). Other chorotypes account for less than 10% each. It should be pointed out that there is an extremely small portion (0.31%) of Illyrian-Balkan chorotype, represented by only one species (*Lamium orvala*), and an unusually high ratio of Mediterranean plants (9.63%). In comparison with some other areas of North-Western Croatia, the flora of Jarun has particularly high proportions of Euro-Asiatic and Mediterranean plants, a relatively high ratio of adventive plants and a lower proportion of cosmopolites (Tab. 3).

Six taxa are listed on the National Red List: *Ophrys apifera* (EN), *Alopecurus geniculatus* (VU), *Carex panicea* (VU), *Cyperus fuscus* (VU), *Orchis militaris* (VU) and *Orchis tridentata* (VU). Additionally, one species is considered near threatened (NT, *Leersia oryzoides*). Fifty six taxa (17.34%) are protected by law, while seven taxa (2.48%) are strictly protected. According to the preliminary check-list of Croatian invasive flora, 25 taxa (7.74%) are classified as invasive plants.

DISCUSSION

Family affiliation of the flora of Jarun generally corresponds with family affiliation of overall Croatian flora (Nikolić, 2013), whereas the families Poaceae, Asteraceae and Fabaceae account for the majority of species in both cases. A greater share of grasses in the case of Jarun points to the ruderality and openness of its habitats, with respect to high anthropogenic influence.

The highest proportion of hemicryptophytes in the life form spectrum (Fig. 2) is in accordance with the expected composition of life forms for temperate zones, as hemicryptophytes normally dominate in areas with a temperate climate (Horvat, 1949). On the other hand, the occurrence of therophytes is unusually high for this climatic region. This is explainable in the context of land-use (Horvat, 1949), as it is known that human activities promote the presence of certain plants (weeds, ruderal and invasive plants), which are often annual; therefore therophytes can be regarded as indicators of anthropogenic influence. As expected, a certain ratio of hydrophytes is present in the life form spectrum, which indicates the presence of water habitats. In respect of the composition of life forms, the flora of Jarun is relatively similar to some other areas of NW Croatia (Tab. 2).

Tab. 1. List of vascular flora of Jarun. Chor – chorological types, LF – life forms, IUCN – threat status, P – legal protection (p-protected, sp-strictly protected), IAS – invasive alien species. New taxa are marked with an asterisk (*), and unconfirmed taxa are followed by a note on previous records, with the references abbreviated in the following way: Marković (1970) – M1, Marković (1973) – M2, Marković (1975) – M3, Marković (1978) – M4, Randić et al. (1981) – R, Lukač (1988) – L, Čičmir (pers. comm.) – Č, Alegro (pers. comm.) – A, herbarium data – ZA.

	Chor	LF	IUCN	P	IAS	Previously noted by
subclass Equisetidae						
Equisetaceae						
Equisetum arvense L.	8	G				
Equisetum telmateia Ehrh.	8	G				R
subclass Magnoliidae						
Aceraceae						
Acer campestre L.*	6	P				
Acer negundo L.	10	P			I	
Acer platanoides L.*	6	P				
Acer pseudoplatanus L.*	6	P				
Amarantaceae						
Amaranthus retroflexus L.*	9	T			I	
Apiaceae						
Aegopodium podagraria L.	7	H				
Daucus carota L.	1	H				
Heracleum sphondylium L.*	7	H				
Pastinaca sativa L.*	7	H				
Araliaceae						
Hedera helix L.	6	P				
Aristolochiaceae						
Aristolochia clematitis L.	3	G				
Asclepiadaceae						
Asclepias syriaca L.	10	G			I	
Asteraceae						
Achillea millefolium L.	9	H				
Achillea pannonica Scheele	5	H				M2
Ambrosia artemisiifolia L.	10	T			I	
Arctium lappa L.*	7	H				
Artemisia verlotiorum Lamotte	10	H			I	
Artemisia vulgaris L.	9	H				
Bellis perennis L.	5	H				
Bidens frondosa L.	10	T			I	
Bidens tripartita L.	7	T				M3, M4
Centaurea nigrescens Willd.*	3	H				
Centaurea rhenana Boreau	7	H				
Cirsium arvense (L.) Scop.*	7	G				
Cirsium vulgare (Savi) Ten.*	7	H				
Conyza canadensis (L.) Cronquist	10	T			I	
Erigeron annuus (L.) Pers.	10	H			I	

