

7. Hrvatski botanički simpozij s međunarodnim sudjelovanjem
7th Croatian Botanical Symposium with international participation



**KNJIGA SAŽETAKA
BOOK OF ABSTRACTS**

Zagreb, 12.-14. rujna 2022.
Zagreb, September 12-14, 2022



Hrvatsko botaničko društvo
Croatian Botanical Society
(organizator / organizer)

UREDNICI / EDITORS

Nina Vuković, Vedran Šegota

IZDAVAČ / PUBLISHED BY

Hrvatsko botaničko društvo
Croatian Botanical Society

DIZAJN / DESIGN

Alan Budisavljević

TISAK / PRINT

ALFACOMMERCE d.o.o., Zagreb

NAKLADA / COPIES

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Hrvatsko botaničko društvo, osmišljeno kao strukovno društvo koje okuplja članove koji se profesionalno ili amaterski bave nekim od aspekata botaničkih znanosti, ove godine slavi dvadesetu obljetnicu osnutka. Tijekom kontinuiranog rada i postojanja, počevši od 2004. godine, Društvo svake treće godine organizira Hrvatski botanički simpozij s međunarodnim sudjelovanjem. Ovaj skup vremenom je postao središnji događaj na kojem se okupljaju botaničari iz čitave Hrvatske, koristeći ovu priliku za povezivanje, suradnju te razmjenu iskustava i znanja, a tradicionalno ga posjećuju i botaničari iz susjednih zemalja i šire. Sedmi simpozij u nizu održava se u redovitom ritmu, usprkos nezahvalnim vremenima obilježenih epidemijom, potresima, ratovima i nesigurnošću.

S posebnim veseljem želimo Vam izraziti dobrodošlicu u Hotel Dubrovnik u središtu Zagreba, gdje ćete tijekom dvodnevnog programa biti u prilici poslušati 27 predavanja i pogledati 51 postersko priopćenje, koje predstavlja ukupno 209 autora iz 13 europskih zemalja (Hrvatska, Srbija, Finska, Slovenija, Italija, Estonija, Austrija, Bosna i Hercegovina, Crna Gora, Portugal, Slovačka, Španjolska i Švedska). Pritom svima želimo ugodan boravak u Zagrebu i uspješna izlaganja!

Simpozij će ugostiti i okrugli stol na temu „Filogeografija biljaka na Balkanskom polutoku“, biti mjesto predstavljanja dvije botaničke knjige i poprište druženja uz botaničku poeziju. Trećeg dana simpozija pripremili smo postkongresnu ekskurziju u Nacionalnom parku Sjeverni Velebit.

Zahvale upućujemo članovima Organizacijskog i Znanstvenog odbora simpozija, studentima iz tehničke podrške, te sponzorima Dvokut Eco d.o.o., Ministarstvo znanosti i obrazovanja, Hrvatska zaklada za znanost, Alfa d.d., Kala, Cedevita, Montana i Nacionalni park Sjeverni Velebit. Također zahvaljujemo i svim sudionicima te pojedincima koji su se na bilo koji način uključili i podržali ovaj skup i njegovo održavanje.

U ime Organizacijskog i Znanstvenog odbora 7. Hrvatskog botaničkog simpozija,

Vedran Šegota & Nina Vuković

Preface

Croatian Botanical Society, designed as a professional society gathering members dealing with different aspects of botanical sciences in a professional or amateur way, marks its 20th anniversary in 2022. Through its continuous work and existence, every third year starting from 2004 the Society organizes Croatian Botanical Symposium with International Participation. With time, the Symposium became the central event of gathering for Croatian botanists who use this opportunity to connect, collaborate and share experiences and knowledge, visited also by botanists from neighbouring countries and wider. 7th Symposium is held in regular dynamics, despite ungrateful times marked with the epidemic, earthquakes, wars and uncertainties.

With utmost joy we wish to welcome you in Hotel Dubrovnik in the centre of Zagreb, where you will be able to listen to 27 lectures and see 51 poster presented by 209 authors from 13 European countries (Croatia, Serbia, Finland, Slovenia, Italy, Estonia, Austria, Bosnia and Herzegovina, Montenegro, Portugal, Slovakia, Spain and Sweden) during a two-day programme. We wish you all a pleasant stay in Zagreb and successful presentations!

The Symposium will also host a Round Table dealing with phylogeography of plants on the Balkan Peninsula, two book presentations and an evening of botanical poetry. On the third day we prepared the post-congress excursion to National Park Northern Velebit.

We thank the members of the Organizing and Scientific Committees, students from our technical team, and sponsors Dvokut Ecro Ltd., Ministry of Science and Education, Croatian Science Foundation, Alfa Plc., Kala, Cedevita, Montana and National Park Northern Velebit. We extend our thanks to all participants and individuals who were included in any way to support this event and its organization.

On the behalf of the Organizing and Scientific Committees of the 7th Croatian Botanical Symposium,

Vedran Šegota & Nina Vuković

Raspored / Schedule

Ponedjeljak, 12. rujna / Monday, September 12

08:00-09:00 Registracija i postavljanje postera / Registration and poster mounting

09:00-9:30 Svečano otvaranje / Opening ceremony

09:30-11:15 Usmena izlaganja / Oral presentations

11:15-11:30 Pauza za kavu / Coffee break

11:30-12:30 Predstavljanje knjige / Book presentation

12:30-14:30 Pauza za ručak / Lunch break

14:30-16:45 Usmena izlaganja / Oral presentations

16:45-17:00 Pauza za kavu / Coffee break

17:00-18:00 Okrugli stol / Round table

18:00-19:00 Posterska izlaganja / Poster session

Utorak, 13. rujna / Tuesday, September 13

09:00-10:45 Usmena izlaganja / Oral presentations

10:45-11:00 Pauza za kavu / Coffee break

11:00-12:00 Predstavljanje knjige / Book presentation

12:00-14:00 Pauza za ručak / Lunch break

14:00-15:45 Usmena izlaganja / Oral presentations

15:45-16:00 Pauza za kavu / Coffee break

16:00-17:00 Botanical poetry

17:00-18:00 Posterska izlaganja / Poster session

20:30 Gala večera / Gala dinner

Srijeda, 14. rujna / Wednesday, September 14

8:00-19:00 Postkongresna ekskurzija u Nacionalni park Sjeverni Velebit / Post-congress excursion to National Park Northern Velebit

Program / Programme

Ponedjeljak, 12. rujna / Monday, September 12

08:00-09:00 Registracija i postavljanje postera / Registration and poster mounting

09:00-9:30 Svečano otvaranje / Opening ceremony

1. sekcija: BOTANIČKI VRTOVI, ZBIRKE I KNJIŽNICE / 1st Session: BOTANICAL GARDENS, COLLECTIONS AND LIBRERIES

Chairs: Antun Alegro & Igor Poljak

09:30-10:00 **UVODNO PREDAVANJE / KEYNOTE LECTURE:** J. Stojanovski: INNOVATIONS IN SCHOLARLY COMMUNICATION

10:00-10:15 G. Sirotić, T. Nikolić: BIBLIOGRAPHY OF THE CROATIAN FLORA AND VEGETATION - PRELIMINARY REVIEW

10:15-10:30 M. Bučar, V. Šegota, A. Rimac, N. Koletić, T. Marić, A. Alegro: BRYOPHYTES AS ORNAMENTALS IN CROATIAN TRADITIONAL NATIVITY SCENES

10:30-10:45 A. Budisavljević: NEW DATABASE APPLICATIONS IN CROATIA FOR STORING ACCUMULATED BOTANICAL DATA

10:45-11:00 V. Šegota, M. Bučar, A. Budisavljević, D. Dianežević, P. Petković, M. Delač, T. Marić, A. Rimac, A. Alegro: BRYOPHYTE COLLECTION WITHIN HERBARIUM CROATICUM (ZA) SAVED FROM OBLIVION

11:00-11:15 M. Marić, I. Vitasović Kosić: USEFUL GARDENS OF THE ISLAND OF LOKRUM IN THE PERIOD 1859-1873 (DUBROVNIK ARCHIPELAGO)

11:15-11:30 Pauza za kavu / Coffee break

11:30-12:30 Predstavljanje knjige / Book presentation
Toni Nikolić: Osnove botaničke nomenklature

12:30-14:30 – Pauza za ručak / Lunch break

2. sekcija: EVOLUCIJA, TAKSONOMIJA I FILOGENIJA / 2nd Session EVOLUTION, TAXONOMY AND PHYLOGENY

(under the sponsorship of the *AmphiAdriPlant* project)

Chairs: Sandro Bogdanović & Peđa Janačković

14:30-15:00 **UVODNO PREDAVANJE / KEYNOTE LECTURE:** N. Kuzmanović: DIVERSIFICATION PATTERNS IN SILICEOUS ALPINE PLANTS ON THE BALKAN PENINSULA

15:00-15:15 A. Terlević, M. Temunović, S. Bogdanović, I. Rešetnik: THE CHALLENGE OF SUBSPECIES DELIMITATION IN *Dianthus sylvestris* Wulfen s.l. ON THE BALKAN PENINSULA: INTEGRATIVE APPROACH TO TAXONOMY

15:15-15:30 P. Tokić, A. Terlević, I. Ljubičić, I. Rešetnik, S. Bogdanović: MORPHOLOGICAL VARIABILITY OF THE *Dianthus ciliatus* COMPLEX (CARYOPHYLLACEAE) IN THE ADRIATIC REGION

15:30-15:45 B. Prekalj, Z. Šatović, Z. Liber, S. Goreta Ban, D. Ban, S. Bogdanović: GENETIC STRUCTURE AND DIVERSITY OF THE *Brassica incana* L. (BRASSICACEAE) COMPLEX IN THE MEDITERRANEAN

15:45-16:00 K. Tumpa, I. Poljak, Z. Šatović, Z. Liber, A. Vidaković, M. Ježić, M. Ćurković Perica, M. Idžojtić: GENETIC DIVERSITY OF SWEET CHESTNUT (*Castanea sativa* Mill.) POPULATIONS FROM THREE CULTIVATION AREAS IN SUBMEDITERRANEAN CROATIA

16:00-16:15 M. Jug-Dujaković, T. Ninčević Runjić, M. Grdiša, Z. Liber, Z. Šatović: THE STORY OF LAVANDIN (*Lavandula × intermedia* Emeric ex Loisel.) FROM ISLANDS HVAR AND VIS

16:15-16:30 M. Zbiljić, B. Lakušić, N. Kuzmanović, D. Stojanović, D. Lakušić: MORPHOLOGICAL DIVERSIFICATION OF *Teucrium montanum* L. *sensu lato* ON THE BALKAN PENINSULA

16:30-16:45 M. Mucko, M. Temunović, I. Ljubičić, S. Bogdanović, I. Rešetnik: RAD-SEQ IN PLANT PHYLOGEOGRAPHY: CASE STUDY OF *Festuca varia* COMPLEX (POACEAE) ON THE BALKAN PENINSULA

16:45-17:00 Pauza za kavu / Coffee break

17:00-18:00 Okrugli stol / Round table (moderatori / moderators: Ivana Rešetnik, Nevena Kuzmanović & Sandro Bogdanović)

I. Rešetnik: PLANT PHYLOGEOGRAPHY OF THE BALKAN PENINSULA: AN OVERVIEW (predavanje / lecture)

18:00-19:00 Posterska izlaganja / Poster session

Utorak, 13. rujna / Tuesday, September 13

3. sekcija: FLORA I BIOGEOGRAFIJA / 3rd Session FLORA AND BIOGEOGRAPHY

Chairs: Božena Mitić & Nina Vuković

9:00-09:30 **UVODNO PREDAVANJE / KEYNOTE LECTURE:** B. Surina, M. Balant, P. Glasnović, I. Radosavljević, Ž. Fišer, N. Fujs, S. Castro: DO HYBRIDIZATION WITH CLOSE BUT ECOLOGICALLY DIVERGENT RELATIVE AFFECT THE MATING SYSTEM AND TRIGGER THE SELFING SYNDROME IN NARROWLY DISTRIBUTED CHASMOPHYTE?

09:30-09:45 G. Mej, V. Šegota, A. Stinca, J. Vukelić, D. Baričević, M. Orešković, F. Taffetani, A. Alegro: TAXONOMIC AND ECOLOGICAL TRAITS OF *Cystopteris dickieana* R. Sim (Cystopteridaceae), ONE OF THE MOST CRYPTIC FERNS IN THE WORLD, RECENTLY REPORTED ALSO FOR THE BALKAN AREA

09:45-10:00 M. Doboš: HYBRIDS FROM MT. PAPUK – RARE OR NEW TAXA FOR CROATIAN FLORA

10:00-10:15 Z. Mesić, D. Petricioli, S. Kipson, M. Ožura, N. Jantol: NEW LOCALITIES OF THE TREE SPURGE (*Euphorbia dendroides* L.) IN CROATIA

10:15-10:30 E. Horvat, M. Šipek, N. Šajna: URBAN HEDGES FACILITATE SPONTANEOUS WOODY PLANTS AMONG THEM SEVERAL INVASIVE ALIENS

10:30-10:45 V. Šegota, A. Alegro, A. Rimac, S. Dragičević: WHO'S AFRAID OF ALTITUDE? – BRYOPHYTES VS. VASCULAR PLANTS ALONG THE ELEVATIONAL GRADIENTS OF DINARIC ALPS (WESTERN BALKANS)

10:45-11:00 Pauza za kavu / Coffee break

11:00-12:00 Predstavljanje knjige / Book presentation

M. Viculin, M. Randić, Ž. Šatović, D. Dučak, Z. Liber, S. Bogdanović, Z. Šatović:
Tustopizde u izobilju - kurcoglava ni za lijek: Samoniklo jestivo bilje otoka Zlarina

12:00-14:00 Pauza za ručak / Lunch break

4. Sekcija VEGETACIJA I EKOLOGIJA / 4th Session: VEGETATION AND ECOLOGY

Chairs: Vedran Šegota & Nina Šajna

14:00-14:30 **UVODNO PREDAVANJE / KEYNOTE LECTURE:** N. Jogan: ROAD VERGES: EXTREME HABITAT TYPE WITH OFTEN NEGLECTED FLORA

14:30-14:45 M. Šipek, N. Šajna: FOREST EDGE CHARACTERISTICS AFFECT ANCIENT FOREST INDICATOR AND ALIEN PLANT SPECIES DIFFERENTLY

14:45-15:00 Z. Mesić, N. Jantol, V. Kušan, M. Augustinović: TESTING OF THE UNMANNED AERIAL VEHICLE FOR HABITAT AND FLORA MAPPING

15:00-15:15 S. Koivusaari, M. Hällfors, J. Hjort, M.-T. Hyvärinen, A. Kotilainen, M. Levo, M. Laurila, Ø. Opedal, L. Pietikäinen, A. Mattila: THE RELATIONSHIP BETWEEN LAND USE AND VARIATION IN TRAITS FOR THREE *Hypericum* SPECIES

15:15-15:30 D. Šincek, N. Baković, T. Uzelac Obradović, S. Žalac: VALORISATION OF THE GRASSLAND COMMUNITIES OF PLITVICE LAKES NATIONAL PARK AND SELECTED KARST POLJES OF LIKA REGION (CROATIA)

15:30-15:45 A. Alegro, A. Rimac, V. Šegota: MACROPHYTE VEGETATION OF KOPAČKI RIT NATURE PARK

15:45-16:00 Pauza za kavu / Coffee break

16:00- 17:00 Botanical Poetry of Maja Maslač

17:00-18:00 Posterska izlaganja / Poster session

20:30 Gala večera / Gala dinner

Srijeda, 14. rujna / Wednesday, September 14

8:00-19:00 Postkongresna ekskurzija u Nacionalni park Sjeverni Velebit / Post-congress excursion to National Park Northern Velebit



Uvodna predavanja

Keynote lectures

ROAD VERGES: EXTREME HABITAT TYPE WITH OFTEN NEGLECTED FLORA

Jogan N.

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Road verges are extreme ruderal habitat types with strong selection pressure. They represent a narrow belt of heavily compacted, crushed stone spread along paved roads. Plants are mown at least once a month and puddles regularly filled. Salt (or sometimes also rough sand) is used during winter deicing, and long-lasting snow piles remain after snowploughing. All the rain from surfaced area overflows the verge but its structure enables quick drainage, small soil particles and nutrients are washed away. During sunny periods temperatures are extremely high. Traffic causes extreme air turbulence, and occasional trampling, and it also produces pollutants (oil, dust, animal corpses). Light conditions are disturbed during nights by traffic and by street lamps. Due to extreme microecological conditions and changing plant propagule pressure (by traffic and maintenance) species turnover (apophyta vs. neophyta) is high, only a couple of well-adapted species can become dominant and some of them are reported as quickly spreading „highway plants“, among them also halophytes. Floristic interest for such ruderal habitat types is lower in the regions with high natural biodiversity, what will be illustrated. Known distribution patterns for some selected road-verge plants were compared and discussed among five CEE countries (CZ, AT, HU, SI, HR). Selected plants were halophilous species (*Cochlearia danica* L., *Dittrichia graveolens* (L.) Greuter, *Plantago coronopus* L., *Puccinellia distans* (Jacq.) Parl., *Spergularia marina* (L.) Griseb.) and *Ambrosia artemisiifolia* L. We can conclude that flora of the road-verge habitat types is strongly neglected in the Southern parts of Europe and in the future, our focus should go beyond *Ambrosia*.

