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NEW RECORDS OF VASCULAR PLANTS FOR THE NEW PART OF THE KRKA NATIONAL PARK

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Following a change in 1997 of the boundaries of Krka National Park, comprehensive floristic field mapping of the new, North-East area of the park using basic MTB 1/64 field units was conducted during 2007 and 2008. In total, 507 plant taxa were recorded, including 92 new taxa for the park flora. The complete vascular flora of the park now consists of 1080 plant taxa, but new taxa are still expected to be discovered.

Key words: flora mapping, Krka National Park, new taxa, Croatia

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Budući da su 1997. granice i površina Nacionalnog parka promijenjene, tijekom 2007. i 2008. provedeno je opsežno terensko kartiranje flore novog, sjeveroistočnog dijela Parka, koristeći osnovna MTB 1/64 polja. Zabilježeno je ukupno 507 biljnih svojti, od kojih su njih 92 nove za floru Parka. Vaskularna flora Parka sada broji ukupno 1080 biljnih svojti, no nalazi novih svojti se i dalje mogu očekivati.

Ključne riječi: kartiranje flore, Nacionalni park Krka, nove svojte, Hrvatska

INTRODUCTION

With an area of 109 km^2, Krka National Park is the fourth largest among eight Croatian national parks. However, the entire hydrological and geological basin of the Krka River is much larger and covers an area of more than 2500 km^2 (BOŽIČEVIĆ, 2007). The key phenomena of the Krka River are the travertine waterfalls and other karst geomorphologic forms which form the backbone for landscape and biological diversity (MARGUŠ, 2007a).

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The conflicting interests of industry, energy, fishing, residence and tourism on one hand, and awareness of the importance of protecting the Krka River in its natural state of order on the other, resulted in the relatively early protection of individual parts of the river by either local or state authorities (MARGUŠ, 2007b). The river section from waterfall Bilušić buk to waterfall Skradinski buk was made a protected natural rarity in 1948 followed, in 1962, by the river section from the waterfall Krčić slap to the foot of the Skradinski buk cascades. Čikola canyon and its river became a natural reserve in 1967 and the river section from the border with Drniš municipality to Šibenik Bridge, a natural reserve in 1968. Finally, in 1985, the Krka River and its coastal areas between the old Croatian fortresses Trošenj and Nečven to Šibenik Bridge, including the lower canyon course of the Čikola tributary, were proclaimed a national park with a total area of approximately 142 km^2. Relatively recently, in 1997, the boundaries and area of the park were revised. The park was shifted more to the North-East, and now embraces an area extending approximately from the town of Knin to the town of Skradin. Consequently, the total area of the Park has been reduced by about 23 % and now spans 109 km^2.

Though the Krka River was proclaimed a national park due to its geomorphologic, hydrological and historical values, the flora of this area is also interesting (HRŠAK, 2007) and has been investigated from as early as the 19th century. A detailed overview of floristic and vegetation surveys conducted up to 1993, including VISIANI (1826, 1842–1852, 1872), HIRC (1909), GAŽI-BASKOVA (1983), SEKULIĆ & LOVRIĆ (1986), GARNWEIDNER (1987), LOVRIĆ & BEDALOV (1987), LOVRIĆ *et al*. (1987), LOVRIĆ & RAC (1989), TRINAJSTIĆ (1993) was completed by MARKOVIĆ *et al*. (1990, 1993). The floristic findings thereafter (MARKOVIĆ *et al*., 1990, 1993; MILOVIĆ, 2007 and MILOVIĆ & MITIĆ, 2009) following the boundary changes in 1997, have been analyzed and revised by MILOVIĆ & MITIĆ (2009), resulting in a total of 988 vascular plant taxa.

The knowledge of the vascular flora of the new, north-eastern part of Krka National Park has been so far only partial. MILOVIĆ & MITIĆ (2009) investigated there just nine localities, belonging to only seven of the total 22 MTB 1/64 units. Therefore, the aim of this work was to make detailed floristic research of the new part of the park in order to update the list of vascular flora after the boundary changes in 1997. Though this research did not include a vegetation study, some processes observed during the fieldwork are commented within this paper.