Eupatorium cannabinum L.*	7	H				
Galinsoga ciliata (Raf.) S.F.Blake*	10	T			I	
Galinsoga parviflora Cav.	10	T			I	Marković (1961, ZA)
Helianthus tuberosus L.	10	G			I	
Inula britannica L.	7	H				M4
Leucanthemum vulgare Lam.	7	H				
Matricaria perforata Mérat*	9	T				
Petasites albus (L.) Gaertn.	5	G				R
Pulicaria dysenterica (L.) Bernh.*	3	G		p		
Senecio erraticus Bertol.	1	H				
Senecio vulgaris L.*	9	T				
Solidago canadensis L.*	10	G			I	
Solidago gigantea Aiton	10	G			I	
Tanacetum vulgare L.	7	H		p		
Tussilago farfara L.	7	G				R
Xanthium albinum (Widder) H.Scholz ssp. *albinum*		T				M1
Xanthium strumarium L. ssp. *italicum* (Moretti) D.Löve	10	T			I	Marković (1961, ZA), M1, M3, M4
Balsaminaceae						
Impatiens balfourii Hooker f.*	10	T			I	
Impatiens parviflora DC.*	10	T			I	
Betulaceae						
Alnus glutinosa (L.) Gaertner	7	P				
Boraginaceae						
Echium vulgare L.	6	H				
Myosotis arvensis (L.) Hill*	7	T				
Myosotis scorpioides L.*	8	H				
Symphytum officinale L.	6	H				
Symphytum tuberosum L.	3	G		p		
Brassicaceae						
Alliaria petiolata (M. Bieb.) Cavara et Grande	7	H		p		
Armoracia rusticana P. Gaertn., B. Mey. et Scherb.	9	G				
Barbarea vulgaris R. Br.	9	H				
Capsella bursa-pastoris (L.) Medik.	1	T				
Cardamine hirsuta L.*	9	T				
Cardamine impatiens L.	7	T				
Cardaria draba (L.) Desv.*	9	H				
Diplotaxis muralis (L.) DC.*	1	T				
Erophila verna (L.) Chevall.*	9	T				
Lepidium campestre (L.) R. Br.*	9	T				
Rorippa amphibia (L.) Besser*	7	Hy				
Rorippa sylvestris (L.) Besser	7	H				
Sinapis arvensis L.*	1	T				
Cannabaceae						
Humulus lupulus L.	7	H				
Caprifoliaceae						
Lonicera caprifolium L.	3	P		p		
Sambucus ebulus L.*	6	G				
Sambucus nigra L.	6	P				