Keywords: highway plants, road verge, ruderal flora

DIVERSIFICATION PATTERNS IN SILICEOUS ALPINE PLANTS ON THE BALKAN PENINSULA

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The mountain ranges of southern Europe, such as the Pyrenees, the Alps, the Apennines, the Carpathians and the Dinaric Mountains, have long been recognised as important hotspots of genetic diversity and areas of high endemism. The topographic complexity of southern Europe, the varied geotectonic history, and the pronounced climatic fluctuations during the Pleistocene have shaped the disjunct distribution of many European high mountain species at different geographic scales. The Balkan

Peninsula hosts the richest flora in Europe and is the region with relatively high environmental stability over long periods of time and great geographic heterogeneity, being the source for the post-glacial northward range expansion of many different plant groups. This makes the Balkans and adjacent regions an excellent place to study various evolutionary processes. It is well known that the mountain flora of the Balkan Peninsula has strong biogeographical links with the neighbouring mountain ranges, especially the Alps, the Carpathians, and the Apennines. Therefore, the evolution and phylogeography of high mountain plants in the Balkans have been increasingly studied in recent years, with many new taxa described. Using complementary molecular methods and relative genome size measurements, we have elucidated the phylogeography and diversification patterns of several high-mountain plant groups that are predominantly characteristic of siliceous alpine habitats but also inhabit sites on calcareous bedrock.

Keywords: bedrock, high-mountain, phylogeography, Southeast Europe

PLANT PHYLOGEOGRAPHY OF THE BALKAN PENINSULA: AN OVERVIEW

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The Balkan Peninsula is one of the major European biodiversity hotspots and a known major glacial refugium for plant species. Its pronounced environmental heterogeneity coupled with relatively high climatic stability over long periods fostered diversification of lineages and enabled the long-term survival of diverse species. The increasing number of studied plant species in the region using modern molecular techniques has provided significant insights into intraspecific lineages, migration routes and locations of Pleistocene refugia. This presentation summarises the available phylogenetic and phylogeographic studies of plants from the Balkans that have revealed complex patterns in the geographic distribution of genetic diversity and challenged traditional taxonomic concepts. Here we will present the updated overview of the phylogeographical patterns and roles of refugia in structuring genetic diversity and highlight the crucial evolutionary processes that shaped the diversity of plants in the region. Molecular clock-based estimations highlight the importance of Pleistocene climatic fluctuations across taxonomic groups and lineage distribution patterns corroborate the persistence of multiple glacial refugia. Spatial congruencies in phylogeographic splits are found and discussed. An examination of phylogeographic connections with adjacent regions i.e. the Alps, the Apennine Peninsula, Asia Minor, the Carpathians and central Europe, also uncover several consistent patterns. Allopatric and adaptive speciation, polyploidy and hybridization are identified as crucial evolutionary mechanisms acting in the Balkan Peninsula and shaping species diversity. Finally, the scientific challenges are identified and the future research prospects with potential to better understand and conserve unique Balkan

flora are highlighted.

Keywords: evolution, genetic diversity, glacial refugia, phylogeny, taxonomy

INNOVATIONS IN SCHOLARLY COMMUNICATION

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With the greater use of computer technologies and the advent of the Internet and Web, we expected significant applications and changes in the system of scientific communication. Although the transformation of printed journals into their digital/online versions marked the 1990s, it was only the Open Access initiative that initiated innovations in the still very traditional scholarly publishing. The share of Open Access publications is growing, and in 2015, at least 45% of journal articles were openly available. Open Access is achieved by different routes, with diamond/platinum (free to publish, free to use and read) and green (self-archiving in open repositories) under particular momentum recently. In order to solve the reproducibility crisis, the focus of research funders is no longer exclusively on journals and books, but all kinds of research outputs are increasingly being shared, such as methods, protocols, research data, code and more. Thematic, institutional, and repositories that mainly store a specific type of research output, such as preprints and research data, play a major role here. The formal publications have not experienced significant improvements in terms of formats, structure and machine readability, although the preprints are starting a real boom and indicate an essential transition. However, the most significant developments are taking place in the area of research assessment, enabling shifts in the researchers' communication patterns and improving its effectiveness. Following the principles of Open Science will enhance scientific rigour, research quality, integrity and inclusiveness. By abandoning the (mis)use of quantitative bibliometric indicators as an exclusive "measure" of researcher's, institution's, project's success, prestige or quality and converting to multidimensional and more qualitative assessment, the complexity of scientific research will be acknowledged, and the impact on society will be measured. In addition, the evolution of the peer review, with higher transparency of the process, will contribute to scholarly communication innovations.

Keywords: bibliometric indicators, journals, Open Access, scientific communication

DO HYBRIDIZATION WITH CLOSE BUT ECOLOGICALLY DIVERGENT RELATIVE AFFECT THE MATING SYSTEM AND TRIGGER THE SELFING SYNDROME IN NARROWLY DISTRIBUTED CHASMOPHYTE?

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Mating systems are the major determinants of intra- and interspecific genetic structure, but may vary within and between plant populations due to various intrinsic and extrinsic factors that often have confounding effects. The transition from outcrossing to selfing is usually triggered by a reduction in population size, followed by the expression of the selfing syndrome. Recent studies suggest that the mating system may be disrupted in marginal habitats, at the limits of species' distribution ranges, or in areas where evolutionarily closely related species co-occur. Of particular interest was whether populations of an obligate and narrowly distributed chasmophyte that inhabits extreme, albeit homogeneous and undisturbed, habitats exhibit characteristics of the selfing syndrome and whether co-occurrence with closely related but ecologically divergent species might affect its mating system. A study model represents all known populations of *Moehringia tommasinii* Marches. (Caryophyllaceae), a narrow endemic chasmophyte in the north-western Adriatic, and a few populations of co-occurring *M. muscosa* L., an ecologically divergent relative with overlapping flowering period. To study the mating systems of each population of *M. tommasinii*, we performed common garden experiments with reciprocal crosses within and between taxa and used molecular markers to assess the population genetic structure and gene flow within and among populations and taxa. Using coefficient of inbreeding, outcrossing rate, population size, seed weight, pollen-to-ovule ratio and floral display size, we looked for evidence of selfing syndrome. Surprisingly high variation in mating systems among populations was revealed, indicating either marked inbreeding or outbreeding depression. Results from controlled hand pollination studies and estimates of pollen-to-ovule ratios suggest that *Moehringia tommasinii* prefers allogamy over autogamy. Populations were genetically structured, suggesting low gene flow among populations. Population size was strongly negatively correlated with inbreeding, while lighter seeds, lower pollen production, and smaller floral display in smaller populations indicated a pronounced selfing syndrome. At a site where *M. tommasinii* and *M. muscosa* closely co-occur, an overall distinct pattern of fruit production in *M. tommasinii* was observed following different pollination treatments. Here, molecular and morphometric data showed evidence of reciprocal hybridization followed by almost complete introgression towards *M. muscosa*.

Keywords: Caryophyllaceae, gene flow, *Moehringia*, pollination biology, species barriers



Usmena izlaganja

Oral presentations

MACROPHYTE VEGETATION OF KOPAČKI RIT NATURE PARK (EASTERN CROATIA)

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Kopački rit is situated in eastern Croatia, northwest of the confluence of the Drava and the Danube, and it is one of the largest and most important fluvial-wetland areas in Europe. It was founded in 1973 as an Ornithological Reserve and in 1993 designated as Nature Park comprising the surface of 177 km². According to the „flood pulse concept“ flood areas are defined as aquatic/terrestrial transit zones where flood dynamic is the main factor shaping habitats and communities. In order to study diversity, composition and conditionality of macrophyte communities we have conducted research during three years on 15 preselected localities with different flood regimes. Regarding the vegetation, the researched localities can be divided into two groups, those with very lush macrophytic vegetation and those without or with very scarce vegetation, where the absence of direct influence of the flood waters of the Danube is the main factor enabling development of the macrophytic vegetation. The vegetation is developed in the area inside the main dyke, in very slow flowing or almost stagnant waters with moderate water level fluctuations. The vegetation belongs mainly to free-floating communities of the class *Lemnetea* intermixed with fragments of the rooted floating or submerged macrophytes from the class *Potametea*. The most widespread order belonging to the first class is *Hydrocharition morsus-ranae* with number of species as *Hydrocharis morsus-ranae*, *Lemna minor*, *L. trisulca*, *L. minuta*, *Wolffia arrhiza*, *Spirodella polyrrhiza*, *Utricularia vulgaris* and ferns *Salvinia natans* and *Azolla filiculoides*. Representatives of rooted vegetation are *Nymphoides peltata*, *Nuphar lutea* and *Nymphaea alba*. Omnipresent is *Ceratophyllum demersum*. Considering occupied surfaces and populations sizes, Kopački rit is the largest and richest area in Croatia with macrophyte vegetation of shallow, eutrophic, slow flowing or stagnant waters. However, severe droughts in last years have negative influence on these habitats and its vegetation.

Keywords: Danube floodplain, *Lemnetea*, Pannonian ecoregion, *Potametea*, wetland

BRYOPHYTES AS ORNAMENTALS IN CROATIAN TRADITIONAL NATIVITY SCENES

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Traditional Christmas nativity scenes (manger scenes, nativity sets) depicting the birth of Christ are commonly decorated with both vascular plants and bryophytes. Although the tradition of using bryophytes as ornamentals in nativity scenes is widespread and found in many countries (a long tradition in Croatia dates back to

the 17th century), there are almost no comprehensive studies of bryophyte diversity engaged in this tradition. The aim of this study was to document the diversity of decorative bryophytes sold during the Advent season at farmers' markets in Croatia (Southeastern Europe). Twenty-eight farmers' markets in the two largest Croatian cities (Zagreb and Split) were studied in the search for local vendors selling bryophytes during the pre-Christmas season. Among 275 collected specimens, 43 moss and four liverwort species were identified. The most frequent species were *Hypnum cupressiforme*, *Homalothecium sericeum* and *Ctenidium molluscum*. Mats, wefts and tufts were the most common life-forms, while pleurocarpous prevailed over acrocarpous mosses, as they are usually pinnately branched and form large carpets, suitable for decorations. The overall selection of bryophytes and the decorations made of them were more diverse and abundant in Zagreb, where 49 vendors at 15 farmers' markets sold 43 species. In Split, at six farmers' markets only 29 vendors sold 18 species. A significant number of species (all liverworts, most acrocarpous mosses and some pleurocarpous), which are less attractive to harvesters, was collected non-intentionally, entangled in carpets of other, more frequent species. Among them, *Rhodobryum ontariense* and *Loeskeobryum brevirostre* are rare and insufficiently recorded in Croatia so far. The present study provided a first perspective on the use of bryophytes in traditional nativity scenes in Croatia and Southeastern Europe, contributing to scarce ethnobotanical documentation of the decorative use of bryophytes in Christmas festivities in Europe and globally.

Keywords: Christmas, ethnobryology, farmers' market, mosses

NEW DATABASE APPLICATIONS IN CROATIA FOR STORING ACCUMULATED BOTANICAL DATA

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Modern research methods and data collection in biology can rapidly produce a very large amount of data, especially if the data is accumulated over several years. Botanists from the Faculty of Science at the University of Zagreb had such instances of large, complex and interconnected data sets where common spreadsheets become insufficient to provide an adequate working environment. As a solution to these problems, two comprehensive web-based database applications were created during the years 2019-2022, each custom-tailored and developed for specific biological data. VRBA (acronym from "*Vrtna baza*" meaning the Garden's database") is a computing environment for plant collection management of the Botanical garden of the Faculty of Science, while ACRO (acronym from "*Aqua Croatica*") is focused on the analysis and storage of the data on macrophytes collected for the purpose of monitoring of the Croatian water bodies. The two databases were developed on the XAMPP open-source cross-platform software stack and they are compatible with both stationary and portable devices. The front-end development was coded in HTML, CSS, and JavaScript with the utilization of the Bootstrap and AdminLTE frameworks. The back-end part of the software was coded with PHP and MySQL (MariaDB). PhpMyAdmin was utilized for administration purposes. Various open-source libraries were deployed with the most prominent ones being: jQuery, LeafletJS, DataTables, D3.js, Select2, and

Font Awesome. Specifically, for VRBA, the custom raster layer for geospatial data was drawn using QGIS 3.24. As of 2022, both databases are fully functional and integrated into the business and research practices.

Keywords: bioinformatics, biomonitoring, data analysis, data storage

HYBRIDS FROM MT. PAPUK – RARE OR NEW TAXA FOR CROATIAN FLORA

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Flora of Mt. Papuk (eastern Croatia) is relatively well known, but there are still surprises left. During recent field studies, several rare hybrids were found in the area, most of them recorded for the first time in Croatia. Although both *Primula vulgaris* Huds. and *P. veris* L. are quite abundant in the area, their hybrid *Primula* × *polyantha* Mill. was spotted in 2020 for the first time. Morphologically exactly intermediate between the parent plants, this plant is easy to recognize and seems quite common because it was found on eight spots. Orchids are also quite famous for hybridization, with hybrid taxa even between the genera, but they are poorly investigated on Papuk. A single specimen of *Orchis* × *angusticruris* Franch., a hybrid between *O. simia* Lam. and *O. purpurea* Huds., was spotted in 2020 near Slatinski Drenovac. Flowering periods of the parental species are barely overlapping so this taxon is probably quite rare elsewhere. *O. simia* is a parent to another hybrid, *Orchis* × *beyrichii* (Rchb.f.) A.Kern, together with *O. militaris* L. This taxon was also recorded as a single specimen on Poljanice above Velika in 2022. Another rare or overlooked hybrid found on Poljanice is *Ophrys* × *hybrida* Pokorny ex Rchb.f., a cross between *O. sphegodes* Mill. and *O. insectifera* L., both abundant species on the same site.

Keywords: hybridization, orchids, Papuk Nature Park

URBAN HEDGES FACILITATE SPONTANEOUS WOODY PLANTS AMONG THEM SEVERAL INVASIVE ALIENS

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Majority of trees and other woody plants growing within urban areas are deliberately planted plants of native or alien origin, whereby alien woody plants are preferred over native ones for ornamental plantings. Parks, gardens, and hedges represent hotspots for woody plants. Opportunities for spontaneous establishment and spread of woody species are scarce in an urban environment, especially if the establishment begins from seeds. We hypothesized that urban hedges may offer safe sites for the establishment of woody plants, which are not planted and reach the hedges with seed dispersal. First, we recorded the presence of planted and spontaneously occurring woody plants

in the urban hedges in the city of Maribor, Slovenia. We evaluated species' invasion potential and ecological requirements. Further on, we studied the relationships between the recorded species richness and composition with hedge characteristics. Here we present results that 102 studied urban hedges facilitated survival and growth of 70 woody plants, belonging to 29 families. Among them, 44 (63%) were alien and 7 (10%) were locally invasive. The two most represented genera were native *Hedera* and *Acer* recorded in 74 (73%) and 54 hedges (53%), respectively. Characteristics of hedges affected richness and composition of spontaneously occurring woody plants, while the hedge forming species had no effect. Our results confirm a general problem that planted ornamental plants represent a source of plant invasions since 95% of recorded alien woody plants were ornamental.

Keywords: invasion source, ornamental plants, plant establishment, urban habitat

THE STORY OF LAVANDIN (*Lavandula × intermedia* Emeric ex Loisel.) FROM ISLANDS HVAR AND VIS

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Lavandin is an iconic plant of Island Hvar, Croatia, where it has been cultivated for decades and gradually brought prosperity to the Island. A story among local inhabitants says that it was brought from Island Vis a century ago. We investigated lavandin landraces from islands Hvar and Vis using Amplified Fragment Length Polymorphism (AFLP) markers. Two well-known cultivars of lavandin ('Grosso' and 'Abrialis') and the parental species (*Lavandula angustifolia* Mill. and *L. latifolia* Medik.) were also included in the analysis. Our assumption was that we were investigating two landraces, but the Neighbor-Joining (NJ) cluster analysis revealed another one. The existence of three landraces was further confirmed by the analysis of genetic structure using BAPS and STRUCTURE softwares. The three detected landraces were 'Bila', 'Budrovka' and 'Budrovka Sveti Nikola'. Our results suggest that 'Bila' and 'Budrovka Sveti Nikola' are polyclonal landraces originating from different hybridization events. Detected intra-cultivar variability could be attributed to the accumulation of somatic mutations.