MATERIALS AND METHODS

Comprehensive field mapping was carried during 2007 and 2008 on multiple trips throughout the growing season. In order to cover as much as possible of the park area, the MTB fields of the Central European flora mapping grid were used. Basic MTB 1/64 units which approximately form rectangles with average measurements of 1,5 x 1,4 km and average area of 2,1 km^2, were applied in the field. The GPS receiver GARMIN 60CSx and 1:25 000 topographic maps were used for determination of the position and the boundaries of the mapping units. The study area comprised of 22 MTB 1/64 units (Fig. 1).

Taxa were determined using standard determination keys and iconographies (HORVATIĆ, 1954; HORVATIĆ, 1967–1973; TUTIN *et al*., 1968–1980, 1993; TRINAJSTIĆ,

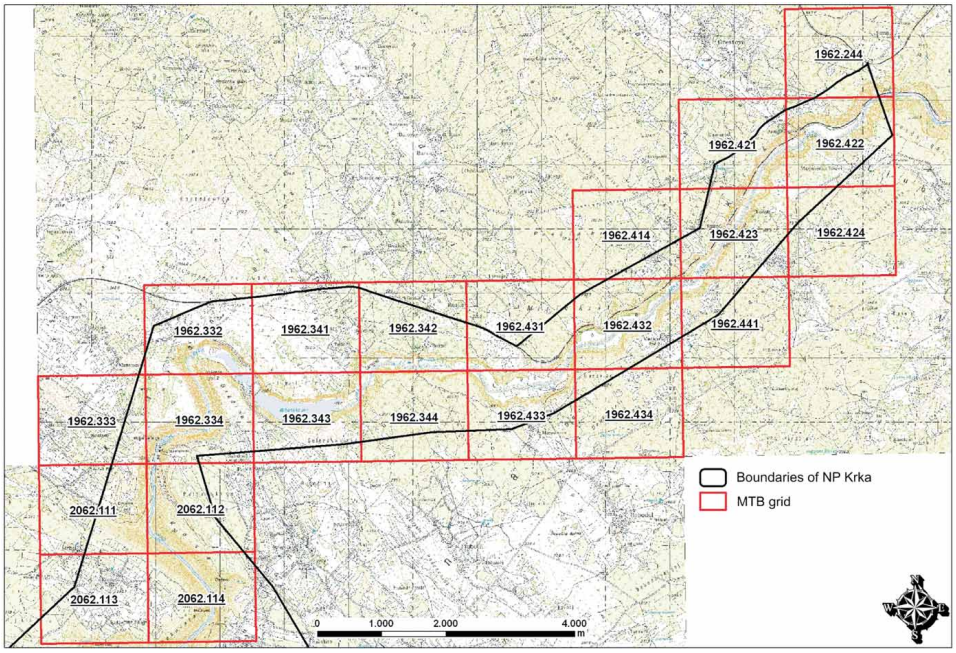

Fig. 1. Study area – the new, NE part of NP Krka with MTB 1/64 unit codes.

1974–1986; PIGNATTI, 1982; JAVORKA, 1991; BURNIE, 1995; LAUBER & WAGNER, 1998; DOMAC, 2002; BLAMEY & GREY-WILSON, 2004; DELFORGE, 2006; MARTINČIĆ, 2007; EGGENBERG & MÖHL, 2007; ROTHMALER & JÄGER, 2009) and several specialists keys (ALEGRO, 2003; ALEGRO *et al.* 2003; ALEGRO & BOGDANOVIĆ, 2003; BOGDANOVIĆ, 2003) and papers (TRINAJSTIĆ, 1990). The nomenclature has been adjusted according to the Croatian Flora Checklist (NIKOLIĆ, 2008), except *Genista sylvestris* Scop. ssp. *dalmatica* (Bartl.) H. Lindb. var. *dinarica* Janch., which is according to HAYEK (1927) and *Hieracium* x *ruprechtii* Boiss. (*H. pilloseloides* x *hoppeanum*) according to SEEL & WEST (1976).

