FLORA ALONG THE LOWER COURSE
OF THE UNA RIVER (CENTRAL CROATIA)

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Floristic research of the area along the lower course of the Una River was conducted during spring of 2009. The floristic list obtained contains 252 vascular plant taxa, out of which three are considered to be under threat of extinction (endangered Dactylorhiza incarnata (L.) Soó and vulnerable Carex rostrata Stokes ex With. and Alopecurus rendlei Eig), while three are data deficient (Stellaria palustris Retz., Orchis laxiflora Lam. ssp. elegans (Heuff.) Soó and Bromus commutatus Schrad.). In the investigated area 14 invasive alien species were recorded, which mainly spread because traditional agricultural practices had been abandoned.

Key words: vascular flora, invasive alien plant species, Croatia

INTRODUCTION

The Una River springs between Lendek and Čaire Mountains in the southeastern part of Lika, a region in Croatia. In its upper part it is a typical karstic river, with an inconsistent profile of flow, while in the lower course it has the characteristics of a wide lowland river (BOGNAR, 2005). It is a right tributary of the Sava River, the confluence being located by Jasenovac (central Croatia). Along its 212 km long flow it partly passes through Bosnia and Herzegovina and partly forms the border between Croatia and Bosnia and Herzegovina. In total, the Una River basin extends over an area of 9368 km², 636 km² of which are in Croatia (ANONYMOUS, 2009a).

The Una River has conformed to the primary geological structure and the activity of tectonic movements. Its valley has complex characteristics defined by the interchange of gorges, basins and valley extensions (BOGNAR, 2005). In the lower course, sediments of the valley of the Una River are of Holocene alluvial origin. The most
abundant are sediments of flood sequences, while slope aprons and riverbed facies can also be found (Magas, 1980; Caslav & Magas, 1980). In the first ca 146 km the Una River flows through the Dinarides, where carbonate rock complexes, limestone and dolomites prevail, and different morphogenetic types of calcareous sinter are well developed. They can also sporadically be found downstream (Matonickin & Pavletic, 1963; Bognar, 2005).

The lower course of the Una River is a part of The Ecological Network of the Republic of Croatia (»Valley of the Una River«, site code HR2000463; Anonymous, 2007) and will form a part of the NATURA2000 proposal. Conservation objectives of this site are the fish species Cottus gobio, Hucho hucho and Rutilus pigus as well as »Surface inland waters and marsh habitats«. The same area has been proposed for protection in the category of Regional Park (IUCN category V). It is a flat, relatively narrow (from ca 50 to 2500 m) but more than 70 km long part, with an area of 39.38 km². It extends between the Croatian border, mostly following the Una River on the southeast and the road that leads from Jasenovac to Hrvatska Dubica on the northwest.

According to the climate classification by Köppen (Bertovic, 1975) the studied area belongs to the temperate C climate, $C_{fbx}$ for the northern part and $C_{sbox}$ for the southern. According to the data of the weather station in Kostajnica for the eleven-year period (1998–2008), the average annual air temperature was 10.9 °C and the average annual amount of precipitation was 1036.4 mm. The average monthly air temperature was highest in July and August (20.7 °C and 20.2 °C, respectively), while in January it was the lowest (0.5 °C). The highest amount of precipitation occurred in September and the lowest in February (Croatian Meteorological and Hydrological Service, unpublished data).

Lakusic et al. (1991) differentiate seven vertical belts on the Una River vertical profile: supra-Mediterranean, submontane, montane, supramontane, subalpine, alpine and subnival. In the lower course of the Una River, the submontane belt with several subbelts dominates. Typical vegetation of this area, developed under the general climate, are mesophyllous sessile oak and hornbeam forests (Epime-box-Carpinetum betuli (Ht. 1938) Borhidi 1963) (Horvat, 1949), while by the mouth of the Una River and its lower course alluvial forests with black alder (Alnion glutinosae Mal. 1929) as well as alluvial willow and poplar forests (Salicion albae Soo 1930 and Populion albae Br.-Bl. 1931) prevail. According to the Habitat Map of Croatia (provided by the State Institute for Nature Protection (http://www.dzzp.hr) and described by Antonic et al., 2005) on this area 20 main habitat types or mosaic areas of two or more different habitat types have been mapped, designated according to the National Habitat Classification (Anonymous, 2009c). It is mostly a typical mosaic rural area with an interchange of cultivated fields, grasslands, hedges, scrubs, forest fragments and ruderal habitats.