Viburnum lantana L.	7	P		p		
Viburnum opulus L.	7	P				
Caryophyllaceae						
Arenaria serpyllifolia L.*	3	T				
Cerastium fontanum Baumg. ssp. *vulgare* (Hartman) Greuter et Burdet*	5	Ch				
Cerastium glomeratum Thuill.*	1	T				
Cucubalus baccifer L.*	7	G				
Petrorhagia saxifraga (L.) Link	3	H				
Saponaria officinalis L.	9	H		p		
Silene latifolia Poir. ssp. *alba* (Mill.) Greuter et Bourdet*	7	H				
Silene vulgaris (Moench) Garcke*	7	H				
Stellaria media (L.) Vill.	1	T				
Celastraceae						
Euonymus europaeus L.*	7	P		p		
Chenopodiaceae						
Chenopodium album L.	9	T				
Chenopodium polyspermum L.*	9	T				
Cichoriaceae						
Cichorium intybus L.	9	H				
Crepis biennis L.	5	H				M2, R
Crepis capillaris (L.) Wallr.*	9	T				
Lactuca serriola L.*	9	H				
Leontodon hispidus L.*	5	H				
Leontodon hispidus L. ssp. *danubialis* (Jacq.) Simonk.*	5	H				
Leontodon taraxacoides (Vill.) Mérat	3	H				M2
Picris hieracioides L.*	7	H				
Sonchus asper (L.) Hill*	7	T				
Sonchus oleraceus L.*	9	T				
Taraxacum officinale Weber	9	H				
Taraxacum palustre (Lyons) Symons	7	H				M4
Clusiaceae						
Hypericum perforatum L.*	7	H		p		
Hypericum tetrapterum Fr.*	7	H				
Convolvulaceae						
Calystegia sepium (L.) R. Br.	7	H				
Convolvulus arvensis L.	7	G				
Cornaceae						
Cornus sanguinea L.*	6	P				
Corylaceae						
Carpinus betulus L.*	5	P				
Corylus avellana L.	6	P				
Cucurbitaceae						
Echinocystis lobata (Michx.) Torr. et Gray	10	T			I	
Dipsacaceae						
Dipsacus fullonum L.*	3	H				

Scabiosa columbaria L.*	3	H				
Scabiosa ochroleuca L.*	7	H				
Euphorbiaceae						
Euphorbia cyparissias L.	7	H				
Euphorbia epithymoides Kern.*	4	Ch				
Euphorbia esula L.	7	H				
Euphorbia helioscopia L.	7	T				
Fabaceae						
Astragalus cicer L.*	7	H				
Astragalus glycyphyllos L.*	7	H				
Coronilla varia L.*	6	H				
Galega officinalis L.*	1	H		p		
Lathyrus aphaca L.	1	T				R
Lathyrus pratensis L.*	7	G				
Lathyrus sylvestris L.*	6	G				
Lotus corniculatus L.	7	H				
Lotus glaber Mill.	9	H				M4
Medicago falcata L.*	7	H				
Medicago lupulina L.	1	T				
Medicago sativa L.*	1	H				
Melilotus albus Medik.*	7	H				
Melilotus altissimus Thuill.*	7	G		p		
Ononis spinosa L.*	6	Ch		p		
Robinia pseudoacacia L.*	10	P			I	
Trifolium campestre Schreber*	1	T				
Trifolium fragiferum L. ssp. *bonannii* (C.Presl) Soják	1	H				
Trifolium pratense L.	7	H				
Trifolium repens L.	7	H				
Vicia cracca L.	7	H				
Vicia sativa L.*	7	T				
Fagaceae						
Quercus robur L.	6	P				
Gentianaceae						
Centaurium erythraea Rafn	7	T		p		M4
Geraniaceae						
Erodium cicutarium (L.) Ľ. Hér.*	1	T				
Geranium dissectum L.*	7	T				
Juglandaceae						
Juglans regia L.*	10	P				
Lamiaceae						
Ajuga reptans L.	7	H				
Ballota nigra L.*	1	G		p		
Clinopodium vulgare L.*	7	G				
Galeopsis speciosa Mill.*	6	T				
Glechoma hederacea L.	7	H				
Glechoma hirsuta Waldst. et Kit.*	3	H				
Lamium maculatum L.	7	H				
Lamium orvala L.*	2	H				