Keywords: 'Bila', 'Budrovka', inter-cultivar variability, intra-cultivar variability, traditional cultivars

THE RELATIONSHIP BETWEEN LAND USE AND VARIATION IN TRAITS FOR THREE *Hypericum* SPECIES

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Environmental change forces species to adjust to new conditions. For successful adjustment however, sufficient phenotypic variation underpinned by phenotypic plasticity and genetic variation must exist within populations. To estimate the abilities of species to cope with change, we need to understand processes that reduce or enhance such variation. Land use is known to affect variation within populations, with increased human land use often leading to reduced population size, increased isolation, and subsequently reduced genetic variation. In this study, we test the effect of land use patterns on the variation of phenotypic traits and their plasticity across the European ranges of three *Hypericum* species, *H. perforatum*, *H. maculatum* and *H. montanum*. Seeds from 23 natural populations of the three species were germinated and grown in four temperature treatments in greenhouse compartments. The seeds were collected from the core, leading and trailing edges of the distribution areas for each species. To date, data on vegetative traits and flowering phenology has been collected, and data on floral traits is currently being collected. Land use variables were extracted from the CORINE Land Cover 2018 data. We expected to see less variation in populations surrounded by more fragmented landscapes, and that this relationship would be stronger for the rarer species *H. montanum*. Preliminary results suggest differences between the three distribution areas in the variance of traits. Here, we present results on variance for multiple traits and their connection to land use characteristics of the landscape surrounding the original populations.

Keywords: adaptation, global change, habitat fragmentation, habitat loss, thermal plasticity

USEFUL GARDENS OF THE ISLAND OF LOKRUM IN THE PERIOD 1859-1873 (DUBROVNIK ARCHIPELAGO)

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Horticulture in the 19th century was marked by great progress in terms of advanced technologies of heated greenhouses that allowed the cultivation and propagation of allochthonous or exotic ornamental species, but also vegetable and fruit crops for which there was great interest at the time, as a result of the physiocratic idea earlier in the 18th century. The aim of this research is to make an inventory of useful horticultural taxa that were grown on the island of Lokrum during the reign of Archduke, later Mexican Emperor Ferdinand Maximilian Habsburg (1832-1867), within the ornamental Lokrum gardens that are protected as a special reserve of forest vegetation. The method of research of original archival documents (written and graphic) was used. A total of 36 fruit taxa were inventoried, out of which 13 were autochthonous and 23 allochthonous (out of which nine allochthonous vegetable crops and cereals). Maximilian applied the concept of “usefulness and comfort” in Lokrum gardens, according to the *ferme ornée* concept. His idea was to grow a culture of *Saccharum* × *sinense* on Lokrum. The fruit crops introduced for the first time in this part of the Adriatic are: *Ananas comosus*, *Musa* × *paradisiaca*, *Musa acuminata* and *Citrus reticulata* ‘Avana’. As early as in 1863, a large plantation of *Solanum tuberosum* and *Fagopyrum esculentum* was planted on Lokrum, an olive grove with five autochthonous varieties and a vineyard with a variety of Malvasia from Madeira, *Vitis vinifera* ‘Malvasia Fina’. This research of Maximilian’s useful gardens can serve as a starting point for the restoration process that awaits these gardens.

Keywords: cultivated species, *ferme ornées*, fruit species, *Saccharum* × *sinense*, vegetable crops

TAXONOMIC AND ECOLOGICAL TRAITS OF *Cystopteris dickieana* R. Sim (CYSTOPTERIDACEAE), ONE OF THE MOST CRYPTIC FERNS IN THE WORLD, RECENTLY REPORTED ALSO FOR THE BALKAN AREA

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Cystopteris dickieana R. Sim (*Cystopteridaceae*) is a circum-holarctic species that grows in rock crevices. Despite its wide distribution range, its presence within this geographical area is highly sporadic and rare. Furthermore, due to the difficulty of distinguishing it within the complex of *C. fragilis* (L.) Bernh. species, its worldwide distribution and ecology are not yet well known and are the subject of numerous studies. For these reasons, the species is to date considered one of the rarest and most cryptic species belonging to the genus *Cystopteris*. In Balkans, the presence of four species belonging to this genus (*C. alpine* (Lam.) Desv.; *C. dickieana*; *C. fragilis*; *C. montana* (Lam.) Desv.) was reported. Consequentially, the recent discovery of *C. dickieana* in the surroundings of the settlement of Sveti Rok (southern Mt Velebit, Croatia) is the first for this part of Europe. The purpose of this work, based on bibliography, herbarium and field research, is to highlight the differences between the different taxa in terms of taxonomic traits and ecological characteristics so as to favour the recognition of *C. dickieana* as a function of morphological characteristics and outline the ecological peculiarities. Some notes on the environment in which the species was found, new taxonomic details and ecological data, and identification key for the different taxa are presented.

Keywords: *Cystopteris fragilis* complex, ecological differentiation, neglected species, pteridophytes, spore morphology

TESTING OF THE UNMANNED AERIAL VEHICLE FOR HABITAT AND FLORA MAPPING

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The unmanned aerial vehicles (drones) are helpful equipment in the habitat and species mapping. Drones equipped with multispectral cameras can provide acquisition of scenes with resolution of less than a centimeter. The use of common (visible spectrum) camera that most of the drones are equipped with, could be useful in mapping of places that are difficult to reach by a researcher. It has been noted on several occasions that mapping habitat types in a specific (flowering, senescence etc.) phenophase of either dominant or differential species could significantly enhance the accuracy of habitat mapping. This method was implemented in the mapping of the habitat type 5330 Thermo-Mediterranean and pre-desert scrub (on islands Sušac, Palagruža, Jabuka, Dugi otok, Kornati, Lastovo and Iž) and 1420 Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) on the Mirna River mouth and on island Zeče, and was shown useful for mapping this type of habitat. In the summer of 2021, the usefulness of drone was tested in the survey of different type of habitat, calcareous rocky slopes with chasmophytic vegetation in Istria. The

identification and mapping of species in such vertically distributed habitats could be problematic because high resolution image is required to detect all necessary details for plant identification. Additionally, following technical problems are detected: need for very precise piloting skills, change of wind speed on different parts of the cliffs, problems with finding take off place and place for piloting, as well as problem with parallax if the take off (starting) point is remote from the observed object.

Keywords: biodiversity monitoring, drone, mapping Natura 2000 habitat type

NEW LOCALITIES OF THE TREE SPURGE (*Euphorbia dendroides* L.) IN CROATIA

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In spring 2022 we have carried out a survey of the localities of *Euphorbia dendroides* L. in Croatia, during a project of mapping of the habitat type 5330 (Thermo-Mediterranean and pre-desert scrub), listed in Annex I of the EU Habitats Directive, in Croatia defined as habitat (sub-) type with the typical species *E. dendroides*. We checked previously recorded localities of *E. dendroides* on the islands of Palagruža, Sušac, Svetac, Lastovo, Jabuka, Dugi Otok and Kornati. Almost all of the previous records were confirmed. Only historical record on the island of Lastovo in Skrivena Luka was not confirmed, while the record in Uvala Sokoline was confirmed. Two new localities of *E. dendroides* were recorded during our survey. The first locality was found near Dugo polje on Dugi Otok island (Telašćica Nature Park). The second locality was recorded in the southern part of the Iž island, on the Cape Parda. Both localities were mapped with the unmanned aerial vehicle (drone). The record on the Iž island presents the northernmost recent record of the tree spurge in Croatia.

Keywords: drone, habitat mapping, habitat type 5330, Natura 2000, unmanned aerial vehicle

RAD-SEQ IN PLANT PHYLOGEOGRAPHY: CASE STUDY OF *Festuca varia* COMPLEX (POACEAE) ON THE BALKAN PENINSULA

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High-throughput, restriction site-associated DNA sequencing (RAD-seq) is widely used for research in fields of population genetics (e.g. for calculations of genetic diversity, distance and structure) and phylogenomics (integrative evolution and genomic analyses on next-generation sequencing data) which combined with spatial spans of investigated populations can provide valuable insights into their phylogeographic patterns. Originally RAD-seq was used to untangle complex infraspecific relationships (among populations of the same species), but nowadays is often used to elucidate interspecific relationships within recently derived phylogenetic groups. Here we present the overview of the original RAD-seq methodology implemented in our research with comprehensive subsequent bioinformatic analyses, pipelines and programs used. Important findings of different analysed short nucleotide polymorphisms (SNP) datasets are shown through most recent and comprehensive published articles dealing with plant species from various genera (e.g. *Aurinia*, *Dianthus*, *Euphorbia* and *Helleborus*), all conducted in south-eastern Europe. Additionally, our preliminary results from 17 sequenced populations within *F. varia* complex from the Balkan and the Apennine Peninsulas and Alps are presented.

Keywords: bioinformatics, *Festuca*, phylogenomics, phylogeography, RAD-seq

GENETIC STRUCTURE AND DIVERSITY OF THE *Brassica incana* L. (BRASSICACEAE) COMPLEX IN THE MEDITERRANEAN

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The species of the *Brassica incana* L. complex are mainly found in the coastal habitats and cliffs of the central Mediterranean. Several authors have recognized three endemic species from Croatia (*B. botteri* Vis., *B. cazzae* Ginzb. & Teyb. and *B. mollis* Vis.) and one endemic *B. raimondoi* from Sicily, classified based on differences in silique characteristics. According to some other authors, these endemic *Brassica* species are treated as synonyms or at subspecific level of *B. incana*. The taxonomic position of these species within the *B. incana* complex has not been studied from a genetic point of view. Therefore, the aim of this study was to determine the genetic diversity and structure of the species included in the *B. incana* complex and to identify the genetic relationships among populations. A total of 23 populations was collected in Italy, Croatia, Albania and Greece. Genetic diversity and relationships among and within the studied populations were determined using the Amplified Fragment Length Polymorphism (AFLP) method, and morphological diversity was determined based on silique traits (number of seeds per silique, silique length and width, petiole and beak length). Analysis of molecular variance (AMOVA) revealed higher genetic diversity among populations (58.59%) compared to within population diversity (41.61%). Differentiation of populations followed a geographic pattern according to

STRUCTURE and BAPS analysis. The neighbor-joining tree divided the populations of the *B. incana* complex into two main groups: the Apennine-Sicilian-Adriatic clade, corresponding to the typical *B. incana* (including *B. raimondoi*), and the central Adriatic clade, corresponding to the *B. botteri* clade. A genetic study revealed that the Croatian population from the island of Koločep (previously attributed to *B. mollis*) is indeed *B. incana*. The Italian populations from the Tremiti Islands and the Mt. Gargano, which were referred as *B. incana*, are actually *B. botteri*, as are the other Croatian populations of *B. mollis* from the Korčula archipelago and *B. cazzae* from the island of Sušac.

Keywords: AFLP, *Brassica incana*, genetic diversity, taxonomy

BIBLIOGRAPHY OF THE CROATIAN FLORA AND VEGETATION – PRELIMINARY REVIEW

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Over time, numerous works by domestic and foreign botanists have been published on Croatian flora and vegetation, but an extensive bibliography has not yet been prepared. Previous attempts of presenting the history of botanical research in Croatia had limited extent and were focused either on particular geographical areas or on the specific taxonomic groups. The aim of our research was to sort out the literature data and make a comprehensive overview of publications relevant to Croatian flora and vegetation published from the beginnings to the present day. The bibliographic material used as a basis was the Flora Croatica Database bibliography (<https://hirc.botanic.hr/fcd/biblio/>), which was revised and supplemented with new bibliographic units. The titles cover literature dealing with vascular plants and mosses relating to the territory of the Republic of Croatia. Publications in the field of floristic, taxonomic, phytogeographical and phytosociological research are included, while some other disciplines (ecology, morphology, cytology, fitochemistry etc.) are listed only if they contain data relevant to the flora. In addition to the autochthonous flora, some basic data on horticultural and agricultural plants are also included. Up to now, the bibliography comprises over 6000 units in forms of books, proceedings, serials, dissertations and manuscripts arranged alphabetically and chronologically according to authors and year. Errors, some of which persisted for generations were discovered and many new titles were added. The intention is to publish the bibliography in electronic as well as in edited and indexed printed form. This bibliography is intended to be a useful source for obtaining reliable literature information for botanists, professionals or amateurs, as well as for students and all others interested to study the Croatian flora.

Keywords: botanical literature, Croatia, vascular plants

WHO'S AFRAID OF ALTITUDE? – BRYOPHYTES VS. VASCULAR PLANTS ALONG THE ELEVATIONAL GRADIENTS OF DINARIC ALPS (WESTERN BALKANS)

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Species composition and species richness along the altitudinal gradients have been a topic of interest in biogeography and ecology for a long time. Comparison of different taxonomic groups along the same elevational gradients are extremely rare globally. A comparative study of the altitudinal distribution of bryophytes and vascular plants on littoral Dinarides was conducted along two complete, about 1600 m long elevational transects in Gorski Kotar and Velebit, embracing eight discrete forest elevational belts. Both taxonomic groups showed similar patterns of alpha diversity, best described by the cubic regression function with diversity maxima approximately between 1100 and 1200 m a.s.l. The total number of taxa of vascular plants and bryophytes is the lowest in the lowest belt of holm oak, and the highest in the complex of spruce communities. Vascular plants exhibit the highest species turnover (beta diversity) on the border of two phytogeographical regions, while the most prominent species turnover of bryophytes appears with evergreen boreal (spruce) and subalpine (pine krummholz) vegetation types. Bryophytes exhibit wider altitudinal ranges and a greater tendency toward exclusively higher elevations compared to vascular plants. Neither vascular plants nor bryophytes follow Rapoport's rule of increment of the average altitudinal range of species with increasing elevation. Flora assemblages along the altitudinal gradients are ecologically primarily defined by gradients of climatic indicator values (temperature and humidity) for both taxonomic groups, while bryophyte assemblages are additionally defined by gradients of substrate characteristics (nitrogen amount and pH reaction). The indicator values for bryophytes exhibit weaker indicator potential in explaining floristic composition compared to indicator values for vascular plants, which proves that these two groups only partially describe the same ecological gradients. This research is one of the few studies of the altitudinal distribution of bryophytes in Europe and the first in the Dinaric Alps and the Balkan Peninsula.

Keywords: Croatia, diversity, Gorski Kotar, richness, Velebit

BRYOPHYTE COLLECTION WITHIN *HERBARIUM CROATICUM* (ZA) SAVED FROM OBLIVION

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World herbaria with over 390 million specimens are being rapidly digitised, providing easy and flexible on-line access to herbarium data. The digitalization of the largest and the oldest Croatian herbarium collection *Herbarium Croaticum* (ZA) started in 2015 and is continuously done through the Flora Croatica Database and *Herbarium Croaticum Virtual herbarium* web interface. So far, this process was entirely focused on vascular plants, while little was known about its bryophyte collection other than from available literature. In the last few years all bryophyte specimens within the collection were systemized and digitised and their nomenclature was updated. The collection keeps around 12000 specimens belonging to as many as 1177 taxa from 408 genera. The same number is estimated for unidentified bryophyte specimens within ZA collection. The most numerous genera are *Sphagnum*, *Rhynchostegium* and *Cinclidotus*, while the most frequent taxa are *Hypnum cupressiforme* Hedw., *Rhynchostegium riparioides* (Hedw.) Cardot, *Tortella tortuosa* (Hedw.) Limpr. and *Cratoneuron filicinum* (Hedw.) Spruce. The digitalization process revealed two new bryophyte species for Croatia – *Hylocomiastrum umbratum* (Ehrh. ex Hedw.) M. Fleisch. and *Timmia barbulooides* (Brid.) Mönk, hidden for decades within the collection. The oldest specimen dates back to 1828. The majority of the collection was accumulated in the first two decades of 20th century (25%) and in the recent 12 years (50%). The collection covers seven continents and Pacific islands, with predomination of European specimens (96.3%). Within Europe, Croatia is the most represented (64.0%) followed by Czech Republic, Austria, Germany, Poland, Hungary, Montenegro and Slovenia. The majority of Asian specimens originate from China, Indonesia and Japan, while USA and Brazil stand out among specimens from Americas. Among as many as 450 collectors, the most fruitful older ones were I. Horvat (8.7%), J. Podpera (5.8%) and Lj. Rossi (5.1%), while predomination of recent contributors V. Šegota (21.2%) and A. Alegro (13.1%) is evident.

Keywords: collection, Croatia, digitalization, herbaria, specimens

VALORISATION OF THE GRASSLAND COMMUNITIES OF PLITVICE LAKES NATIONAL PARK AND SELECTED KARST POLJES OF LIKA REGION (CROATIA)

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Grassland communities in the Lika region are under significant distress in recent decades due to the changes in land use, specifically land abandonment. The understanding of these processes is of high interest for protected areas, Natura 2000 sites, as well as for long term planning of agricultural development of the Lika region. The aim of this study was to collect new data on grassland communities and selected non-grassland habitats, their valorisation and conservation, recognition of present

trends, and the possibilities of future agricultural development of the region. The study was conducted from March to September of 2021 dominantly on grasslands (83 plots), but also on several heaths (12 plots), bogs (4 plots), and helocrene spring (1 plot). During the study nine grassland associations belonging to dry, mesic, and wet grassland types were recorded, together with associations of transitional and acidophilic bogs and one heath association. Among the 663 recorded taxa, 84 are listed in the Red Book of vascular plants and/or are under legal protection in Croatia. Detected changes at researched sites were caused by local intensification of mowing and use as pastures due to national agricultural incentives. Still, land abandonment was identified as the greatest threat to the conservation of grasslands. Valorisation of these sites, regarding their compatibility for the future agricultural development, showed high potential but also highlighted the need for the careful planning in accordance with the carrying capacity of individual sites. This study contributed to the knowledge on the current state of the grasslands in the Lika region and represent an adequate baseline for future strategic planning and conservation efforts.