The list of vascular plants presented in this paper comprises taxa found during this research, majority of which for the first time in Krka National Park. Four of them have been registered previously by MARKOVIĆ *et al.* (1990, 1993). Three of them have been registered in the area recently excluded from the park and for the other one findspot information is missing. On the list, these taxa are marked with an asterisk (*) in front of their name. Cultivated taxa, following previous papers, have not been included on the list. The taxa on the list follow the alphabetical order of plant families, genera, species, subspecies and varieties. Names of species are followed by the codes of their associated MTB 1/64 units.

RESULTS AND DISCUSSION

During field research in the new area of Krka National Park, in total 507 species, subspecies and varieties were registered. Ninety two among them are new findings for the park and are presented in this paper. *Rhamnus saxatilis* Jacq. has been previ-

ously recorded by MARKOVIĆ *et al.* (1993) as *Rhamnus saxatilis* Jacq. ssp. *saxatilis* but on localities outside of the recent boundaries of the park. This is the case with *Poa angustifolia* L. and *Rosa sempervirens* L. as well. *Rhamnus catharticus* L. has been previously recorded by MARKOVIĆ *et al.* (1990), but since information about exact findspot of this species in the park is missing, it is included in the present list.

Eight taxa were recorded at subspecies and one at variety level and are therefore listed as new for the park, although most of them have certainly been registered before, but only at species level. *Helianthemum nummularium* (L.) Mill. ssp. *grandiflorum* (Scop.) Schinz et Thell. and *Helianthemum nummularium* (L.) Mill. ssp. *obscurum* (Čelak.) Holub have most likely been recorded previously as *Helianthemum nummularium* (L.) Mill., *Stipa pennata* L. ssp. *eriocaulis* (Borbás) Martinovský et Skalický as *Stipa pennata* L., *Onobrychis arenaria* (Kit.) DC. ssp. *tommasinii* (Jord.) Asch. et Graebn. as *Onobrychis arenaria* (Kit.) DC., *Scrophularia canina* L. ssp. *bicolor* (Sibth. Et Sm.) Greuter as *Scrophularia canina* L. and *Vicia sativa* L. ssp. *cordata* (Hope) Batt. as *Vicia sativa* L. (MARKOVIĆ *et al.*, 1993).

Ophrys sphegodes Mill. ssp. *tommasinii* (Vis.) Soó was probably recorded as *Ophrys sphegodes* Mill. and *Silene italica* (L.) Pers. ssp. *nemoralis* (Waldst. et Kit.) Nyman as *Silene italica* (L.) Pers. (MILOVIĆ & MITIĆ, 2009).

Genista sylvestris Scop. ssp. *dalmatica* (Bartl.) H. Lindb. var. *dinarica* Janch., with its distinctively hairy stem and leaves, might have been recorded as *Genista sylvestris* Scop. ssp. *dalmatica* (Bartl.) H. Lindb. Since different varieties and forms are not listed as separated taxa in the Croatian Flora Checklist, the presence of particular variety is stressed here.

Plant taxa identified to species level, but existing previously as subspecies in previous records, are not included in the following list:

Spermatophyta
Angiospermae
Magnoliatae
Aceraceae
Acer obtusatum Waldst. et Kit. ex.Willd. (1962 334)
Acer pseudoplatanus L. (1962 334)
Apiaceae
Aegopodium podagraria L. (1962 433)
Laserpitium latifolium L. (1962 343)
Pastinaca sativa L. (1962 334,2062 114)
Peucedanum longifolium Waldst. et Kit. (2062 111)
Aristolochiaceae
Aristolochia lutea Desf. (1962 344)
Asteraceae
Carduus acanthoides L. (1962 244, 1962 344, 1962 414, 1962 421, 1962 431, 1962 432, 1962 433, 1962 434)
Petasites albus (L.) Gaertn. (1962 342)
Berberidaceae
Berberis vulgaris L. (1962 434)
Boraginaceae
Myosotis sparsiflora Pohl (1962 343)