The area along the lower course of the Una River has not been floristically well researched. The only floristic research that at least partly includes this area has been conducted by Segulja et al. (1998). They were researching the wider area of Zrinska gora, which includes the area besides Una River. For the whole of the research area they noted 682 vascular plant taxa.

Considering the obvious lack of exact floristic data of this area, we think it is useful to publish the results of our research.
MATERIALS AND METHODS

Fieldwork was carried out during spring (April-June) of 2009 at different locations in the area of the ecological site »Valley of the Una River« (ANONYMOUS, 2007). Vascular flora was investigated at point localities whose positions were determined using a Garmin GPSMAP 60CSx GPS Receiver. Taxa not recorded at these exact localities and frequent taxa have been assigned to the MTB 1/64 field in which they were recorded. Point localities and MTB 1/64 fields investigated are listed in Tab. 1 and depicted in Fig. 1. For MTB 1/64 fields, the geographic coordinates of their centroids have been used.

Localities of recorded taxa have been listed behind the name of each taxon according to the coordinate codes listed in the Tab 1.

Tab. 1. Investigated point localities and MTB 1/64 fields

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Taxa were determined using standard determination keys and iconographies (JAVORKA & CSAPODY, 1975; TUTIN et al., 1968–1980; TUTIN et al., 1993; DOMAC, 1994; ROTHMALER, 1995). The nomenclature has been adjusted according to the Croatian Flora Checklist (NIKOLIĆ (ed.), 2010). Plant families and genera with their appertain - ing species and subspecies are listed in alphabetical order within higher systematic units. As well as newly recorded taxa, the floristic list also contains taxa that had previously been noted by ŠEGULJA et al. (1998) for the research area. These taxa are marked with * in front of the name of each taxon.

Species considered to be invasive alien plant species according to BORŠIĆ et al. (2008) are denoted with the abbreviation IAS. Subspontaneously occurring cultivated species are marked with the abbreviation NAT. Taxa listed in the Red Book of Vascular Flora of Croatia (NIKOLIĆ & TOPIĆ (eds.), 2005) are marked with their corresponding threat category: CR – critically endangered, EN – endangered, VU – vulnerable. Also, DD – data deficient taxa have been denoted.

Taxa protected by the Nature Protection Act (ANONYMOUS, 2005; ANONYMOUS, 2008; ANONYMOUS, 2011) and listed in the Ordinance on Designating Wild Taxa Protected and Strictly Protected (ANONYMOUS, 2009b) are denoted as P – protected and SP – strictly protected.

RESULTS

Taxa of vascular plants along the lower course of the Una River (including taxa cited in ŠEGULJA et al., 1998) are as follows:
PTERIDOPHYTA

Equisetaceae
*Equisetum arvense L. C3, T6, C6, T8, T16, T17, C12, C16, C19, C20, T26
*Equisetum palustre L.
Equisetum telmateia Ehrh. C2, C11, C15, C18

Hypolepidaceae
Pteridium aquilinum (L.) Kuhn C14, C15, T30

Ophioglossaceae
*Ophioglossum vulgatum L. (P)

SPERMATOPHYTA

GYMNOSPERMAE

Cupressaceae
Juniperus communis L. T28

ANGIOSPERMAE

MAGNOLIATAE

Aceraceae
*Acer campestre L. C20
*Acer negundo L. (IAS) T2, T3, C3, T5, T6, C6, C8, C13, C14, T20, T22, T24, C20

Amaranthaceae
*Amaranthus albus L.

Apiaceae
*Aegopodium podagraria L. (P) C6, T9, T12, T14, C11, T17, C13, C17, T22, T24 (P)
*Aethusa cynapium L.
*Anethum graveolens L.
*Angelica archangelica L. (IAS)
Angelica sylvestris L. C6, T14, T17, C19

Anthriscus sylvestris (L.) Hoffm. T24

*Chaerophyllum aureum L.
*Daucus carota L.

Heracleum sphondylium L. C6, T12, T13, C11, T17, C13, T19, C15, C16, C19, C20, C21

*Oenanthe fistulosa L. T17, C12
*Oenanthe silaifolia M. Bieb.
*Pastinaca sativa L. C3, C6, T8, T13, T15, C15, C16, C18, C20, T26, C24, T32

*Pimpinella major (L.) Huds. (P)
*Pimpinella saxifraga L. (P)
*Smyrnium perfoliatum L.