Keywords: agricultural development, endangered plants, grassland abandonment, national agricultural incentives, Natura 2000 sites

FOREST EDGE CHARACTERISTICS AFFECT ANCIENT FOREST INDICATOR AND ALIEN PLANT SPECIES DIFFERENTLY

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Forest fragments (FF) in agricultural or urban matrix are important biodiversity refugia. However, their conservation is of major concern. Forest edges adjacent to arable fields and settlements are pruned to various extent (simplified) to prevent spreading of forest vegetation. Simplification of edges lead to reduction of their barrier function thus FF become more susceptible to disturbances from the surrounding landscape. We studied effect of FF edge characteristics (exposition, structure and adjacent land use) on ecologically important plant groups: forest specialist, representing ancient forest indicator plants (AFI) and (invasive) alien plant species, indicating preservation and ecosystem degradation, respectively. The study included 48 lowland FF in NE Slovenia, differing in edge characteristics. Vegetation was surveyed in plots, arranged in transect from the northern edge through the forest interior to the southern edge. Results revealed that the forest edge characteristics differently affected studied plant groups. AFI richness was affected only by exposition but not by structure of the edge or adjacent land use. The highest richness of AFI was in forest interior, following by northern edge. On the other hand, (invasive) alien plant richness was the highest on southern edges, following by northern edge. Our results confirmed general ecological preferences of alien plant species, which prefer warmer, lighter and nutrient richer sites. On the other hand, AFI did not respond to nutrients but were affected by light conditions and soil moisture. Our results indicate that FF edge characteristics determine plant species composition quality in terms of AFI and (invasive) alien plants species.

Keywords: adjacent land use, degradation, edge structure, invasion, preservation

THE CHALLENGE OF SUBSPECIES DELIMITATION IN *Dianthus sylvestris* Wulfen s. I. ON THE BALKAN PENINSULA: INTEGRATIVE APPROACH TO TAXONOMY

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Balkan Peninsula is one of the diversity centres for the morphologically highly variable and taxonomically inconsistently treated *Dianthus sylvestris* Wulfen. The current taxonomic concept provided in the Flora Europaea is based on names published by Hayek in 1924. One of the overall aims of our comprehensive study combining phylogeographic methods (RADseq), morphometry, environmental niche analyses and genome size estimates, is to explore the intraspecific relationships within the Balkan populations of *D. sylvestris*, and to provide the revised taxonomy. Our results suggest two morphological entities, the north-western and the south-eastern group of populations, distinct by the epicalyx scales shape, calyx length and petal denticulation. These entities correspond to the two identified genetic clusters, with the split occurring around the Neretva River valley. The genetic structure does not support current taxonomy, except for *D. sylvestris* subsp. *tergestinus* (Rchb.) Hayek. Given that the type specimen of *D. sylvestris* subsp. *nodosus* (Tausch) Hayek is not known, and its diagnostic character, puberulent lower part of the stem, turned out to be variable within the population level, we suggest leaving this form of variability within *D. sylvestris* s.l. without taxonomic designation. The holotypes of two south Balkan subspecies, *D. sylvestris* subsp. *alboroseus* F.K. Mey. and *D. sylvestris* subsp. *kozjakensis* Micevski, are highly similar and based on our results they belong in the same morphometric and genetic clusters. Several populations from the south-eastern group show morphologically intermediate forms between *D. sylvestris* subsp. *alboroseus* and *D. sylvestris* subsp. *bertisceus* Rech. f. and cannot be clearly assigned to subspecies. Finally, *D. sylvestris* subsp. *bertisceus* showed the greatest genetic admixture, as well as problematic morphological distinction, especially when populations from the Alps are considered.

Keywords: Balkan Peninsula, morphometrics, over-splitting, taxonomy

MORPHOLOGICAL VARIABILITY OF THE *Dianthus ciliatus* COMPLEX (CARYOPHYLLACEAE) IN THE ADRIATIC REGION

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The *Dianthus ciliatus* complex has three morphologically very similar subspecies that are geographically well defined in the Adriatic region. The nominal subspecies *D. ciliatus* subsp. *ciliatus* occurs in northern and central Adriatic and in central Italy, while *D. ciliatus* subsp. *dalmaticus* (Čelak.) Hayek is endemic to southern Adriatic and *D. ciliatus* subsp. *medunensis* (Beck et Szyszyl.) Trinajstić is endemic to Montenegro and Albania. Because of previously unclear morphological distinctions and due to the overlapping of morphological characters, it was not possible to define the subspecies unambiguously. A morphometric analysis was performed on the collected herbarium materials of the three subspecies, in total including 66 individuals from 22 populations across the Adriatic region (11 populations of *D. ciliatus* subsp. *ciliatus*, seven populations of *D. ciliatus* subsp. *dalmaticus*, and four populations of *D. ciliatus* subsp. *medunensis*). Seventeen quantitative and five qualitative morphological characters were analysed. Descriptive and multivariate statistics were performed, and seven morphological characters that describe the size and shape of epicalyx scales had statistically significant differences among subspecies. Those seven characters (epicalyx height, outer second scale width and length, outer first scale width and length, inner scale length and apex length of first outer scale) can be used to better distinguish between *D. ciliatus* subsp. *ciliatus* and the other two subspecies. *Dianthus ciliatus* subsp. *dalmaticus* and *D. ciliatus* subsp. *medunensis* can also be distinguished on the basis of petal colour and petal denticulation. Based on this morphometric analysis, an identification key for the subspecies of *D. ciliatus* complex was given, and a taxonomic revision of herbarium specimens from CNHM, ZA, ZAGR and ZAHO was also performed.

Keywords: amphi-Adriatic species, Balkan, *Dianthus*, endemics, morphometry

GENETIC DIVERSITY OF SWEET CHESTNUT (*Castanea sativa* Mill.) POPULATIONS FROM THREE CULTIVATION AREAS IN SUBMEDITERRANEAN CROATIA

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Sweet chestnut (*Castanea sativa* Mill.) has been cultivated in semi-wild orchards of Sub-Mediterranean Croatia for centuries. Two such historical cultivation areas are Lovran and Lovrin on the Istrian peninsula, while the third one is located on the island Cres. From these three cultivation areas, both grafted and ungrafted individual trees were sampled. Six genomic simple sequence repeat (gSSR) and nine EST-derived SSR

(EST-SSR) loci were used to explore population diversity and clonality, as well as the population genetic structure. Five closely related clones have been found within the grafted group. Within the ungrafted group, many hybrids resulting from spontaneous cross-pollination between the cultivated and wild chestnuts have been found. Thus, the three analyzed populations have varying levels of diversity and clonality. The analyzed semi-wild orchards defined by a diverse genetic structure represent a hotspot for further selection and could result in the creation of locally adapted, high-yielding varieties of chestnuts.

Keywords: microsatellites, population structure, semi-wild orchards, sweet chestnut, traditional varieties

MORPHOLOGICAL DIVERSIFICATION OF *Teucrium montanum* L. *sensu lato* ON THE BALKAN PENINSULA

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Teucrium montanum L. is a semi-woody evergreen small shrub distributed in southern and central Europe, Asia Minor, and Algeria in North Africa. The species has a very wide ecological valence occurring in various Mediterranean, sub-Mediterranean, continental as well as oro-Mediterranean and Alpine habitats. Due to its wide ecological valence and broad distribution, *T. montanum* displays high morphological variability, which is reflected in a large number of described taxa associated with it. In Europe, about thirty taxa have been described at specific and infraspecific levels, of which only *T. montanum* subsp. *montanum* and *T. montanum* subsp. *helianthemoides* (Adamović) Baden are accepted, while all the others are considered synonyms of *T. montanum*. The observed morphological diversity is reflected in the presence of six taxa described from the Balkan Peninsula: *T. montanum* subsp. *helianthemoides*, *T. montanum* var. *hirsutum* Boiss., *T. montanum* var. *modestum* Heldr., *T. montanum* var. *parnassicum* Čelak., *T. pannonicum* A. Kern., and *T. skorpili* Velen. During field research throughout the Balkans, seven morphologically more or less well-defined groups with relatively solid geographical differentiation were observed. Five of the seven groups fit the already described infraspecific taxa, while two groups are morphologically specific but do not correspond to the existing taxa. The aim of this study was to describe the overall morpho-anatomical variability of *T. montanum sensu lato* in the Balkans and to determine whether the seven identified groups can be distinguished based on morpho-anatomical characters. The most typical populations of these groups could be separated quite well based on the quantitative morphological traits. Multivariate analysis of all samples showed a solid separation of three groups and a significant number of individuals with intermediate positions. Other groups did not show statistical diversification but possess a specific combination of morphological characters by which they can be identified.



Posterska izlaganja

Poster presentations

CONTRIBUTION TO THE FLORA OF FRESHWATER AND RIPARIAN HABITATS ALONG THE DRAVA RIVER IN CROATIA

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This study covers seven locations along the Drava River from Lake Ormož to Donji Miholjac. Floristic data were recorded on 60 plots, of which 52 are located within habitat types listed in the Habitats Directive (3130, 3150, 3260, 3270, 91E0 and 91F0) while the remaining plots are positioned on hygrophilous and mesophilic grasslands of orders *Arrhenatheretalia elatioris* Tx. 1931 and *Potentillo-Polygonetalia avicularis* Tx. 1947. Field survey was conducted during 2016 and 2017. Plot sizes varied from 10 × 10 m for forests, 4 × 4 m for grasslands and coastal-amphibious habitats, to 2 × 2 m for aquatic habitats with the addition of 50 m long transects. Presence and cover of plant species were recorded according to the Braun Blanquet or Kohler for aquatic habitats. Data analysis and visualisation were done in R. In total, 263 different taxa that belong to 166 genera and 71 families were documented. The most represented genus is *Carex* with 10 taxa and the largest families are Poaceae, Asteraceae, Lamiaceae and Cyperaceae. Regarding life form, most of the recorded taxa are hemicryptophytes, followed by therophytes, phanerophytes and geophytes. Overall, 16 taxa are strictly protected and 18 are included in Red Book of Vascular Flora of Croatia. Three species: *Carex bohemica* Schreb., *Limosella aquatica* L. and *Scirpus mucronatus* L. are considered critically endangered (CR). Additionally, 15 invasive plant taxa were recorded of which *Solidago gigantea* Aiton was the most common. For comparison, four habitat groups were singled out. The highest number of plant taxa were recorded in forests (127) followed by grasslands (101), coastal-amphibious (80) and aquatic (78) habitats. Analysis of ecological indicator values between the groups shows statistically significant differences regarding light, moisture and nutrients availability unlike temperature, continentality and soil reaction values.

Keywords: ecological indicator values, Habitats Directive, invasive plant species, threatened plant species

FOREST VEGETATION ALONG LESKA EDUCATIONAL PATH IN RISNJK NATIONAL PARK (CROATIA)

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Forests are fundamental phenomenon of the Risnjak National Park. Their structure, floristic composition and richness of communities was one of the main reasons for establishment of the protected area. Along with the peak Veliki Risnjak (1528 m) and

the spring of the Kupa River, Leska valley is one of the most visited parts of the Park as it is located near its main entrance in Crni Lug. A 4.2 km long educational path passes through the valley, first of its kind in Croatian protected areas at the time of its construction in 1993. This research aimed to analyse and map the forest communities along Leska educational path. Vegetation data were collected according to standard phytosociological method in July 2019. Overall, 27 relevés were entered into TURBOVEG database, all further data analysis and visualisation were performed in JUICE 7.1, Excel and R with packages *vegan* and *rstatix*. Processing of georeferenced data was performed in QGIS Desktop 3.12.3. The results of cluster analysis and interpretation of previous research show the presence of two forest communities: *Blechno-Abietetum* (Horvat 1938) Horvat in Cestar 1967 and *Omphalodo-Fagetum* (Tregubov 1957 corr. Puncer 1980) Marinček et al. 1993. In total, 31 differential species were identified with criteria of minimum frequency 50% and fidelity (Φ) coefficient ≥ 30 . The comparison of EIVs weighted by species cover shows statistically significant differences between communities according to light, temperature, soil reaction and nutrients availability values. The map of forest vegetation along Leska educational path in the scale of 1:10 000 includes an area of 310 ha, with *Omphalodo-Fagetum* covering 275 ha and the *Blechno-Abietetum* covering 35 ha.

Keywords: *Blechno-Abietetum*, ecological indicator values (EIVs), floristic characteristics, forest vegetation mapping, *Omphalodo-Fagetum*

LEGENDS ABOUT PLANTS AND EXPLANATIONS OF THEIR LATIN NAMES AS MOTIVATIONS FOR PUPILS TO LEARN ABOUT PLANTS

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The aim of this work was to explore developing motivation for learning about plants by associating common plant names with meaning of those names in classical languages, mainly Latin, as well as legends about plants in question. In order to encourage a more positive attitude and interest in plants as living beings, five plant species (common smilax – *Smilax aspera* L. laurel – *Laurus nobilis* L., ivy – *Hedera helix* L., bougainvillea – *Bougainvillea spectabilis* Willd. and cypress – *Cupressus sempervirens* L.) were studied in biology classes in high school. The selected plants are associated with certain stories and legends. In some of the cases, the Latin name of a plant describes its features, such as the plant's color or the shape of its leaves. The pupils processed the teaching content by working in groups and making posters, thus developing presentation skills and teamwork. For the preparation of posters, pupils used the materials brought to class by themselves. By using different sources of knowledge, they practiced recognizing facts relevant to their research, but also combined content from several subjects: Latin language, musical culture, history and biology. After presenting their work, pupils were assessed for their ability to apply processed content to new tasks and examples. Teaching was conducted in a motivating environment with active learning and development of skills. In addition to the pupils learning by combining knowledge from several subjects, they also developed awareness of the need to protect plant species, especially at the local community.

Keywords: active learning, classical languages, plants in legends and stories

FIRST FLORA OF THE MARJAN HILL IN SPLIT (SOUTH CROATIA)

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Until recently, the first known floristic records for the Marjan Hill in town of Split dated from the 19th century, reported by R. Visiani and F. Petter. Here we present an even older record, containing 30 plant taxa, dating from the year 1682. The British traveller, botanist and protestant priest Sir George Wheler (1650–1723) published the list of plants in an itinerary named “A Journey into Greece”. An excerpt from Sir Wheler’s account: “Nearer the Town, I clambered up a high Rock, that commands it, to take a prospect of it with my Pencil; where I began to wish that I had had more skill to have designed one of the most delightful places that I had ever seen...” This itinerary also represents the first record of some endemic plants such as *Centaurea ragusina* L., *Aurinia sinuata* (L.) Griseb. and *Genista sylvestris* Scop. subsp. *dalmatica* (Bartl.) H. Lindb. in Split. Since the descriptions (naming) of species do not belong to Linnaean binomial system, detailed literature analysis of each mentioned plant was needed. Having conducted a field research, we confirm all the species can still be found in the area.

Keywords: endemic plants, first record, George Wheler, pre-linnaean

A NEW SPECIES OF *Centaurea* (ASTERACEAE) FROM DALMATIA (CROATIA)

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Centaurea lovricii, a new tetraploid ($2n = 4x = 36$) species is described and illustrated from the island of Vis in central Dalmatia (Croatia). It occurs on calcareous cliffs near the sea with NW exposition, together with several other rare endemic species. Its morphological features, distribution, ecology, conservation status and taxonomical relationships are here examined. As concerns its morphology, it is closely related with endemic *C. glaberrima* Tausch and *C. divergens* Vis. of *Centaurea* sect. *Centaurea*, from which it differs in having more succulent leaves with larger and less incised leaflets, larger capitula, larger phyllaries, with appendages more developed, provided with denser and undulate fimbriae, larger florets, and larger achenes, with longer pappus.

In addition, a new iconography and lectotypification for endemic *C. glaberrima* and *C. divergens* is given.

Keywords: Adriatic, *Centaurea glaberrima* complex, morphology, taxonomy, typification, Vis

FOREST FLORA DIVERSITY AROUND THE SNIJEŽNICA LAKE (NORTHEASTERN BOSNIA AND HERZEGOVINA)

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Sniježnica Lake is located in northeastern Bosnia and Herzegovina, 30 km east of the city of Tuzla. The area surrounding Sniježnica Lake is dominantly rural landscape, which lays at 390 m a.s.l., mostly hilly with steep slopes and with dense forest vegetation. Since this area has a great potential to be ecological and touristic center of Bosnia and Herzegovina, the aim of this research was to investigate the floristic diversity of the area. The floristic research was conducted during 2021 in mixed deciduous forests dominated by *Carpinus betulus* and *Quercus petraea*, which surround the lake. Recorded and collected plant species were identified and analysed in the laboratory. The most important species were photographed in the field due to their significant ecological characteristics. In total, 65 plant species were identified, belonging to 19 plant families. In the tree layer 12 plant species were found, belonging to families *Fagaceae*, *Rosaceae*, *Aceraceae*, *Tiliaceae*, and *Oleaceae*. In the shrub layers nine plant species, from *Rosaceae*, *Ranunculaceae*, *Caprifoliaceae*, *Cornaceae*, *Ericaceae* and *Betulaceae* families, were recorded. The highest floristic richness was recorded in the herb layers where 44 plant species were found, most of which belong to families *Asteraceae*, *Ranunculaceae*, *Lamiaceae*, *Fabaceae* and *Caryophyllaceae*. The favorable ecological conditions of the investigated area supports preserved floristic biodiversity, which can serve as a base for future development of ecological tourism in northeastern Bosnia and Herzegovina.