Onosma dalmatica Sheele (1962 244, 1962 333, 1962 341, 1962 414, 1962 422, 1962 424, 1962 431, 1962 432, 1962 433,1962 434, 1962 441)

Brassicaceae

Hirschfeldia incana (L.) Lagr.-Foss. (1962 434)

Rorippa palustris (L.) Besser (1962 342)

Cactaceae

Opuntia ficus-indica (L.) Miller (1962 344, 1962 433)

Campanulaceae

Campanula rapunculoides L. (1962 333, 1962 422, 1962 441)

Caprifoliaceae

Lonicera caprifolium L. (1962 422)

Caryophyllaceae

Cerastium dubium (Bast.) Guépin (1962 334, 1962 341)

Dianthus carthusianorum agg. (1962 344, 1962 421, 1962 423)

Dianthus ferrugineus Miller ssp. *liburnicus* (Bartl.) Tutin (1962 423)

Silene italica (L.) Pers. ssp. *nemoralis* (Waldst. et Kit.) Nyman (1962 423)

Stellaria alsine Grimm. (1962 342, 1962 431)

Cichoriaceae

Crepis capillaris (L.) Wallr. (1962 432)

Crepis tectorum L. (1962 342)

Hieracium x *ruprechtii* Boiss. (*H. pilloseloides* x *hoppeanum*) (1962 441)

Scorzonera austrica Willd. (1962 424)

Cistaceae

Helianthemum nummularium (L.) Mill. ssp. *grandiflorum* (Scop.) Schinz et Thell. (1962 434)

Helianthemum nummularium (L.) Mill. ssp. *obscurum* (Čelak.) Holub (1962 244, 1962 333, 1962 341, 1962 343, 1962 421, 1962 422, 1962 423, 1962 424, 1962 434)

Cucurbitaceae

Bryonia alba L. (1962 332, 1962 441)

Dipsacaceae

Knautia dinarica (Murb.) Borbás (2062 114, 1962 244)

Knautia purpurea (Vill.) Borbás (1962 244, 1962 421)

Euphorbiaceae

Euphorbia nicaensis All. (1962 422)

Mercurialis perennis L. (1962 342)

Fabaceae

Astragalus vesicarius L. (1962 343)

Coronilla valentina L. (1962 244, 1962 334, 1962 421)

Dorycnium germanicum (Gremli) Rikli (1962 244)

Genista sericea Wulfen (1962 344, 1962 434)

Genista sylvestris Scop. ssp. *dalmatica* (Bartl.) H. Lindb. var. *dinarica* Janch. (1962 434)

Lathyrus nissolia L. (2062 114, 1962 414)

Onobrychis arenaria (Kit.) DC. ssp. *tommasinii* (Jord.) Asch. et Graebn. (1962 244, 1962 421, 1962 422, 1962 423, 1962 431)

Trifolium montanum L. (1962 344)

Trifolium rubens L. (1962 344, 1962 423, 1962 431, 1962 432)

Vicia cracca L. (1962 342, 1962 423)

Vicia lathyroides L. (1962 431, 1962 441)

Vicia sativa L. ssp. *cordata* (Hope) Batt. (1962 332, 1962 333, 1962 342, 1962 343, 1962 433)