Araliaceae
*Hedera helix L. T20, T30

Aristolochiaceae
Aristolochia clematitidis L. C3, T5, C5, C6, C11, T17, C12, C15, C20, C24
Asclepiadaceae
   Asclepias syriaca L.  (IAS)  C1, T1, C3, C6

Asteraceae
   *Achillea millefolium L.  T2, T3, C3, C6, T8, T9, C8, T12, C10, T15, C11, T17, C12, T18, T20, C15, C16, C18, C19, C22, T26, C23, C24, T27, C26
   *Ambrosia artemisiifolia L.  (IAS)  C3, T5, T6, C5, C8, T13, C10, T15, T17, T19, C15, C16, T22, C18, T25, C24
   *Anthemis arvensis L.  C14
   *Arctium lappa L.  C13, T19, T22
   *Arctium minus Bernh.
   *Artemisia vulgaris L.  C3, C5, T8, T13, C10, T15, C11, C12, C13, T19, C18, C19, C20, C24, C26
   *Bellis perennis L.  C1, T9, C8, C9, C13, T19
   *Bidens tripartita L.
   *Carduus acanthoides L.
   *Centaurea jacea L.  C6, T8, C18, T26, C23
   *Centaurea jacea L. subsp. angustifolia Greml
   Chamomilla suaveolens (Pursh)
      Rydb.  (IAS)  C8, C21
   *Cirsium arvense (L.) Scop.  T25, C24
   *Conyza canadensis (L.) Cronquist  (IAS)
   Erigeron annuus (L.) Pers.  (IAS)  C3, C5, C6, T8, C9, T13, T15, T16, C11, T17, T12, T18, T19, C14, T20, C15, C16, T21, T22, C19, C20, T25, C22, C23, C24, T27, T29, T30, T32
   *Eupatorium cannabinum L.  T16
   Helianthus tuberosus L.  (IAS)  T29
   *Inula britannica L.
   *Leucanthemum vulgare Lam. (incl. Leucanthemum praecox) (Horvatić) Horvatić  C3, C6, T8, C18, C19, T26
   Matricaria perforata Mérat  C8
   Petasites hybridus (L.) P. Gaertn., B. Mey. et Schreb.  T24
   *Pulicaria dysenterica (L.) Bernh.
   *Senecio aquaticus Hill
      Senecio erraticus Bertol.  C3, C18
   *Senecio jacobaea L.  (P)
   *Senecio vulgaris L.  C9
   *Tanacetum vulgare L.  (P)  C3

Balsaminaceae
   *Impatiens parviflora DC.

Berberidaceae
   *Berberis vulgaris L.  (P)

Betulaceae
   *Alnus glutinosa (L.) Gaertner  T12, T14, T20, C19
Boraginaceae

Cerinthe minor L. C24

*Lithospermum arvense* (as Buglossoides arvensis (L.) I. M. Johnst.)

Myosotis arvensis (L.) Hill C4, C5, C6, T10, C9, C16, T25, T26

Symphytum officinale L. T2, C3, T6, C6, T11, T17, C12, C13, C17, T24, C20, C23

Symphytum tuberosum L. (P) T20

Brassicaceae

*Alliaria petiolata* (M. Bieb.) Cavara et Grande (P) T3, C6, T9, C8, T12, C17

*Arabidopsis thaliana* (L.) Heynh.

*Armoracia rusticana* P. Gaertn., B. Mey. et Scherb.

*Brassica nigra* (L.) Koch (P)

*Brassica oleracea* L. (P)

Calepina irregularis (Asso) Thell. C1, C9, T17

*Capsella bursa-pastoris* (L.) Medik. C1, C8, T12, C16, T17, C17, T25

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\*Digitaria\textit{ sanguinalis} (L.) Scop.

\*Echinochloa\textit{ crus-galli} (L.)\ P. Beauv.

\*Elymus\textit{ repens} (L.) Gould (as Agropyron\textit{ repens} (L.)\ PB.) C3, C4, T8, T10, C10, C12, T15, C13, C14, T21

\*Festuca\textit{ pratensis} Huds. C3, T8, C10, C18, C20, T26

\*Festuca\textit{ rubra} L.