Keywords: biodiversity, deciduous forest, species, Tuzla

ASSESSMENT OF ALLERGENIC POTENTIAL IN URBAN GREEN AREAS: A CASE STUDY OF THE RIBNJAK PARK IN ZAGREB

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Urban green areas have positive effects on human well-being by improving health, reducing stress, and providing the setting for leisure pursuits. They also play an important role in improving air quality, reducing noise, mitigating the impact of urban heat islands, and conserving biodiversity. However, pollen emission by higher plants during the pollination period can threaten human health prompting an allergic response.

Therefore, the health risks associated with allergenic plants are an important public health aspects of urban green areas. Among the different methods to evaluate the allergenicity of plants, we used the value of potential allergenicity (VPA) in this study. The allergenicity of each species was calculated according to a series of biological parameters based on data provided in literature: type of pollen emission (pe), duration of main pollination period (dpp) and allergenic potential (ap). The multiplication of these three parameters (pe, dpp and ap) gives a value of potential allergenicity (VPA) ranging from 0 to 36, defining five allergenicity classes: zero, low, moderate, high or very high. In this study, 85 taxa were analysed in Ribnjak Park in Zagreb, including 59 trees and 26 shrubs. It was found that 62 taxa (72.9%) have zero or low allergenicity, while 12 taxa (14.1%) have moderate, and 11 taxa (12.9%) high to very high allergenicity. The taxa with the highest VPA were: *Betula pendula* Roth (VPA = 36), *Corylus avellana* L., *C. colurna* L. (VPA = 24), *Fraxinus americana* L., *F. excelsior* L., *Juglans nigra* L., *J. regia* L., *Juniperus chinensis* L., *J. horizontalis* Moench and *Taxus baccata* L. (VPA = 18). This research contributed to the identification of allergenic species in urban green areas of the city of Zagreb as well as knowledge of their allergenicity. It will be necessary to perform further field research to included also herbaceous species.

Keywords: allergenic plants, human health, shrubs, trees, value of potential allergenicity (VPA)

FLORA AND HABITATS OF THE SIGNIFICANT LANDSCAPE OF THE BARAĆ CAVES

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The Significant Landscape of the Barać Caves is located in the Municipality of Rakovica and covers an area of 5.19 km². The area geomorphologically belongs to the Slunj Plateau, which is a south-eastern part of the large Una-Korana Plateau, belonging to the Dinaric karst. This area has not been systematically botanically researched so far; therefore, there are almost no floristic data. In the period 2019-2021 floristic and vegetation research of the area was carried out. The aims of the research were to produce a list of flora and record endemic, rare, threatened and protected taxa, determine their distribution, and produce a detailed habitat map of the area. For purposes of the habitat mapping, the area was explored by a drone. So far, 526 plant taxa have been recorded. Among them, 29 are strictly protected, four endemic, one Critically Endangered, three Endangered, 11 Vulnerable, 10 Near Threatened, while three are of Least Concern and two are Data Deficient. Altogether 18 allochthonous taxa (out of which 10 invasive), and 27 habitat types were recorded, among which forests and colline and montane mesic scrubs and thickets prevailed, while the share of dry mountain grasslands is small. Most significant habitats are wet habitats, like common reed beds, beds of large sedges, grey willow carrs, and wet meadows. These habitats are highly threatened due to drying out and pollution, and the conversion of such habitats into arable land. Although their share in the total area surface is relatively small, they represent a significant vegetation complex outside the forests of the Landscape area.

Keywords: botany, Croatia, habitat mapping, protected area

FLORA OF THE ŽEŽEVICA AREA (CENTRAL DALMATIA, CROATIA)

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Based on the research conducted in 2020, this study presents a list of vascular flora in the area of Žeževica settlement, located in central Dalmatia. The floristic list contains 436 species and subspecies distributed in 83 families. The most represented families are Poaceae (9.63%), Fabaceae (9.40%) and Asteraceae (6.88%). Hemicryptophytes (34.63%) and therophytes (30.96%) are dominant among the life forms, and phytogeographic analysis showed that the largest number of taxa belongs to the Mediterranean (35.55%) and Southern European (21.56%) floral element. A total of 25 endemic, 32 strictly protected, and 19 endangered taxa were recorded. The endangered species were determined according to the Croatian Red Book of Vascular Flora and classified in the following IUCN categories: CR, EN, NT, VU, LC and DD. Among them, *Papaver hybridum* L. stands out as a critically endangered species and *Hibiscus trionum* L. as an endangered species. Out of altogether 29 allochthonous species (27 neophytes and 2 archaeophytes), 16 species (3.67%) are classified as invasive plants.

Keywords: endangered plants, endemic species, floristic analysis, invasive taxa, Mediterranean

IMPACT OF *Impatiens glandulifera* Royle EXTRACT ON OXIDATIVE STRESS PARAMETERS IN SEEDLINGS OF *Sinapis alba* L. AND *Raphanus sativus* L.

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The aim of this study was to examine the impact of Himalayan balsam (*Impatiens glandulifera* Royle, Balsaminaceae) extract on parameters of oxidative stress in white mustard (*Sinapis alba* L., Brassicaceae) and radish (*Raphanus sativus* L., Brassicaceae) seedlings. The seeds of mustard or radish (n = 25) were placed in Petri dishes on filter paper impregnated with *I. glandulifera* (Čučerje, Croatia) leaf methanolic extract in doses 1.5, 3 or 6 mL (in three replicates) and germinated in controlled environment for 3 days. In the experiments, negative (seeds exposed to distilled water) and positive controls (seeds exposed to 0.02 M CuSO₄) were included. After germination, the seedlings were weighed, and plant tissue homogenate prepared. In supernatants of plant tissue homogenates polyphenols were assessed with Folin-Ciocalteu's reagent, anthocyanins by use of pH differential method, glutathione (GSH) with Ellman's reagent and malondialdehyde by TBA assay, spectrophotometrically. The difference

among groups was tested by one-way ANOVA followed by Dunnett's test ($p < 0.05$). After 3-days of exposure to *I. glandulifera* extract in dose of 1.5 mL the reduction of fresh weight of mustard seedlings was observed, while even the highest dose (6 mL) of the extract had no effect on radish seedlings fresh weight. In mustard seedlings, 3-days of exposure to the highest dose of *I. glandulifera* extract (6 mL) reduced the levels of polyphenols and anthocyanins, and increased the level of GSH. The level of oxidative stress parameters in radish seedlings was not affected by 3-days of exposure to *I. glandulifera* extract. Reduction in the levels of polyphenols and anthocyanins and increase in the level of GSH indicate that extract of *I. glandulifera* induced oxidative stress in *S. alba* seedlings.

Keywords: allelopathy, germination, mustard seedlings, non-enzymatic antioxidants, radish seedlings

MEDIEVAL PANTRY IN THE COURTYARD OF BANSKI DVORI PALACE (ZAGREB, CROATIA)

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In 2021, the Croatian Conservation Institute conducted a multidisciplinary conservation-restoration and an archaeological research of Banski dvori Palace to determine the phases of historical development. Archaeological excavations involved the northern courtyard, the area of the former Rauch Palace. The results have confirmed the continuity of the existence of the Zagreb's Upper Town plateau settlement since the period of prehistory to the present day. During the research, the remains of a buried basement building were investigated and interpreted as the remains of an underground storage room of a medieval town house, dating from the 13th and 14th centuries. Remains of ceramic pottery and numerous botanical remains were discovered in the filling of the excavated building. During the archaeobotanical analysis, a total of 1492 plant findings were isolated, out of which only 32 were carbonized. Over 40% of the remains were found in five clay pots, and other remains were found in the surrounding sediment. Over 94% of the findings represent cultivated and wild edible woody plants, mainly *Vitis vinifera* L. (940 macrofossils), *Prunus avium* (L.) L./*P. cerasus* L. (260), *Prunus spinosa* L. (122) and *Rubus plicatus* Weihe & Nees (28). Some of the species, such as *Vitis vinifera* and *Prunus persica* (L.) Batsch have been cultivated, while others, such as *Cornus mas* L. and *Prunus spinosa*, tell us that medieval inhabitants supplemented their diet by collecting and consuming fruits from nature. Plum stones were also found, but based on their morphology, it was not possible to define whether they were fruits of *P. domestica* s. l., or *P. cerasifera* Ehrh. Cultivated and wild edible herbaceous plants make 3.7% of the findings and are represented by the remains of the vegetable species *Cucumis sativus* L. (13), the spice plant *Foeniculum vulgare* Mill. (13) and two cereals *Panicum miliaceum* L. (28) and *Triticum aestivum* L./*T. durum* Desf. (1). A few remaining findings (34) have been undetermined due to poor preservation.

Keywords: archaeobotany, Middle Ages, underground storage room, vessels

ACTIVE LEARNING ABOUT BRYOPHYTES THROUGH SETTING A MUSEUM EXHIBITION

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It is now widely accepted that active participation of pupils during lessons contributes to a better acquisition of knowledge. One of the methods of active learning is extracurricular teaching, such as teaching in a museum. In this project, we decided to enhance the participation of pupils by engaging them in various stages of setting up an exhibition. We teamed up with the Natural History Department of the National Museum Zadar, planning to set up an exhibition entitled 'Bryophytes'. Pupils from three different high schools in Zadar participated in the preparation and setting up the exhibition. Some of the pupils were asked to collect samples of bryophytes. Pupils were first informed about the species and habitats of bryophytes, and the method of collecting samples from the environment, emphasizing the importance of preserving the environment and collecting as few samples as possible in order to avoid disturbing the natural balance. The pupils were instructed on how to make "boats" for bryophytes, label the collected samples and preserve them until they were handed over to the curator in the museum. Also, an online lecture on bryophytes by a bryophyte-specialist Prof. Antun Alegro was organized for all pupils. Some of the pupils designed and painted graffiti with bryophyte-related concepts, which also became an integral part of the exhibition. Finally, all of the pupils visited the exhibition and had the opportunity to view their own work in the exhibition. Through participating in setting up the exhibition and visiting the exhibition afterwards, pupils learned about the richness and diversity of bryophytes in Croatia, became aware of the need to preserve biodiversity and noticed the importance and role of bryophytes in nature. This study demonstrates that the involvement of pupils in setting up an exhibition offers great means to promote both the acquisition and application of knowledge.

Keywords: extracurricular teaching, museum exhibition, school

THE EFFECT OF *Globularia alypum* L. METHANOLIC EXTRACT ON SEED GERMINATION AND ON THE LEVEL OF OXIDATIVE STRESS IN *Raphanus sativus* L. SEEDLINGS

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The aim of this study was to explore the effects of *Globularia alypum* L. methanolic

(MeOH) extract on radish (*Raphanus sativus* L.) seed germination and on the level of non-enzymatic antioxidants in radish seedlings in the presence of excess copper ions (II). Seeds (25 per replicate) were pre-treated (pre-soaked) for two hours with *G. alypum* MeOH extract dissolved in distilled water (50, 500 and 5000 µg/mL) and afterwards treated with 3.5 mL of 0.005 M CuSO₄. After five days of germination in light at 20 ± 2 °C, germination parameters were assessed, the root and hypocotyl lengths measured, and the dry masses of radish seedlings weighed. Afterwards, seedling tissue homogenates were prepared using 5% (w/v) trichloroacetic acid (1:10). The Folin-Ciocalteu's reagent was used to determine the total phenolic contents, while glutathione (GSH) levels were evaluated using the Ellman's reagent. All measurements were performed in triplicate. Significant differences between copper treatment and negative control (distilled water) were assessed using Student's t-test, and those between copper treatment with and without *G. alypum* pre-treatment using one-way analysis of variance (ANOVA) with Dunnett's *post-hoc* test (α = 0.05). Treatment with 0.005 M CuSO₄ significantly decreased all measured parameters compared to negative control. The two lower concentrations of *G. alypum* MeOH extract (50 and 500 µg/mL) significantly increased germination percentages of radish seeds (76 ± 0 and 76 ± 11% vs. 52 ± 14%), while all extract concentrations increased hypocotyl lengths (5.60 ± 0.21, 5.91 ± 0.23 and 6.46 ± 0.03 mm vs. 4.90 ± 0.27 mm). Furthermore, all MeOH extract solutions significantly increased total phenolic content and GSH levels of radish seedlings. Obtained results indicate that *G. alypum* may reduce the negative effects of copper-induced oxidative stress in radish seeds.

Keywords: copper-induced oxidative stress, germination parameters, hypocotyl and radicle length

CYPSELA MICROMORPHOLOGY OF *Centaurea crithmifolia* Vis. AND *C. friderici* Vis. subsp. *jabukensis* (Ginyb. et Tayber) Greuter FROM THE CENTRAL ADRIATIC

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This study investigates the micromorphology of cypselae of two endemic *Centaurea* taxa: *Centaurea crithmifolia* Vis. and *C. friderici* Vis. subsp. *jabukensis* (Ginyb. et Tayber) Greuter from the Adriatic volcanic island of Jabuka, using scanning electron microscope (SEM). The fruit of both taxa is differentiated into cypselae and pappi. Common micro characters found in both cypselae are: non-ribbed body; lateral and concave insertion; absence of carpodium; elongated epidermal cells longitudinally parallel to the long axis of the cypselae; lack of glandular trichomes; undeveloped epicuticular secretion; dentate pericarp rim; and structure of the pappus. The pappus is dimorphic, barbata-aristate, consisting of free, numerous bristles differing in size and shape, shorter than the cypselae. The outer pappus is pluriseriate, formed by short triangular bristles and long, narrow, subulate, barbellate bristles, while the inner pappus is shorter, connate at the base, formed by subulate, barbellate bristles organized in one whorl. Pinnules are restricted to the margins of the bristles and sparsely on the dorsal surface, while the ventral surface is smooth. The apex of the

bristle is acute. Differences are seen in the basis shape, cypsela surface and hairiness. In cypselae of *C. crithmifolia* the basis shape is rotund, while in *C. friderici* subsp. *jabukensis* it is obtuse. In cypselae of *C. crithmifolia* epidermal cells are distinct, rod-shaped with short, obtuse end walls; the cell boundaries are thick and the centers of the cells are placed at equal levels with the boundaries; the anticlinal walls of the epidermal cells are straight and the ornamentation is fine-sulcate. In contrast to the cypsela of *C. friderici* subsp. *jabukensis*, epidermal cells are not distinct, while ornamentation is striate. Unicellular, twisted acute trichomes are only present on the cypsela surface of *C. friderici* subsp. *jabukensis*. The results contribute to the knowledge on the micromorphology and taxonomy of the studied endemic taxa and provide features for their easier identification.

Keywords: endemic, pappus, SEM, taxonomy

HIGH GROWING TEMPERATURE AFFECTS THE ANTIOXIDANT POTENTIAL OF BROCCOLI SEEDLINGS (*Brassica oleracea* L. convar. *botrytis* (L.) Alef. var. *cymosa* Duch.)

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Due to climate change, plants are exposed to abiotic stress, especially high temperatures. To combat those stressful conditions, they developed antioxidant mechanisms which help them to reduce reactive oxygen species. To investigate how high temperature affects the antioxidant potential of broccoli seedlings (*Brassica oleracea* L. convar. *botrytis* (L.) Alef. var. *cymosa* Duch.), in the winter of 2021/2022, within the scope of the TEMPHYS project (IP-2020-02-7585), we cultivated three biological replicas of broccoli seedlings at high temperature (38 °C day/33 °C night) and three biological replicas at regular temperature (23 °C day/18 °C night) as a control group. Extracts of lyophilized broccoli tissue were made in 70% ethanol, and antioxidant potential was measured using four methods: ABTS, DPPH, FRAP and β -carotene bleaching. The obtained values were compared to those of standard Trolox solution of the same concentration as our extracts (i.e. 30 mg/mL for all the methods, except for FRAP which was 15 mg/mL). Based on the results of ABTS, FRAP and β -carotene bleaching method, high temperature significantly increased antioxidant potential of broccoli seedlings. However, DPPH method indicated a reduction of antioxidant potential. All the methods were significantly positively correlated with each other, except the DPPH which was negatively correlated with other methods. Both, at high and regular temperature, statistical methods principal component analysis and hierarchical clustering revealed higher similarity between second and third biological replicas, and separation of first biological replica. However, all biological replicas grown at high temperature tended to cluster together and clearly separated from those at regular temperature. In conclusion, based on three out of four used methods, high temperature significantly increased antioxidant potential of broccoli seedlings, suggesting further research into the effect on plant metabolism.