Lamium purpureum L.*	7	T				
Lycopus europaeus L.	7	G		p		
Mentha aquatica L.	7	Hy		p		
Mentha arvensis L.*	8	H				
Mentha longifolia (L.) Huds.*	7	H		p		
Mentha pulegium L.	7	H		p		M3, M4
Prunella vulgaris L.	9	H				
Salvia glutinosa L.*	7	H				
Salvia pratensis L.	6	H				
Stachys palustris L.*	8	G				
Stachys recta L.*	3	H		p		
Stachys sylvatica L.*	8	H				
Teucrium chamaedrys L.*	3	Ch		p		
Thymus pulegioides L. ssp. *chamaedrys* (Fr.) Guşul.	3	Ch		p		
Lentibulariaceae						
Utricularia vulgaris L.	7	Hy		sp		A
Lythraceae						
Lythrum salicaria L.	7	H		p		
Malvaceae						
Malva alcea L.*	3	H				
Malva sylvestris L.*	7	H				
Moraceae						
Morus alba L.*	10	P				
Morus nigra L.	10	P				R
Nymphaeaceae						
Nuphar lutea Sibth. et Sm.	7	Hy		p		
Oleaceae						
Ligustrum vulgare L.*	5	P				
Onagraceae						
Epilobium tetragonum L.*	7	H				
Oenothera biennis L.	10	T			I	
Oxalidaceae						
Oxalis acetosella L.	7	G		p		R
Oxalis dillenii Jacq.*	10	H				
Oxalis fontana Bunge*	10	H				
Papaveraceae						
Chelidonium majus L.	7	H				
Papaver rhoeas L.*	1	T		p		
Plantaginaceae						
Plantago lanceolata L.	7	H				
Plantago major L.	7	H				
Plantago major L. ssp. *intermedia* (Gilib.) Lange	7	H				M3
Plantago media L.*	7	H				
Polygonaceae						
Fallopia convolvulus (L.) Á.Löve*	1	T				
Polygonum aviculare L.	7	T				

Polygonum hydropiper L.	7	T		p		M3
Polygonum lapathifolium L.	5	T				
Polygonum lapathifolium L. ssp. *incanum* (F.W.Schmidt) Schubl. et Mart.	5	T				M3
Polygonum lapathifolium L. ssp. *lapathifolium*	5	T				M3
Polygonum mite Schrank	5	T				
Polygonum persicaria L.*	9	T				
Reynoutria japonica Houtt.	10	G			I	
Rumex crispus L.	7	H				
Rumex obtusifolius L.*	7	H				
Portulacaceae						
Portulaca oleracea L.*	1	T				
Primulaceae						
Anagallis arvensis L.*	1	T				
Lysimachia nummularia L.	6	H				
Lysimachia vulgaris L.*	7	H				
Primula vulgaris Huds.*	3	H				
Ranunculaceae						
Caltha palustris L.	8	H		p		
Clematis vitalba L.	6	P				
Ranunculus acris L.	7	H		p		
Ranunculus bulbosus L.*	7	H		p		
Ranunculus circinatus Sibth.	7	Hy		p		R
Ranunculus ficaria L.	6	G		p		
Ranunculus repens L.	7	H		p		
Ranunculus sardous Crantz	1	H		p		M3, M4
Thalictrum lucidum L.*	6	H		p		
Resedaceae						
Reseda lutea L.	1	H		p		
Rhamnaceae						
Frangula alnus Mill.	7	P				
Rosaceae						
Agrimonia eupatoria L.	7	H		p		
Crataegus monogyna Jacq.	7	P		p		
Filipendula ulmaria (L.) Maxim.	7	H		p		
Fragaria vesca L.	7	H				R
Geum urbanum L.*	7	H		p		
Potentilla anserina L.*	8	H		p		
Potentilla heptaphylla L.*	5	H				
Potentilla reptans L.	7	H				
Prunus avium L.*	7	P		p		
Prunus padus L.*	7	P				
Rosa canina L.*	9	P		p		
Rubus caesius L.	7	P				
Sanguisorba minor Scop.*	7	H		p		
Rubiaceae						
Asperula cynanchica L.*	3	H				
Galium aparine L.	7	T				
Galium mollugo L.*	7	H				