Fagaceae
Quercus cerris L. (1962 334)
Fumariaceae
Fumaria judaica Boiss. (1962 332, 1962 342, 1962 421, 1962 433, 1962 441)
Globulariaceae
Globularia punctata Lapeyr. (1962 333)
Lamiaceae
Betonica officinalis L. ssp. *serotina* (Host) Murb. (1962 344, 1962 421)
Mentha x *verticillata* L. (1962 343)
Micromeria kerneri Murb. (1962 333, 2062 111)
Linaceae
Linum catharticum L. (1962 244, 1962 423)
Lythraceae
Lythrum portula (L.) D. A. Webb (1962 342)
Orobanchaceae
Orobanche purpurea Jacq. (1962 332, 1962 334)
Ranunculaceae
Clematis recta L. (2062 114, 1962 332, 1962 334, 1962 341, 1962 342)
Delphinium staphisagria L. (2062 114)
Rhamnaceae
**Rhamnus catharticus* L. (1962 244)
**Rhamnus saxatilis* Jacq. (1962 334, 1962 434, 2062 111, 2062 114)
Rosaceae
Filipendula vulgaris Moench (1962 434)
Fragaria vesca L. (1962 244, 1962 332, 1962 341, 1962 414, 1962 421, 1962 422, 1962 423, 1962 431, 1962 433, 2062 114)
Potentilla argentea L. (1962 332, 1962 333)
Potentilla heptaphylla L. (1962 341)
Prunus padus L. (1962 423)
**Rosa sempervirens* L. (1962 332, 1962 334, 1962 341, 1962 342, 1962 423, 1962 432, 1962 433, 2062 114, 1962 244)
Sorbus aucuparia L. (1962 422)
Rubiaceae
Cruciata glabra (L.) Ehrend. (2062 111)
Salicaceae
Salix eleagnos Scop. (1962 342)
Scrophulariaceae
Scrophularia canina L. ssp. *bicolor* (Sibth. et Sm.) Greuter (1962 244)
Veronica anagalloides Guss. (1962 343)
Liliatae
Alismataceae
Alisma lanceolatum With. (1962 343)
Cyperaceae
Carex caryophyllea Latourr. (1962 342, 1962 423, 1962 433, 1962 434)
Carex liparocarpos Gaudin (1962 334, 1962 343, 1962 422, 1962 423, 1962 434, 1962 441)
Carex remota L. (1962 332, 1962 333)
Carex sylvatica Huds. (1962 334)

Liliaceae

Allium gutatum Steven ssp. *dalmaticum (*A.Kern. ex Janch.) Stearn (1962 342, 1962 343, 1962 344, 1962 414, 1962 431, 1962 432, 1962 433, 1962 434)

Allium paniculatum L. (1962 244, 1962 424)

Anthericum ramosum L. (2062 111)

Ornithogalum dalmaticum Speta (1962 332, 1962 341, 1962 342, 1962 421, 1962 423, 1962 431, 1962 432, 1962 433, 1962 441)

Ornithogalum narbonense L. (1962 244, 1962 341, 1962 422, 1962 423, 1962 433, 1962 434, 1962 441)

Polygonatum odoratum (Mill.) Druce (1962 342)

Orchidaceae

Ophrys sphegodes Mill. ssp. *tommasinii* (Vis.) Soó (2062 114)

Poaceae

Achnatherum calamagrostis (L.) P. Beauv. (1962 334)

Alopecurus bulbosus Gouan (1962 441)

Bromus inermis Leyss. (2062 114, 1962 422)

Danthonia alpina Vest (1962 423)

Leersia oryzoides (L.) Sw. (1962 114, 1962 333, 1962 342, 1962 343)

Phleum pratense L. ssp. *bertolonii* (DC.) Bornm. (1962 344, 1962 423)

**Poa angustifolia* L. (1962 342)

Poa compressa L. (1962 342)

Stipa pennata L. ssp. *eriocaulis* (Borbás) Martinovský et Skalický (1962 244, 1962 414, 1962 422, 1962 423, 1962 424, 1962 432, 1962 433, 1962 434, 1962 441)

Potamogetonaceae

Potamogeton natans L. (2062 111)

Potamogeton trichoides Cham. et Schltdl. (1962 342)

According to existing data, Krka National Park represents the third findspot of the bulbous foxtail (*Alopecurus bulbosus* Gouan) in Croatia. This grass species is known from Jadrtovac near Šibenik (MILOVIĆ, 2002) and the Raša river valley in Istria (HORVATIĆ, 1963). According to 'The Red Book of Vascular Flora of Croatia' (NIKOLIĆ & TOPIĆ, 2005), it is currently considered a critically endangered species, although its status in this category is not certain since data on its distribution are lacking. The species *Delphinium staphisagria* L. is also considered an endangered species. It should be noted that the taxa *Dianthus carthusianorum* is determined only at an aggregate level, since it was collected after blooming and a more precise determination was not possible. The finding of the hybrid *Hieracium* x *ruprechtii* Boiss. (*H. pilloseloides* x *hoppeanum*) seems to be the first in Croatia (there are no other citations of this taxa in the botanical literature at present), but because hybridization among *Hieracium* species is very common and a serious revision of the genus in Croatia has not yet been made, this statement must be taken with caution.