\*Holcus\textit{ lanatus} L. T8, T15, C12, C16, T21, T22, C18, C20, T26, C24

Hordeum\textit{ murinum} L.  T10

Lolium\textit{ multiflorum} Lam. C3, C5

\*Lolium\textit{ perenne} L. C3, T10, T17, C15, C22, T26

\*Panicum\textit{ capillare} L. (IAS)
DISCUSSION

Up to this contribution, the only floristic data concerning the investigated area were those of Šegulja et al. (1998). In their work they registered 682 vascular plant taxa. As they were investigating the wider area of Zrinska gora, they also included the area along the Una River in their research. However, the localities in their work were listed only generally, without precisely describing the locality or giving exact coordinates, so taxa limited only to the investigated area could not be exactly determined. Out of their list we have extracted 225 taxa which had the localities that we considered to be in our investigated area, such as: »valley of the Una River«, »by the Una River«, »Kostajnica«, »Unčani«, »Dvor« etc.

During our research we registered 252 vascular plant taxa. This list can not be considered final as fieldwork has not been carried through the whole vegetational season but only in one part (April-June). Because of the scarcity of the data regarding the investigated area, we nevertheless find it useful to publish our results. Thorough investigation of vascular flora should be continued in other parts of the vegetational season.

Although vascular plants are not a conservation objective of the Ecological Network site »Valley of the Una River«, one of the conservation objectives is »Surface inland waters and marsh habitats«, a category which comprises some habitat types that are considered to be rare and threatened in Croatia (Anonymous, 2009c). In this sense, by the Una River, marshland communities of the alliances Phragmition australis W. Koch 1926 and Magnocaricion elatae W. Koch 1926 occur, but only sporadically and on small surfaces. Loss of aquatic and moist habitats (especially because of drainage and regulation; cf. Nikolić & Topić (eds.), 2005) means that many water and marsh plant taxa are now facing the threat of extinction and are therefore listed on the national red list and protected by the law. Special attention to this type of vegetation is therefore needed. As water plant species have their vegetational peak during July and August, they have not been thoroughly investigated during our research.
From the nature protection/conservation point of view, taxa under threat of extinction as well as rare and threatened habitats are especially evaluated in considering an area for protection. In the list we have placed special emphasis on taxa that are considered to be under threat of extinction i.e. that are listed in the Red Book of Vascular Flora in Croatia (NIKOLIĆ & TOPIĆ (eds.), 2005). There are only three such taxa recorded in the investigated area: one endangered (Dactylorhiza incarnata) and two vulnerable (Carex rostrata and Alopecurus rendlei). Since the species Alopecurus rendlei was listed as vulnerable it has been found on numerous new localities so its status requires re-evaluation (TOPIĆ, pers. comm.). Data deficient taxa have also been listed, as taxa in this category could also be under threat of extinction (IUCN STANDARDS AND PETITIONS SUBCOMMITTEE, 2010). There are three data deficient taxa recorded: Stellaria palustris, Orchis laxiflora ssp. elegans and Bromus commutatus.

ALEGRO et al. (2006) have shown that moderate anthropogenic influence in the continental part of Croatia enriches floristic diversity by enhancing habitat diversity. Especially significant in this sense are grasslands, which, as seminatural habitats, contain the greatest number of species. On the researched area, among all grasslands, mesophyllous grasslands (National Habitat Classification code: C.2.3.; Order Arrhenatheretalia) predominate (Habitat Map of Croatia; http://www.dzzp.hr). Some of these grasslands except an early-spring phase with most of their area under water also have a dry summer phase when all the water withdraws and the area dries up. Therefore species characteristic of drier grassland could also be found on them.

Invasive alien species represent an accentuated threat on the investigated area. During our research we have recorded 14 invasive alien plant species. The most widespread and prominent among them are Acer negundo, Ambrosia artemisiifolia, Amorpha fruticosa, Echinocystis lobata, Erigeron annuus and Robinia pseudoacacia. This area has suffered extreme depopulation from the 1990s (MIŠETIĆ, 2002), which caused extensive agricultural activities to be abandoned. On abandoned cultivated fields Ambrosia artemisiifolia, the most allergenic plant in Europe, flourishes. In the lowest part of the Una River course, where traditional cattle breeding also ceased and especially in areas suspected of being mined, Amorpha fruticosa has spread and forms dense stands today. On the other hand, despite the fact that the area has been depopulated in recent time, the anthropogenic influence is still high. As settlements are more or less evenly distributed along the whole area, there is no part of the area that is devoid of human influence, which also facilitates a spread of IAS.

CONCLUSION

The area along the lower course of the Una River has not been sufficiently floristically studied, with only one wider investigation that has at least partly included this area. Our results represent a contribution to the knowledge of vascular flora of this area but the list presented cannot be considered final. Therefore, floristic investigations on this area should continue.

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ŠAŽETAK

Flora donjeg toka rijeke Une (središnja Hrvatska)
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