Galium palustre L.	7	G				M3, M4, R
Galium verum L.*	7	H		p		
Salicaceae						
Populus alba L.	7	P				
Populus nigra L.	7	P				
Populus tremula L.*	7	P		p		
Salix alba L.	7	P				
Salix eleagnos Scop.	5	P				R
Salix fragilis L.	7	P				
Salix purpurea L.	7	P				
Salix triandra L.	7	P				R
Scrophulariaceae						
Chaenorhinum minus (L.) Lange*	1	T				
Kickxia elatine (L.) Dumort.*	1	T				
Linaria vulgaris Mill.*	7	G		p		
Melampyrum nemorosum L.*	7	T				
Odontites vulgaris Moench*	7	T				
Scrophularia canina L.	3	H				M2
Verbascum pulverulentum Vill.*	3	H		p		
Veronica anagallis-aquatica L.	6	H				M4
Veronica arvensis L.*	7	T				
Veronica chamaedrys L.	7	Ch				
Veronica hederifolia L.*	7	T				
Veronica persica Poir.*	10	T			I	
Veronica serpyllifolia L.*	7	H				
Solanaceae						
Solanum dulcamara L.	7	P		p		
Solanum lycopersicum L.*	10	T				
Solanum nigrum L.*	8	T		p		
Tiliaceae						
Tilia cordata Mill.	5	P				
Tilia platyphyllos Scop.*	5	P				
Ulmaceae						
Ulmus glabra Huds.*	5	P				
Ulmus laevis Pall.	4	P				
Urticaceae						
Urtica dioica L.	8	H				
Valerianaceae						
Valeriana officinalis L.*	4	H		p		
Valerianella locusta (L.) Laterrade*	1	T		p		
Verbenaceae						
Verbena officinalis L.	1	H				
Violaceae						
Viola arvensis Murray*	1	T		p		
Vitaceae						
Parthenocissus quinquefolia (L.) Planchon*	7	P			I	
Vitis vinifera L.*	9	P				

subclass Liliidae						
Alismataceae						
Alisma lanceolatum With.*	7	G				
Alisma plantago-aquatica L.	7	G				
Alliaceae						
Allium ursinum L.*	7	G				
Amaryllidaceae						
Galanthus nivalis L.	3	G		p		
Cyperaceae						
Carex distans L.	6	H				R
Carex elata All.	6	H				R
Carex flacca Schreb. ssp. *flacca**	7	G				
Carex hirta L.	7	H				
Carex panicea L.*	7	G	VU	sp		
Carex sylvatica Huds.*	7	H				
Carex tomentosa L.*	7	G				
Cyperus fuscus L.	7	T	VU	sp		
Eleocharis palustris (L.) Roem. et Schult.	8	G				M3, M4
Scirpus triqueter L.	3	G				M3
Dioscoreaceae						
Tamus communis L.*	3	G		p		
Hydrocharitaceae						
Elodea canadensis Michx.	10	Hy			I	Gjurašin (1920, ZA)
Iridaceae						
Iris pseudacorus L.	7	G		sp		
Juncaceae						
Juncus articulatus L.	8	H				
Juncus bufonius L.	8	T				Marković (1971, ZA)
Juncus compressus Jacq.	7	G				M4
Juncus inflexus L.*	7	H				
Liliaceae						
Ornithogalum umbellatum L.*	3	G		p		
Orchidaceae						
Ophrys apifera Huds.	3	G	EN	sp		Č
Orchis militaris L.	7	G	VU	sp		R
Orchis tridentata Scop.	3	G	VU	sp		Č
Poaceae						
Agrostis stolonifera L.	7	H				M3, M4, R
Alopecurus geniculatus L.	7	H	VU	sp		M4
Arrhenatherum elatius (L.) P.Beauv. ex J.Presl et C.Presl*	1	H				
Avena sativa L.*	1	T				
Brachypodium pinnatum (L.) P.Beauv.*	7	H				
Bromus hordeaceus L.*	7	T				
Bromus sterilis L.*	7	T				
Calamagrostis epigejos (L.) Roth*	6	G				