Keywords: ABTS, β -carotene bleaching, climate change, DPPH, FRAP

SPONTANEOUS OCCURRENCE AND SEED GERMINATION OF *Gleditsia triacanthos* L. IN SLOVENIA

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When alien plants are introduced to new regions, they can significantly alter the existing ecosystems. They can rapidly expand their distribution and form competitive interactions with native plants. The honey locust (*Gleditsia triacanthos* L.) is an ornamental tree originating from North America and introduced in Europe around 1700. The species is already occurring spontaneously outside cultivated areas *via* seed propagation, which is very interesting since *G. triacanthos* produces hard seeds, hence physical damage of the seed coat is necessary for germination. To investigate possible reasons for seed coat damage, enabling germination, in urban environment several scarifying agents were tested (damage by cars, infestation with bruchid beetles, ethanol, dish soap, pepsin-hydrochloric acid solution, mechanical scarification). Results are provided as mean and median germination time and final germination percentage in each treatment. Locations of spontaneously growing honey locust trees identified in Maribor (field work) and Ljubljana (collected from the literature) are also shown. Our results suggest that an interaction between honey locust and bruchid beetles facilitates seed germination.

Keywords: alien species, germination, hard seeds, novel interactions

FLORA OF THE „OTOK MLADOSTI“ – GREEN LUNGS OF THE LUBREG AREA

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So far, no floristic data have been recorded for anthropogenic water surfaces in the Ludbreg area in Hrvatsko zagorje (north-western continental Croatia). Therefore, the aim of our work was to explore the vascular flora along part of the Bednja River – on the “Otok mladosti” (“Island of Youth”). Fieldwork was carried out during the vegetation seasons 2016 and 2021. Plants were geocoded, collected, identified and subjected to standard floristic analysis. In the studied area of approximately 1 km², a total of 207 taxa of vascular plants from 71 families have been recorded. The most abundant families are Poaceae (10.2%), Asteraceae (7.2%), Fabaceae (6.3%), Rosaceae (4.8%) and Scrophulariaceae (4.3%). The life form spectrum indicates the dominance of hemicryptophytes (42.6%) and the prevailing geoelement is Eurasian (59.0%), which classifies the studied area as the Euro-Siberian-North American region. Two taxa are strictly protected, while no threatened taxa were recorded. The alien flora is represented by 44 taxa (21.3%), with the same share of archaeophytes and neophytes. Almost all neophytes (18 taxa) belong to invasive species. The largest

number of plant taxa was recorded in meadows and ruderal habitats. Nevertheless, although the analysis of alien taxa and habitats may initially indicate a significant anthropogenic impact, the share of urbanophobic species is significantly higher than urbanophilous (32.3% vs. 20.4%), which potentially justifies the colloquial name of the study area - green lungs of the town of Ludbreg.

Keywords: alien flora, continental Croatia, floristic analysis, Hrvatsko zagorje, native flora

TRADITIONAL USE OF WILD PLANTS OF ZABOK RURAL AREA

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Ethnobotanical research conducted so far in Croatia has mainly covered the coastal areas of the country, while the continental parts have been explored to a significantly lesser extent. The research of Hrvatsko zagorje (northwestern Croatia) is currently ongoing; therefore, the aim of this work is to present the preliminary ethnobotanical data recorded for the town of Zabok and its rural surrounding area, respectively. The survey was conducted during 2017 and 2018 within 16 settlements, when 32 informants were interviewed (average age of 70), regarding the traditional knowledge of wild plants usage. The use of 116 taxa of vascular flora classified into 54 families was recorded in the study area. The most used plants belong to families Asteraceae (24.07%), Rosaceae (18.51%) and Lamiaceae (12.96%). The most frequently used plant parts are leaves and other aerial parts (55.20 %), followed by flowers (22.72%), fruits (14.28%), whole plant (3.90%) and underground parts (3.90%). The research has shown that 116 plant taxa have been used in 204 ways. Plant parts are mainly used as infuses (16.17%), in human nutrition (15.68%), for medical purposes (15.68%) and as brandy flavourings (11.27%). These are the first ethnobotanical data for the abovementioned area, thus this research contributes to the preservation of traditional botanical knowledge of Hrvatsko zagorje, which will complement other ethnobotanical research in this area.

Keywords: ethnobotany, Hrvatsko zagorje, native useful plants, northwest Croatia

POLLEN MICROMORPHOLOGY OF *Galanthus reginae-olgae* subsp. *vernalis* Kamari FROM THE EASTERN ADRIATIC COAST

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Pollen of *Galanthus reginae-olgae* subsp. *vernalis* Kamari (spring-flowering Queen Olga's snowdrop), collected from a population in Konavle, near Dubrovnik, Croatia, has been studied to provide taxonomically informative data. Symmetry, polarity, size, shape, aperturation and ornamentation of 27 pollen grains from five flowers were examined using a scanning electron microscope (SEM), and the obtained numerical data were processed employing descriptive statistical procedures. The results show that the examined pollen grains are bilaterally symmetric, heteropolar, monosulcate, oblate in equatorial view (polar axis to equatorial diameter ratio / mean \pm standard deviation / 0.58 ± 0.08), elliptic in polar view, and small in size (equatorial diameter $22.51 \pm 2.92 \mu\text{m}$). The exine sculpturing pattern is microperforate-microrugulate. In addition, the morphometric analysis revealed that the size of the exine surface structures is as follows: rugulae width $0.13 \pm 0.02 \mu\text{m}$, perforation diameter $0.24 \pm 0.04 \mu\text{m}$. The number of perforations per $5 \times 5 \mu\text{m}$ is 94 ± 4.93 . This is the first detailed study of the micromorphology of pollen of *G. reginae-olgae* subsp. *vernalis*, and supplemented by palynomorphological data on other snowdrops, the results may prove to be useful for delimitation of certain taxa within the genus.

Keywords: Croatia, palynomorphology, Queen Olga's snowdrop, taxonomy

FLORA OF SUBMEDITERRANEAN DRY GRASSLANDS AT THE FOOT OF THE PROMINA MOUNTAIN (NORTH DALMATIA, CROATIA)

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Studied area is located on the plateau at the foot of the Promina Mountain and between the canyons of the Krka and Čikola rivers. It is dominated by forest and scrub of pubescent oak and oriental hornbeam (*Quercus-Carpinetum orientalis* Horvatić 1939) and two alliances of submediterranean dry grasslands (*Chrysopogono grylli-Koelerion splendidis* Horvatić 1973 and *Scorzonerion villosae* Horvatić 1949). Majority of observed grasslands are in different successional stages. A series of surveys of vascular plant taxa was conducted in years 2019–2021, followed by the analysis of the flora and life-forms. Also, detailed habitat map was created, with habitats additionally divided according to the degree of succession towards forest vegetation. Hence, Ellenberg's ecological indicator values and CSR strategies were calculated for grasslands and grasslands in succession, to identify potential vegetation differences. Altogether, 236 species and subspecies were recorded on grassland habitats, with a larger number of species recorded on both grassland types in succession, rather than on preserved grasslands. Recorded taxa belong to 156 genera and 55 families, among which the largest are *Poaceae* and *Fabaceae*. Almost half of the recorded taxa are hemicryptophytes, followed by therophytes and phanerophytes. In total, 21 strictly protected taxa were recorded, including 15 endemics. Twelve taxa are included in the IUCN Red List, with only two species belonging to one of the three threatened categories (VU). In addition, two invasive alien plant species were found. As expected, ecological indicator values of recorded taxa indicate warm and sub-Mediterranean

open habitats with dry and neutral to moderately acidic nitrogen-poor soils. Based on their life strategies, all four grassland categories are located almost in the middle of the Grime triangle, with a slight shift towards CS strategy. No significant differences were observed regarding the indicator values or life strategies calculated for studied grassland types and their successional stages.

Keywords: ecological indicator values, life-forms, life strategies, succession

THE RELATIONSHIP BETWEEN DIVERSITY AND PRODUCTIVITY OF GRASSLANDS IN ZAGREB AREA (NW CROATIA)

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A research on the floristic and ecological characteristics of grasslands in Zagreb area was conducted in June and July 2020. Eight localities, each containing two 1 m² plots, were processed. This included cutting the vegetation from 0.5 m² of each plot, drying and weighing it. Also, analysis of flora, life-forms, CSR strategies and Ellenberg's ecological indicator values was performed, while for each taxon four different functional traits were used to calculate functional diversity index. Floristic composition of each quadrat was analysed and the presence of two vegetation communities, *Festuco-Brometea* and *Molinio-Arrhenatheretea*, has been determined. One strictly protected taxon, *Anacamptis pyramidalis* (L.) Rich., was recorded; while the most represented families were Poaceae, Fabaceae and Asteraceae. The most common life form was hemicryptophytes and the floral element Eurasian. Although indigenous taxa dominate, two invasive plants: *Echinocystis lobata* (Michx.) Torr. et A. Gray and *Erigeron annuus* (L.) Desf. have been recorded. The analysis of Grimes' CSR life strategies classified grasslands closest to the competitive strategy. Functional diversity of plots was calculated and compared with the number of taxa and plant biomass collected within the plots. Functional diversity values ranged from 1.121 to 2.060 and dry biomass from 251.4 to 586.8 g m⁻² per quadrat. Correlation analyses linked a decrease in the number of taxa and functional diversity with an increase in biomass and specific leaf area. Functional diversity was positively correlated with the number of taxa, plant dry matter content and leaf dry matter content. In order to obtain more detail insights into relations of these parameters, it is necessary to conduct this type of research in other grassland communities in Croatia.

Keywords: biomass, functional diversity, functional traits, life-forms, origin

ADJUSTMENTS OF TEACHING MATERIALS TO STUDENTS WITH LEARNING DIFFICULTIES IN PROCESSING THE TOPIC OF PHOTOSYNTHESIS

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The integration of students with learning difficulties into the education system requires the adaptation of new materials and assessment methods, which is a challenge for every teacher. The goal of an inclusive teacher is to conduct teaching in such a way that even students with learning difficulties actively participate in the teaching process and acquire life skills necessary for a good adaptation to a constantly changing society. This paper deals with the presentation of new materials (similar to those used in biology workbooks in 7th grade and 8th grade chemistry for students with all types of learning difficulties) that have been prepared especially for each student with different learning difficulties. They are prepared for teaching biology and chemistry, more precisely the concept of photosynthesis (topic Nutrition in 7th grade and topic Carbon cycle in nature in 8th grade) for work with students with learning difficulties. The preparation of such materials requires much more effort from the teachers, but the results obtained on a small sample of students so far indicate better adoption of the outcomes.

Keywords: assessment methods, biology and chemistry, learning outcomes, photosynthesis, students with difficulties

TRADITIONAL USE OF WILD AND CULTIVATED MEDICINAL PLANTS IN THE BARANJA AREA

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The area of Baranja is rich in fertile soil and characterized by great diversity of plant species of which many have medicinal properties and are used in medicine, cosmetics and nutrition. However, knowledge about the identification, collection and usage of medicinal plants among the local community in this area has been insufficiently investigated, so the questionnaire survey was conducted from June to September 2019. A total of 27 respondents from the area of the town of Beli Manastir and the suburbs of Šumarine, Šećerana and Luč participated in the research. The results showed that the respondents used a total of 44 plant taxa from 24 families, out of which the majority belongs to families Rosaceae, Asteraceae and Lamiaceae. Medicinal plants are most often used by respondents who are between 61 to 70 years old. Respondents collect a total of 43.2% of wild plants, while 56.8% are cultivated. Medicinal plants are most commonly used to treat and prevent respiratory, digestive, cardiovascular and neurological disorders, and for nutrition. Leaves and fruits are most commonly used, and among possible preparations, tea is most commonly prepared. All respondents stated that their parents or grandparents collected and cultivated many more medicinal plants and used them to prepare various tinctures, syrups or ointments. In order to preserve the knowledge about medicinal plants and encourage more frequent use, it is necessary to conduct additional research in other places in Baranja.

Keywords: Eastern Croatia, ethnobotany, ethnomedicine, medicinal preparations

VASCULAR AND BRYOPHYTE FLORA OF THE ISLET OF MRDUJA (EASTERN ADRIATIC, CROATIA)

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The Croatian Adriatic coast with 1246 islands, islets, rocks and ridges was recognized as a botanical hotspot within the Mediterranean basin. Mrduja is the only islet situated within the Split straits (Splitska vrata), a narrow passage between the islands of Šolta and Brač. Although in the last 25 years a significant effort has been made to explore Croatian uninhabited islets and reefs, the flora of Mrduja has never been thoroughly researched. The objective of this study was to investigate both vascular and bryophyte flora of the islet. The field study was performed in 2017 and 63 taxa of vascular plants and six bryophytes were recorded. Habitat types were also assigned to each taxon and the vegetation profile of the islet was created. The predominance of Poaceae (13%) and Fabaceae (8%), terophytes (30%) and Mediterranean floral elements (73%) clearly demonstrate the Mediterranean phyto-geographical position of the islet. Almost one-third of the taxa were found on anthropogenic habitats, even though they are exceptionally rare on the islet, proving that even a slight human presence can have a profound impact on the flora of an island.

Keywords: anthropogenic influence, Brač, floral elements, islet, Mediterranean, Šolta

INVENTORY OF WOODY TAXA OF MALI BRIJUN AND ST. JEROLIM ISLANDS (NATIONAL PARK BRIJUNI)

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Brijuni islands are located along the western coast of Istria (northern Adriatic). Due to the diverse and specific landscapes and heritage, the area was declared a National park and Memorial area in 1983. On the islands of Mali Brijun and Sv. Jerolim an inventory and valorization of woody taxa was performed during spring and summer of 2021. The valorization of woody taxa according to morphological and biological characteristics due to which some species may have a negative effect (non-native invasive species) was performed. In total 47 different woody taxa were recorded, 31 on each island. The woody taxa include trees, shrubs and semi-shrubs. On the island Mali Brijun 17 taxa belong to trees, 29 taxa belong to shrubs and 10 taxa to semi-shrubs. On the island Sv. Jerolim, nine taxa belong to trees, 17 taxa belong to shrubs and 10 to semi-shrubs. There are 15 taxa in common for both islands, and 16 taxa are specific to each of these islands. The plants belong to 43 different genera: *Acer*, *Agave*, *Ailanthus*, *Arbutus*, *Asparagus*, *Carpinus*, *Cedrus*, *Cistus*, *Crataegus*, *Cupressus*, *Dorycnium*, *Euphorbia*, *Ficus*, *Fraxinus*, *Helichrysum*, *Hippocrepis*, *Jacobaea*, *Juniperus*, *Laurus*, *Lonicera*, *Melia*, *Morus*, *Myrtus*, *Nerium*, *Olea*, *Opuntia*, *Phillyrea*, *Phyllostachys*, *Pinus*, *Pistacia*, *Pittosporum*, *Prunus*, *Quercus*, *Rhamnus*, *Ruta*, *Smilax*, *Salicornia*, *Spartium*, *Tamarix*, *Teucrium*, *Viburnum*, *Vitex* and *Yucca*. Altogether 17 woody taxa

are autochthonous and 30 allochthonous. Five taxa belong to gymnosperms and 42 belong to angiosperms. It can be concluded that autochthonous woody taxa dominate in the study area. Invasive species tree of heaven (*Ailanthus altissima* (Mill.) Swingle) and Indian fig (*Opuntia ficus-indica* (L.) Mill.) have been reported before in the Mediterranean part of Croatia.

Keywords: Brijuni islands, protected area

PHYTOPLANKTON DIVERSITY AT ONE STATION IN LASTOVO ARCHIPELAGO (SOUTHERN ADRIATIC)

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Phytoplankton community diversity was studied during stratification period at one station in the southern side of island Lastovo (Cape Struga). Phytoplankton was sampled every 12 h from 13th to 21st July 2021 with Niskin bottles. Samples were analyzed (n=59) by Utermöhl method on inverted light microscope Zeiss Axiowert 200. A total of 95 taxa has been determined, out of which: 58 diatoms, 27 dinoflagellates, six coccolithophores, and four other autotrophs which included chlorophyceae, chrysophyceae and cryptophytes. The microphytoplankton community was dominated by diatoms (37.03%), while dinoflagellates (3.3%) and coccolithophores (0.57%) contributed less. Nanophytoplankton comprised dinoflagellates (38.31%), coccolithophores (6.92%) and other autotrophs (14.35%). Dominant species, defined as species or groups with abundance >500 cells L⁻¹, and the frequency of occurrence in samples >40 %, were *Cylindrotheca closterium*, *Guinardia flaccida*, *G. striata*, *Gyrodinium fusiforme*, *Hemiaulus chinensis*, *Leptocylindrus danicus*, *Proboscia alata*, *Pseudo-nitzschia delicatissima*, *Rhizosolenia imbricata*, *Scrippsiella* sp., and *Thalassionema frauenfeldii*. Maximal recorded cell abundance was 1.3 ×10⁵ cells L⁻¹, and species richness 10.22. Pielou's evenness (J'=0.58) indicates phytoplankton species are not evenly distributed in the community, which can be explained by overall higher nanophytoplankton abundances. Shannon-Weiner (H') is 2.67, and Simpson diversity index (1- 1/n) is 0.84, showing community does not have high diversity.