The floral inventory of the new part of the park covered all types of habitats and vegetation. The study area belongs to the deciduous (i.e. sub–Mediterranean) vegetation zone represented mainly by a community of downy oak and oriental hornbeam (ass. *Querco-Carpinetum orientalis* H-ić 1939), and partly by a community of European hop hornbeam and downy oak (ass. *Ostryo-Quercetum pubescentis* (Horvat 1950) Trinajstić 1979). After centuries of human impact, this community is most frequently degraded either into a form of low forest or shrubland dominated by

Christ's thorn thickets (ass. *Rhamno intermediae-Paliuretum* Trinajstić 1995) and dry rocky grasslands. Abandonment of traditional pasturage and wood cutting caused by strong depopulation in the last few decades has inverted this process in the direction of progressive vegetation succession. The most prominent process noticed on the abandoned grasslands is the rapid expansion of the red-berried juniper (*Juniperus oxycedrus*), phenomena that has been described as a transitional phase towards Christ's thorn thickets or oriental hornbeam underbrush, or rather of a mosaic blend of pasture land, Christ's thorn thickets and oriental hornbeam underbrush (cf. MARKOVIĆ, 2007, TRINAJSTIĆ, 2008). The spread of red-berried juniper in vegetation stands dominated by Christ's thorn in Krka National Park was previously noted by ŠEGULJA (1990). This rapid process requires further investigation in the future. Wetland vegetation and flooded forests or shrublands along the river banks are relatively rare, both in the study area and in total park area.

It must be pointed out that some parts of the river canyon are mine suspected areas and it was not been possible to investigate flora there. Hence, it is expected that some new species might be found once this area is demined.

CONCLUSIONS

Prior to this research 988 plant taxa from Krka National Park had been recorded. During this research 92 new taxa were added and the complete vascular flora of the park now consists of 1080 plant taxa. Due to the variety of habitats and the fact that some parts of the park are still mine suspected areas, new plant taxa are still expected to be discovered. The knowledge about the distribution of each plant taxa in the park will help to improve park management, especially concerning treatment of rare and endangered species. Rapid expansion of some wood species noticed on abandoned grasslands and pastures currently represents major problem for biodiversity maintenance. Therefore active protection planning is in the focus of further investigation.

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SAŽETAK

Novi podaci o vaskularnim biljkama novog dijela Nacionalnog parka »Krka«

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Flora NP Krka relativno je dobro poznata i do ovog istraživanja brojala je ukupno 988 biljnih svojti. Nakon pomicanja granice Parka 1997. godine, stvorila se potreba za inventarizacijom vaskularne flore novonastalog sjeveroistočnog dijela Parka. Tijekom 2007. i 2008. godine provedeno je opsežno terensko kartiranje po osnovnim MTB 1/64 poljima. Zabilježeno je ukupno 507 vrsta, podvrsta i varijeteta, od kojih njih 92 predstavlja nove nalaze za floru Parka. Na istraživanom području uočen je proces progresivne vegetacijske sukcesije koji se javlja kao posljedica depopulacije prostora, napuštanja tradicionalnog stočarenja i sječe, a posebno se ističe rapidno zaraštavanje napuštenih travnjaka i pašnjaka borovicom (*Juniperus oxycedrus*), koje bi trebalo detaljnije istražiti. Vaskularna flora NP Krka sada sadrži ukupno 1080 biljnih svojti, no ovaj broj zasigurno nije konačan s obzirom na raznolikost staništa te nedostupnost zbog miniranosti pojedinih dijelova Parka.