Cynodon dactylon (L.) Pers.	9	G				
Cynosurus cristatus L.	7	H				L
Dactylis glomerata L.	7	H				
Digitaria sanguinalis (L.) Scop.*	7	T				
Echinochloa crus-galli (L.) P. Beauv.	10	T				
Eleusine indica (L.) Gaertn.*	10	T			I	
Elymus repens (L.) Gould	8	G				
Eragrostis minor Host*	7	T				
Festuca pratensis Huds.	7	H				
Holcus lanatus L.*	7	H				
Koeleria pyramidata (Lam.) P.Beauv.*	5	H				
Leersia oryzoides (L.) Sw.	7	G	NT	p		Gjurašin (1920, ZA), Marković (1970 and 1972, ZA), M3
Lolium multiflorum Lam.*	1	T				
Lolium perenne L.	6	H				
Milium effusum L.	7	G				R
Panicum miliaceum L.*	7	T				
Phalaris arundinacea L.	8	G				
Phleum pratense L.*	7	H				
Phragmites australis (Cav.) Trin. ex Steud.*	9	G				
Piptatherum miliaceum (L.) Coss.*	1	H				
Poa angustifolia L.	7	H				M2
Poa annua L.	7	T				
Poa compressa L.	7	H				
Poa pratensis L.	8	H				
Poa trivialis L.	8	H				
Setaria pumila (Poir.) Schult.	10	T				
Setaria viridis (L.) P.Beauv.*	1	T				
Sorghum halepense (L.) Pers.*	9	G			I	
Sporobolus neglectus Nash	10	T				Marković (1972, ZA), M2
Sporobolus vaginiflorus (Torr.) Wood	10	T				Marković (1972, ZA), M2

Phytogeographically, the researched area belongs to Illyrian province, lower forest belt of *Erythronio-Carpinion betuli* (Horvat, 1938) Marinček in Wallnöfer *et al*. 1993., generally characterized by Central-European elements, as well as a large number of Illyrian-Balkan taxa (Horvatić, 1967). However, the composition of chorotypes shows that the flora of Jarun only weakly reflects this phytogeographical position, the Eurasian chorotype being much more present in the spectrum than the European and Central-European types, and the Illyrian-Balkan chorotype is almost absent. In addition, adventive plants are present with a relatively high proportion (Fig. 3). Such a general character of Jarun flora is a consequence of intensive anthropogenic influence, in a form of habitat modification and frequent disturbance. When compared to some other areas in NW Croatia, Jarun shows a specifically strong prevalence of the Euro-Asiatic chorotype, as well as the unusually high ratio of plants of the Mediterranean type. In the same time, the ratio of cosmopolite plants is comparably very low (Tab. 3). These differences arise from different approaches in the treatment of plants in terms of their chorology. Using our approach based on Landolt *et al.* (2010), a large number of taxa that are considered cosmopolite by Horvatić *et al*. (1967/1968) are here treated as Euro-

Tab. 2. Life form ratios (in percentages) for Jarun and some areas in NW Croatia with seminatural landscapes: Konjščina (Stančić, 1994), Martinci (Martinko, 2009), Vukova Gorica (Alegro *et al*., 2006), Stupnik (Mitić *et al*., 2007), Konopljenka and Piškorovo (Hudina *et al*., 2012) and Savica (Alegro *et al*. 2013).