Keywords: community structure, diversity indices, dominant species, phytoplankton counts

METABARCODING OF SIZE-FRACTIONED PLANKTON AFFECTED BY ISLAND-TRAPPED WAVES ALONG LASTOVO ISLAND (ADRIATIC SEA)

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Island-trapped waves (ITWs) represent a phenomenon whereby the Earth's rotation causes the trapping of surface and internal waves at sea-coast boundaries, (in)directly

affecting plankton diversity, dynamics and abundance. In this study we identified plankton taxa and their relative abundance of amplicon sequence variants - ASVs in seawater column at Struga station on Lastovo Island using amplicon metabarcoding with 16S rRNA and 18S rRNA genes. Sampling took place on two instances; before (13th July) and during the ITWs phenomena (21st July 2022); and large volume of seawater (approx. 4L) was fractioned with filters of different pore-sizes to targeted different classes of taxa (pico: 0.2-3µm; nano: 3-20µm and micro: >20µm). Most dominant bacteria were Alphaproteobacteria and Gammaproteobacteria, which altered in relative abundance between 15% to 47% and 11% to 21%, respectively. Third dominant bacterial class, Cyanobacteria, were most abundant in samples collected 13th of July when their abundances were 11-36% of total ASVs, while at 21st their abundance significantly dropped to levels 3-5% of total ASVs. Differences in community composition among size-fractions were observed mostly between nano and microplankton vs. picoplankton, where for example Actinobacteria were significantly more abundant in larger fractions; while in pico-fraction archaeal taxa Nitrososphaeria were recorded in higher rel. abundances (8-12%). Eukaryotic plankton also showed significant differences in community composition among size classes, with mixotrophic Dinophyceae dominating in nano fraction (30-65%), parasitic Syndiniales dominating in pico-fraction (25-50%), while larger Arthropoda (ciliates and copepods) and Cnidaria (very likely parts of mesozooplankton, e.g. jellyfish) dominated in micro-fraction (69-87%).

Keywords: 16S rRNA, 18S rRNA, environmental DNA, NGS

MORPHOMETRY OF *Festuca bosniaca* Kumm. et Sendtn. (POACEAE) AND RELATED SPECIES

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The genus *Festuca* L. (Poaceae) comprises perennial grasses with leaf blades mostly rolled or conduplicate, inflorescence in form of a panicle composed of two- to several-flowered spikelets, with specific upper glume, lemma and awn morphology. *Festuca bosniaca* and its closely related species within *F. varia* complex occupy large area and diverse habitats in southern Europe, thus exhibiting a variety of morphological characters in leaf and panicle morphology. Total of 112 individuals divided through 34 populations representing seven species (*F. adamovicii*, *F. bosniaca*, *F. calva*, *F. cyllenica*, *F. eskia*, *F. varia* and *F. versicolor*) were collected over the Balkan and the Apennine Peninsulas and the Alps. Most important diagnostic morphometric characters (anatomical and habitus) considering leaf and panicle segment were measured. Quantitative morphometric characters between closely related species were examined with exploratory data analysis and ANOVA, Tukey post hoc and Kruskal-Wallis were performed in order to obtain significant ($p < 0.001$) characters within the dataset. This process generated ten characters used in subsequent PCA

analysis. Additionally, we performed RDA to test morphometric multivariate variation in response to explanatory environmental and geographical data. Our results showed very little or no species-specific discriminatory characters, concluding that taxonomic identification based solely on morphology remains very challenging. Nevertheless, combined morphometry with environmental and geographical variables showed differences in correlation of some phenotypes (e.g. *F. versicolor*) with geography and environmental conditions.

Keywords: *Festuca*, habitus, morphology, statistics

VOLATILE COMPONENTS OF *Centaurea spinosociliata* Seenus

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The composition of volatile organic compounds (VOCs) of fresh flowering heads (capitula) of *Centaurea spinosociliata* Seenus (Asteraceae, Circum-Mediterranean clade – CMC, subsect. *Centaurea*) from Otrić, Croatia was analyzed. Plant material was collected in August 2021, and flowering heads were frozen until extraction. The essential oil was obtained by simultaneous distillation and extraction using Likens–Nickerson type apparatus and analyzed by GC-FID/GC-MS. In total, 41 compounds were identified out of 45 detected, representing 91.11% of the total VOCs content. Peaks that were lower than 0.1% were not included. Sesquiterpenes were the most represented class of compounds (65.13%), with sesquiterpene hydrocarbons being more abundant (39.91%) than oxygenated sesquiterpenes (25.22%). Aliphatic compounds were also present in high amount (30.96%), while monoterpenes were the least abundant, with α -pinene detected only (0.13%). Germacrene D was identified as a principal compound (11.65%), followed by caryophyllene oxide (10.32%) and hexanal (7.64%). The essential oil composition of *C. spinosociliata* was previously investigated, and a few differences were noted when compared to the results of the current study. Taxonomic implications are further discussed.

Keywords: Circum-Mediterranean clade, flowering heads, frozen plant material, volatile organic compounds

INTERESTING BRYOPHYTE RECORDS FROM NORTH BAČKA, SERBIA

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Bačka region in Vojvodina province is one of the least bryologically explored areas

of Serbia, with only 344 records and 69 species known up to day. Aim of this study was to investigate bryophyte flora on several floristically interesting localities situated in the northernmost part of Serbia. Selected localities stand out in the uniform agricultural landscapes of Vojvodina province for their ecological peculiarities and floristic richness, therefore representing important centers of biodiversity in this part of the country. Moreover, they host significant and unique bryophyte flora. Sandy and saline habitats of Subotička peščara, Selevenjske pustare and Tavankut, as well as surrounding rural and agricultural areas were investigated. Beside bryofloristic study of the area, this research has brought new distribution data for some rare species, as well as several interesting under-recorded tiny ephemeral mosses. This study will allow to better understand ecology and bryofloristic diversity of the rare, fragile natural habitats, as well as agricultural habitats. Furthermore, new spatial data of the important species will provide greater protection and monitoring of species, especially in the protected areas in Vojvodina province.

Keywords: bryoflora, rare species, saline areas, sands, Vojvodina

NEW RARE PLANT TAXA IN THE FLORA OF DINARA AND KAMEŠNICA MOUNTAINS (CROATIA)

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The vascular flora of Dinara and Kamešnica Mts was investigated along three mountain trails during the vegetation seasons from 2019 to 2021. The floras of Dinara and Kamešnica Mts are not very well explored and this is a valuable contribution in which we report here some rare plant taxa in the flora for the first time. These new plant taxa are: *Allium fuscum* Waldst. et Kit., *Astragalus hypoglottis* L., *Chouardia lakusicii* (Šilic) Speta, *Dianthus ciliatus* Guss. subsp. *dalmaticus* (Čelak.) Hayek, *Erysimum raineri* Polatschek, *Festuca alpina* Suter, *Fraxinus excelsior* L., *Gypsophila fastigiata* L., *Himantoglossum adriaticum* H. Baumann, *Hyssopus officinalis* L., *Iris adriatica* Trinajstić ex Mitić, *Matthiola fruticulosa* (L.) Maire, *Minuartia graminifolia* (Ard.) Jav. subsp. *clandestina* (Port.) Mattf., *Saponaria bellidifolia* Sm., *Scabiosa delminiana* Abadžić, *Scorzonera hispanica* L., *Scrophularia bosniaca* Beck, *Silene vallesia* L. subsp. *graminea* (Rchb.) Nyman, *Sternbergia colchiciflora* Waldst. et Kit., *Veronica dalmatica* Padilla-García, Rojas-Andrés, López-González et M.M.Mart.Ort. and *Viscum album* L. subsp. *austriacum* (Wiesb.) Vollm. We also present general distribution maps for those rare plant taxa of the Croatian flora.

Keywords: Dinaric Alps, endemics, flora, new species, rare species

EPICUTICULAR LEAF ALKANES IN BALKAN JUNIPERS – FUNCTION AND VARIABILITY

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The genus *Juniperus* L. (Cupressaceae) consists of ca. 67 species that mainly grow in the northern hemisphere. The genus is divided into three sections: *Caryocedrus*, *Juniperus* and *Sabina*. Species belonging to all three sections grow wild in the Balkans. Junipers are evergreen shrubs that predominantly inhabit dry open areas. They are very well adapted to life in open areas, with xeromorphic leaves and thick cuticular layer on their surface. The cuticle serves as the ultimate barrier to water loss. It is composed of soluble lipids (waxes) embedded in a polyester matrix. The chemical composition of the waxes is under strong genetic control. Among the compounds constituting the cuticular waxes, *n*-alkanes have been studied extensively as chemophenetic markers in different plant families. Objective of this work was to study leaf *n*-alkane composition of seven junipers from the Balkans growing in different climates. *n*-alkanes were washed briefly from the surface of the leaves using *n*-hexane, purified using mini-columns and concentrated prior to GC-MS and GC-FID analysis. Bioclimatic data were taken from WorldClim 2.0 dataset. Phytochemical analyses showed domination of *n*-C33 alkane in all samples. Three other *n*-alkanes (C29, C31 and C35) were also present in high abundances. The *n*-alkane profile based on the dominance of long-carbon-chain *n*-alkanes varied based on the taxon. Potential influence of climate on the variability of leaf alkanes is also discussed.

Keywords: bioclimatic data, Cupressaceae, cuticule

A TAXONOMIC REVISION OF *Campanula* SECTION *Decumbentes* (CAMPANULACEAE) IN THE BALKAN PENINSULA

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Campanula hawkinsiana Hausskn. & Heldr. and *C. ramosissima* Sm. are among the poorly investigated *Campanula* species distributed in the Balkan Peninsula. *Campanula hawkinsiana* is a perennial that mostly occurs on serpentine and, less frequently, on limestone substrates at elevations from 200 to 2000 m above sea level. It inhabits rocks and screes in the mountains of northern Greece and southern Albania. *Campanula ramosissima* is an annual, occurring on limestone and flysch substrates, at elevations between 15 and 1400 m above sea level. It is distributed in southern Montenegro, western Albania, western and southern Greece and it is introduced in Italy. According to traditional classifications based mainly on the morphological features of calyx and capsules, these two species have been assigned to different

sections. Recent phylogenetic studies of the genus *Campanula* have shown that these two species are closely related, and they belong to the section *Decumbentes* together with the two species from the Iberian Peninsula (*C. decumbens* A. DC. and *C. dieckii* Lange). However, none of these published studies included a larger number of population samples of *C. hawkinsiana* and *C. ramosissima*, nor were they studied in detail at the morphological level. Moreover, during our floristic studies in the Balkan Peninsula, we observed a large morphological variability within the populations of *C. ramosissima*. In this study, molecular analyses based on DNA sequencing (ITS, cpDNA: rpl32-trnL and psbA-trnH) and AFLP fingerprinting together with classical morphometric analyses were applied to the extensive population sampling of these two species to investigate the phylogenetic relationships between them and to gain insights into morphological variability. Results showed that *C. hawkinsiana* is highly divergent from *C. ramosissima* at both the genetic and morphological levels. Molecular analyses revealed three groups within populations of *C. ramosissima* that are well defined genetically, morphologically, and geographically. Based on the obtained results, we propose a new taxonomic treatment of *C. ramosissima*.

Keywords: AFLP, Balkan Peninsula, *Campanula ramosissima*, *Campanula hawkinsiana*, cpDNA, ITS, morphometrics

***Chouardia litardierei* (Breistr.) Speta (HYACINTHACEAE) GENOME SEQUENCE**

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Valuable knowledge of the mechanisms of the speciation, one of the fundamental evolutionary processes, could be gained by exploring complex interactions among environment, phenotype, epigenotype, and genotype in a species characterized by exceptional ecological plasticity. For gathering as much information as possible on this subject, amethyst meadow squill (*Chouardia litardierei* (Breistr.) Speta), a species characterized by extreme ecological plasticity, was chosen as a study system. In-depth analysis of various aspects of local adaptation and divergence processes requires the availability of a studied species' draft genome assembly, so that (epi) genome annotations essential for interpretations of ecotypes characteristics can be performed. Here we report a high-quality genome sequence of *Chouardia litardierei*. The species has n=13 chromosomes and is characterized by a large genome with an estimated size of 4.1 Gb. Genome sequences were generated using Pacific Bioscience HiFi technology. 6,526,182 Hi-Fi reads with a total size of 94.54 Gb and an average read length of 14.5 Kb were obtained. Sequences were assembled into contigs using the hifiasm software (v. 0.16.1-r375). Chromosomal assemblies were generated with Illumina Hi-C reads (1.72 billion reads, 432.3 Gb) using the Juicer, 3d-dna, and Juicebox scaffolding tools. The final assembly comprised 13 main scaffolds, thus being in agreement with the expected chromosome number. The average GC content is 42.9%. BUSCO analysis confirmed the high completeness of the assembly, as only 2.6% of the liliopsida_odb10 dataset was missing. The high proportion of genome

repeats was confirmed. RepeatMasker screening against the curated libraries for Viridiplantae repeats (Dfam and Repbase) revealed 17.6% retrotransposons, 1.2% DNA transposons, and 1.4% simple repeats. De novo identification of repeats found 55.6% retrotransposons, 2.6% DNA transposons, and 8.1% unknown repeats. In total, 80.9% of the genome is masked with repetitive elements. The gene calling pipeline has generated 30,000 reliable protein-coding gene models.

Keywords: *Chouardia litardierei*, draft genome assembly

MORPHOLOGICAL AND PHENOLOGICAL CHARACTERIZATION OF SELECTED *Chouardia litardierei* (Breist.) Speta AND *C. lakusicii* (Šilić) Speta POPULATIONS

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Chouardia (Hyacinthaceae) is a genus restricted to Dinaric Alps that was recently described and segregated from *Scilla*. It comprises two species, *C. litardierei* (Breist.) Speta, known as a type species of periodically flooded karst fields across western parts of the Balkan Peninsula, and *C. lakusicii* (Šilić) Speta, found in dry, stony, calcareous grasslands and rock crevices of Montenegro, southern parts of Bosnia and Herzegovina, and Croatia. *Chouardia lakusicii*, as a distinct taxon, was described after vague morphological and phenological characterization of a limited number of individuals from only a few populations. Consequently, it is possible these assumed species present merely divergent ecotypes of the same polymorphic taxon. In addition, based on the ecological preferences, the third ecotype can be recognized as well, the one growing in the coastal grasslands of Northern Dalmatia, Croatia. As a part of substantially larger research activities that aim at deciphering the genomic background of the adaptive divergence process, a comprehensive common garden experiment that included 540 individuals (60 individuals from each of three selected populations from each ecotype) was set. During the 2022 vegetation season, we have measured numerous phenological and morphological characters. Based on preliminary analysis, strong contrasts among populations were observed. However, for the majority of these characters, differences were ecotype-independent, meaning they cannot be used as reliable descriptive elements. Here we present the obtained results and discuss their importance for further research on *Chouardia* as a study system for ecological divergence.

Keywords: *Chouardia*, common garden experiment, morphology, phenology

FLORISTIC NOVELTIES FROM THE ISLAND OF HVAR (SOUTHERN CROATIA)

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Island of Hvar is one of the few Dalmatian islands whose flora has been explored over a long period of time since the first half of the 19th century until our days. The first known data on the island's flora dates back to as early as 1818. According to all the available sources, 1245 plant taxa have been recorded on the island so far, including neighbouring islets. Recent botanical field study was carried out in the period between 2017 and 2022 in all seasons. Several interesting new or rare vascular plant taxa for the island were registered. The luxurious population of the rare short-living fern, *Anogramma leptophylla* (L.) Link, was found in the olive grove in the vicinity of the Stari Grad, being the fourth recent finding in Croatia. Another fern, *Adiantum capillus-veneris* L., registered on Hvar only in 1852, was found on several localities within the old town of Hvar, growing on shaded city walls within chasmophytic vegetation. Two rare South African allochthonous species, *Senecio angulatus* L. f. and *Oxalis pes-caprae* L. were found for the first time on the island. The first species shows invasive behaviour – beside several populations cultivated in gardens and graveyard, three garden escapees were found in the cities of Hvar and Jelsa. Among new island plant species is one rare, or more probably under-studied autumn flowering daffodil *Narcissus serotinus* L., flowering in large populations near city of Vrboška. The inventory of the Mediterranean temporary ponds revealed several floristic novelties, e.g. macrophytic *Ranunculus peltatus* Schrank and *Potamogeton nodosus* Poir., as well as procumbent annual grass *Crypsis schoenoides* (L.) Lam. which proliferate on the desiccated pond bottoms during the summer droughts. The same ponds keep the populations of extremely rare charophyte *Tolypella intricata* (Roth.) Leonh., being the second known locality in Croatia.