Life forms (%)	Jarun	Konjščina	Martinci	Vukova Gorica	Stupnik	Konopljenka & Piškorovo	Savica
P	13.00	8.9	15.1	11.4	10.9	14.5	14.2
Ch	1.86	5.0	2.7	4.0	3.1	3.1	1.4
H	42.41	45.0	52.1	52.3	49.6	48.1	47.9
G	16.10	13.9	13.7	13.5	10.0	10.8	10.1
T	24.77	24.0	16.1	13.5	24.0	22.2	19.1
Hy	1.86	3.3	0.3	1.3	2.4	1.1	5.9

Tab. 3. Chorotype ratios (in percentages) for Jarun and some areas in NW Croatia with seminatural landscapes: Konjščina (Stančić, 1994), Martinci (Martinko, 2009), Vukova Gorica (Alegro *et al*., 2006), Stupnik (Mitić *et al*., 2007), Konopljenka and Piškorovo (Hudina *et al*., 2012) and Savica (Alegro *et al*., 2013). Some specific values for the flora of Jarun are bolded.

chorotype (%)	Jarun	Konjščina	Martinci	Vukova Gorica	Stupnik	Konopljenka & Piškorovo	Savica
medit	**9.63**	1.0	1.0	1.5	2.0	1.4	9.7
illyr-balk	0.31	0.7	-	1.2	0.2	-	0.7
S-europ	7.76	9.4	7.6	11.3	9.0	9.1	3.1
atlantic	-	0.2	-	0.2	0.4	-	-
E-europ-pont	0.93	0.9	1.0	1.2	0.9	1.1	2.1
SE-europ	-	0.5	1.0	0.6	0.4	0.6	-
C-europ	5.90	2.9	3.8	4.8	4.2	3.1	6.3
europ	7.76	11.5	11.0	12.6	11.5	11.1	3.8
euro-asiat	**44.10**	33.2	34.8	31.9	32.5	30.1	48.3
circ-holart	5.28	7.9	6.6	8.4	7.3	6.3	8.7
cosmop	**8.39**	26.4	25.2	23.1	27.7	27	3.1
adv	**9.94**	5.5	7.9	3.4	3.7	10.2	13.2

Asiatic (e.g. *Plantago major*, *Poa annua*, *Populus nigra*, *Ranunculus repens*, *Rumex crispus*, *Trifolium repens*) or Mediterranean (e.g. *Anagallis arvensis*, *Capsella bursa-pastoris*, *Diplotaxis muralis*, *Trifolium campestre*, *Verbena officinalis*). The main reason for this is that since the work of Horvatić *et al*. (1967/1968) the distribution of many species has become better understood, therefore we have decided to choose a more modern approach to chorology. For example, the above-mentioned Mediterranean species are treated as widespread by Horvatić *et al*. (1967/1968), but they were historically more narrowly distributed in the Mediterranean, and have been secondarily spread to larger areas in more recent times through anthropogenic habitats, as ruderal or weed species. In the

most recent study on the flora of Savica, Alegro *et al.* (2013) used a similar approach to chorology; and consequently the ratios of chorotypes within their results show great similarity with our data (Tab. 3).

With less than 2% of flora under the threat of extinction, Jarun is not a remarkable site in the sense of providing habitats for threatened plants. In terms of their preservation, it is notable that out of six threatened plants, only two have been confirmed during this study (*Carex panicea* and *Cyperus fuscus*). The occurrence of three threatened orchids in the researched area is mentioned by other authors: *Orchis militaris* by Randić *et al*. (1981) and *Ophrys apifera* and *Orchis tridentata* by Čičmir (pers. comm.). However, those species were not recorded during this survey. Orchids generally prefer less ruderal habitats, corroborated with indicator values for nitrogen which are low for these species (Ellenberg *et al*., 1991), thus their scarce appearance on Jarun is expected. At the same time, the embankment of the River Sava in the immediate proximity of the researched area provides a more favourable habitat for orchids, with as many as 13 species recorded (Kranjčev, 2005).

Keeping it in mind that the construction of the Jarun Recreational and Sports Centre lasted several years and was not finalized until the end of the 1980s (Sabolić, 2003), it is noteworthy that most of the previous literature and herbarium data refer to the time before or during this period. This might be one of the explanations for not confirming certain taxa, while other taxa are newly found. Also, it should be stressed that 10 out of 25 invasive species are recorded for the first time in this study, indicating that the colonization by invasive species might be an ongoing process.

As a summary, in the flora of Jarun the most represented is the family of grasses, an unusually large proportion of therophytes is found, the most numerous chorotype is the one of Euro-Asiatic plants and a high ratio of adventive plants is present. In addition, as much as 7.74% of its flora is listed as invasive, indicating anthropogenically disturbed habitats and high nitrogen availability. Our analysis reveals that the composition of the flora strongly reflects the character of Jarun, as a heavily visited, widely used, and regularly maintained area. Although not a residential district, the researched area undoubtedly shows the characteristics of an urban environment. In spite of this, with 323 taxa in its flora, Jarun is floristically relatively rich and diverse. It should be pointed out that during the construction of Jarun, special care was given to landscape architecture, in order to preserve the existing natural features in the best possible way (Sabolić, 2003). Thanks to this approach, the southern parts of the researched area remained more authentic, remnants of natural wetland and marsh habitats, providing a considerable biological value to Jarun. All these facts point to the conclusion that dramatic habitat changes and intensive use inevitably influence floristic diversity and it is important to bear these considerations in mind when planning interventions into nature.

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SAŽETAK

Vaskularna flora Jaruna (Zagreb, Croatia)

N. Vuković, I. Boršić, D. Župan, A. Alegro & T. Nikolić

Floristička istraživanja Rekreacijsko-sportskog centra Jarun provedena su tijekom vegetacijske sezone 2006. i djelomično u 2008. godini, pri čemu je sastavljeno ukupno 56 flornih listi. Nakon obrade flornih listi i dostupne literature, za istraživano područje je ustanovljena prisutnost ukupno 323 biljne svojte iz 70 porodica, od čega je 156 svojti navedeno prvi put, dok 49 prethodno zabilježenih svojti nije potvrđeno u ovom istraživanju. Od porodica su najbrojnije trave (Poaceae, 11,76%), zatom slijede glavočike cjevnjače (Asteraceae, 9,94%), mahunarke (Fabaceae, 6,81%) i usnače (Lamiaceae, 6,81%), što se općenito podudara s redoslijedom porodica prema brojnosti u ukupnoj flori Hrvatske. Spektar životnih oblika pokazuje da su hemikriptofiti najčešći životni oblik (42,41%), iza čega slijede terofiti (24,77%). Prema sastavu životnih oblika, Jarun ne pokazuje specifičnost u odnosu na neka druga područja sjeverozapadne Hrvatske. U spektru flornih elemenata prevladavaju euroazijske biljke (44,10%), te je zabilježen relativno veliki broj adventivnih (9,94%) i mediteranskih biljaka (9,63%), dok je udio ilirsko-balkanskog flornog elementa vrlo malen (0,31%). Osim navedenih specifičnosti, Jarun se ističe malim brojem kozmopolitskih vrsta u odnosu na neka druga područja sjeverozapadne Hrvatske, no istaknuto je da navedene specifičnosti dijelom proizlaze iz različitog pristupa horologiji u odnosu na prijašnju literaturu. Svega šest vrsta se nalazi na Crvenom popisu (*Ophrys apifera*, *Alopecurus geniculatus*, *Carex panicea*, *Cyperus fuscus*, *Orchis militaris* i *Orchis tridentata*), dok je invazivnih vrsta zabilježeno ukupno 25, što predstavlja relativno veliki broj. Rezultati analize flore su u skladu s urbanim položajem i načinom korištenja istraživanog područja kao centra za sport i rekreaciju. Iako pod velikim utjecajem čovjeka, obzirom na broj zabilježenih svojti, Jarun se može smatrati floristički relativno bogatim područjem.