Keywords: allochthonous, Dalmatia, fern, macrophytes, plant species

FLORISTIC PECULIARITIES OF THE NATURA 2000 SITE MAČKOVEC FISHPONDS (NORTHERN CROATIA)

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NATURA 2000 site Mačkovec Fishponds (HR2001034) is one of the seven Special Areas of Conservations (SACs) in Međimurje County (Northern Croatia). The site encompasses three artificial retentions, with total area of 3 ha, subject to significant changes in water level. The site is designated as important for the preservation of

amphibian habitats of the *Littorelletea uniflorae* and *Isoeto-Nanojuncetea* vegetation, according to the Habitats Directive. Characteristic plants of these vegetation types are generally small ephemerophytes, forming short annual or perennial vegetation. This pioneer vegetation is characteristic for land and water interface zones of lakes, pools and ponds, and develops on nutrient-poor soil during periodic drying of these standing waters. The botanical inventory of this site, conducted during the summer of 2022, revealed several floristic peculiarities. Dominant plant species forming annual vegetation of dried pond floor were *Filaginella uliginosa* (L.) Opiz), *Cyperus michelianus* (L.) Link and *Eleocharis ovata* (Roth) Roem. et Schult. The latter is an endangered (EN) species with sparse distribution across Croatia. Among the vascular plants, a large population of ephemeral thalloid liverwort *Riccia cavernosa* Hoffm. was covering the bare cracked soil and the vertical faces of soil fissures. This rare short-lived bryophyte is associated with moist and fine textured substrata of the lacustrine drawdown zones. It was only recently confirmed for Croatian byoflora. Along the margins of the retentions, minute vascular plants *Lythrum portula* (L.) D. A. Webb and *Callitriche palustris* L. were registered, along with the ephemeral moss *Physcomitrium sphaericum* (C. F. Ludw. ex Schkur.) Brid., for which this is the second known site in Croatia. Rare data deficient (DD) *Elatine hexandra* (Lapierre) DC., found on this site in 2006, was not confirmed. Although the vascular and bryophyte species of *Littorelletea uniflorae* and *Isoeto-Nanojuncetea* are considered relatively rare and threatened in Europe, the low number of records in Croatia is to a considerable extent the result of insufficient research into ephemeral habitats and their flora in general.

Keywords: *Eleocharis ovata*, ephemerophytes, *Isoeto-Nanojuncetea*, *Physcomitrium sphaericum*, *Riccia cavernosa*

BIODIVERSITY LOSS DRIVERS IN FOREST FRAGMENTS OF THE AGRICULTURAL LAND BETWEEN MARIBOR AND ČAKOVEC: EUTROPHICATION AND NON-NATIVE SPECIES PRESENCE

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We present preliminary results of the bilateral Slovenian – Croatian project: “Degradation status of forest fragments in the agricultural alluvial plain of the Drava River between Maribor and Čakovec”. The key challenge, which the project addresses, is the conservation of biodiversity in agricultural landscape, specifically recognizing the importance of forest fragments trapped within intensive agricultural landscape of the fertile plain of the Drava River. Forest fragments often represent a habitat and rare shelter for many plant and animal species endangered at European and national levels. Several decades of biodiversity loss in this area is mainly driven by: a) transition from traditional to intensive land use, causing the disappearance of former landscape elements, such as forest edges and forest fragments; b) abandonment of less profitable land such as flooded areas and wooded meadows; and (c) frequent presence of anthropogenic disturbances, which allow the introduction and dispersal of weeds and invasive alien plants (IAS). Specifically, we focused on the biodiversity loss drivers operating at edges of forest fragments: weeds, alien plants and IAS

presence and their potential to intrude, nutrient deposition and soil characteristics/ composition. Results showed similar conditions for Slovenian and Croatian locations. However, indicating stronger human impact in Slovenia, if fragments were located near larger settlements, while in Croatian locations weeds were more frequently observed. Further, we discuss the degradation status of forest fragments based on the recorded conditions and species richness with particular emphasis on the importance of eutrophication and non-native species presence.

Keywords: carbon, Drava, IAS, inventory, nitrogen, soil properties

BROCCOLI SEEDLINGS EXTRACTS CHANGE THE ACTIVITY OF α -AMYLASE AND α -GLUCOSIDASE: EFFECT OF GROWING TEMPERATURE

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Plants challenged with high temperature (HT) undergo many adaptive mechanisms at molecular levels to keep normal physiological function. Such adaptations consequently influence their bioactivity. In this work, within the scope of the TEMPHYS project (IP-2020-02-7585), we investigated the effect of HT on the antidiabetic activity of broccoli (*Brassica oleracea* L. convar. *botrytis* (L.) Alef. var. *cymosa* Duch.) seedlings. The activity was spectrophotometrically assessed via the percentage of inhibition of α -amylase and α -glucosidase, enzymes required for carbohydrate digestion. Enzyme inhibitory activity was calculated from the equation: % inhibition = $100 - [(A_t - A_{tb} / A_c - A_{cb}) \times 100]$, where A_t was absorbance of test, A_{tb} was absorbance of test blank, A_c was absorbance of control, and A_{cb} was absorbance of control blank. Seedlings were grown in a climatic chamber with temperature range 23°C/16h, 18°C/8h for control group, and 38°C/16h, 33°C/8h for HT group. The extracts were prepared from freeze-dried plant material using boiling (100°C) water followed by incubation on rotary extractor for 1 hour at 23°C. The results showed that broccoli seedlings aqueous extracts were more efficient in the inhibition of α -amylase (88% relative to the standard acarbose), than α -glucosidase (67% relative to the standard acarbose). HT significantly ($p \leq 0.05$) decreased the potential to inhibit α -amylase (80%), however it improved the potential to inhibit α -glucosidase (70%). These results show that high growing temperature significantly changes the biological effects of plants; moreover, their activity toward different enzymes is specifically affected. Further more detailed analyses into the effect of global warming on cruciferous (Brassicaceae) vegetables bioactivity are needed.

Keywords: antidiabetic activity, digestive enzymes, food, global warming, microgreens

GENETIC RELATIONSHIPS AMONG *Pistacia* TAXA IN THE CROATIAN FLORA BASED ON AFLP

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In the Croatian flora the genus *Pistacia* L. (Anacardiaceae) is represented with *P. lentiscus* L., *P. terebinthus* L., their hybrid *P. × saportae* Burnat and cultivated *P. vera* L. Additionally, in 1985, Radić described *P. calcivora* Radić as an endemic taxon from the Mt. Biokovo. Aim of our research was to determine genetic relationships between four putative indigenous taxa of the genus *Pistacia* in Croatia (*P. lentiscus*, *P. terebinthus*, *P. × saportae* and *P. calcivora*) using Amplified Fragment Length Polymorphism (AFLP) molecular markers. Specifically, we aimed to determine the presence of the hybrid *P. × saportae* and to validate the presence of *P. calcivora*. For this purpose, we collected putative hybrid individuals of *P. × saportae* from the islands of Šolta, Korčula and Vis, as well as three populations of *P. calcivora* from the Mt. Biokovo, identified on the basis of leaf morphology. In addition, at each sampling site we collected individuals of both parental species (*P. lentiscus* and *P. terebinthus*). Our first preliminary results indicate the presence of two separated groups of populations. First group included all individuals of *P. terebinthus* and the individuals initially assigned to the potential taxon *P. calcivora*, suggesting that at the molecular level there is no support for the described taxon *P. calcivora*. The second group corresponded to *P. lentiscus* and included the majority of the putative hybrid individuals of *P. × saportae*. However, several putative hybrid individuals were placed between the two parental taxa, indicating that *P. × saportae* is present in Croatia.

Keywords: AFLP, Croatia, endemic species, hybrid, *Pistacia*

NEW FINDINGS OF FRESHWATER RED ALGAE FROM FAMILY LEMNACEAE (BATRACHOSPERMALES, RHODOPHYTA) IN SERBIA

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The paper presents new data about distribution of freshwater red algae from Lemnaceae family collected from 15 localities in Serbia during the summer of 2021. All samples were collected from running water with turbulent flow. Algal material was collected at depths ranging from 0 to 50 cm. Samples of red algae (sporophyte) were collected by separating the talus from the stone or rock in the aquatic environment using tweezers. Tali cross-sections were made by hand with a razor, dipped in glycerin and observed with a Carl Zeiss M1 light microscope, AxioCam MRC5 camera and AxioVision 4.9 software. Morpho-anatomical identification of collected algae was done using Zeiss Stemi DV4 stereo microscope and relevant literature. Based on morphological and reproductive characteristics, five taxa were identified: *Lemanea fluviatilis*, *L. fucina*, *L. rigida*, *Paralemanea annulata* and *P. torulosa*. The most common species in the collected material was *L. fucina*, found at six localities: the Daička River, the Lopižinska River, the Mrčki Brook, the Studena River, the Jelovička River and the Rosomačka River. *Lemanea rigida* was found at three localities: the

Pirevski Brook, the Kladnička River and the Visočica River. *Lemanea fluviatilis* was found at two localities: the Jelovička River and the Dojkinačka River. *Paralemanea catenata* was found on three localities: the Srednja River, the Vrelo River and the Dojkinačka River, while *P. torulosa* was found on one locality: the Brusnička River. Water at all investigated sites was neutral to slightly alkaline with moderately water temperature and well oxygenated. These new data about distribution and ecology of freshwater rhodophytes are important for protection and conservation of these rare and endangered algae in Serbia.

Keywords: *Lemanea*, *Paralemanea*, red algae, Serbia

PHYSIOLOGICAL AND BIOCHEMICAL RESPONSE OF *Arabidopsis thaliana* (L.) Heynh. WITH MODIFIED BPM EXPRESSION TO UV-B RADIATION

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Solar radiation is a source of energy for photosynthesis and an important signal for regulating plant growth and development. However, high light intensity and ultraviolet (UV) radiation can lead to oxidative stress in plants. The main objective of this research was to evaluate the effect of UV-B radiation on the model plant *Arabidopsis thaliana*. Photosynthetic efficiency, hydrogen peroxide (H_2O_2) content, level of lipid peroxidation, antioxidant enzyme activity and proline content were used as measurable parameters to evaluate the effect of UV-B stress on plants. In addition to the wild type, the *A. thaliana* lines with altered expression of *BPM* genes (*oeBPM1* and *amiR-bpm*) were studied. *BPM* proteins belong to the MATH-BTB (*BPM*) protein family, which is involved in the regulation of developmental processes and stress response in plants. Immunodetection of the *BPM1*-GFP protein in the *oeBPM1* line confirmed the highest accumulation of the protein after treatment with UV-B radiation dose of $\sim 800 \text{ J cm}^{-2}$. After exposure to UV-B, changes were observed in the H_2O_2 content of the wild type and the *oeBPM1* line, as well as in the antioxidant enzyme activities of the wild type, and in the maximum quantum efficiency of photosystem II in the *oeBPM1* line. The *oeBPM1* line showed a better stress response than the other two lines due to a stronger basic activity of antioxidant enzymes. The *amiR-bpm* line showed a higher H_2O_2 content and a higher level of lipid peroxidation compared to the wild type and the *oeBPM1* line. The obtained results suggest that *BPM* proteins are involved in the regulation of certain physiological and biochemical processes under both optimal and UV-B stress conditions.

Keywords: antioxidant enzymes, H_2O_2 , lipid peroxidation, MATH-BTB, photosynthetic efficiency

INVENTORY OF THE VASCULAR FLORA OF THE SUSEDGRAD FOREST PARK (ZAGREB, CROATIA)

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On the southwestern slopes of Medvednica, in the 14th century, the splendid fortified town of Susedgrad was built, of which only a dilapidated ruin remains today. The Susedgrad Forest Park belongs to the area of legally protected Medvednica Nature Park, within the city of Zagreb. Vascular flora was for the first time investigated during 2020 and 2021 vegetation seasons. A total of 164 taxa were recorded. The species are herbarized, digitalized and available through the ZAGR Herbarium online platform (<http://herbarium.agr.hr/hr>). The inventoried flora belongs to 56 families, of which the most represented are Asteraceae and Lamiaceae with nine taxa (6%) each, followed by Apiaceae, Brassicaceae, Cichoriaceae and Ranunculaceae with eight taxa (5%) each. The most frequent life forms are hemicryptophytes (46%), followed by phanerophytes (16%) and therophytes (15%). Arctic and sub-Atlantic floral element and sub-Atlantic and Eurasian are equally (16.5%) dominant. It is noticeable that in the area of Medvednica, from the phytogeographical aspect, several phytogeographical areas overlap. The inventory recorded five invasive (*Erigeron annuus*, *Veronica persica*, *Acer negundo*, *Ailanthus altissima*, and *Robinia pseudoacacia*) and eight endangered plant taxa. Today, the Susedgrad Forest Park is in a very bad condition, the vegetation is not regularly maintained, the park furniture is also in disarray, and the walls of the castle are falling into disrepair. Due to the increasing number of plants growing from the walls, for example the invasive *Robinia pseudoacacia*, the stability of the walls is further impaired causing exceptional damage. The results of this research can serve as a basis for further evaluation and preservation of this forest park as a sustainable urban natural ecosystem.

Keywords: invasive plants, Medvednica, Nature Park, ZAGR

SECONDARY SEXUAL DIMORPHISM AND CONE PHENOTYPIC VARIABILITY IN TWO ALLOPATRIC JUNIPER SPECIES: *Juniperus oxycedrus* L. AND *J. deltoides* R.P.Adams.

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Juniperus oxycedrus L. and *J. deltoides* R.P.Adams are evergreen dioecious shrubs or small trees distributed in the western and eastern Mediterranean, respectively. Both species are widespread in their natural range and grow in xeric environments, on limestone or siliceous terrain, commonly affected by fires. Due to morphological similarities, *J. deltoides* was only recently delimited as a cryptic species from *J.*

oxycedrus. In order to further investigate and analyze the distinctive characters of these two species, we studied eight morphological traits related to needles and seven traits related to cones. Since the needle morphology varies between male and female individuals in dioecious plants, we also examined morphological differences between sexes. The analyses included descriptive and multivariate statistical methods performed on data from six populations from the western and eastern Mediterranean region. The results showed that the needles of *J. oxycedrus* were slightly longer, wider, and less variable than those of *J. deltoides*. The same trend was observed in cone morphology, where *J. oxycedrus* displayed higher values in all measured cone traits, confirming the morphological distinction between the two species. Furthermore, sexual dimorphism was detected in most of the measured needle traits, especially in *J. oxycedrus*, where needles of female individuals had higher values in seven of eight morphological traits. Although this study confirmed sexual dimorphism in terms of needle morphology, there was no consistent pattern of distribution between the two species. Our results demonstrate the high diversity within juniper species in arid and semiarid ecosystems of the Mediterranean region and open the field for further studies.

Keywords: allopatric speciation, cone morphology, needle morphology, phenotypic variability, sexual dimorphism

FLORA OF SIGNIFICANT LANDSCAPE „PROLOŠKO BLATO“ (DALMATIA, CROATIA)

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Significant landscape „Prološko blato“, near the town of Imotski, was floristically researched during the three-year period (from 2019 to 2021). This resulted with 291 taxa mentioned for the first time. In total, according to available literature data and conducted fieldwork, 657 taxa of vascular flora were recorded. The paper analyzes floral elements, life forms and highlights threatened (CR – 5, EN – 2, VU – 11, NT – 18, DD – 6, LC – 7), strictly protected and 26 endemic taxa.

Keywords: Croatia, flora, Prološko blato

ANALYSIS OF „ORDER Liliaceen“ FROM THE C. STUDNICZKA'S HERBARIUM

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The large herbarium collection of Carl Studniczka is located within the Botanical Department of the Natural History Museum in Split (Herbarium Code: NHMS). The review and analysis of his extensive herbarium material began about ten years ago, as a part of the project of protection, preservation, restoration and presentation of old herbarium collections. Work on the editing of this historical collection is continuously carried out, and the purpose of this research was to analyse the part of the material that was originally designated as the Order “Liliaceen”. In total 159 herbarium sheets were found and analysed. Most of the material was collected in Europe (154 sheets), 35 of which were collected in Croatia, while the rest of the material originates from Austria, Italy, Romania, France, Czech Republic, Montenegro, Poland, Switzerland, USA, Germany, Hungary, Slovenia, Belgium, Serbia, Russia and Sweden. Most of the herbarium sheets belong to the “Flora Dalmatiens” collection. Compared to the part of Studniczka’s herbarium that has previously been analysed, some new sub-collections (Helvetischer Verein, Herbarier Oscar de Dieudonné, Magyar flora Pest megye and Wiener Tausch-Herbarium), as well as new collectors (Bayer J., Hackel, Kolombatović and Lenz Heinrich) have been recorded in this analysis. Most of the herbarium sheets were collected by Studniczka himself (85). The oldest herbarium sheet dates from 1868 while the newest one is from 1904. According to Studniczka, there are 20 genera with 93 species and six varieties within the analysed 159 herbarium sheets, which should be subjected to the current taxonomic analysis in the next step.

Keywords: flora, historical herbaria collections, Natural History Museum Split, NHMS

URBAN STOCKS OF INVASIVE ALIEN PLANTS – A CASE STUDY OF THE TOWN OF DUGO SELO

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The aim of our research was to test the susceptibility of maintained urban areas to the spread of invasive alien plants. A case study was conducted in the small town of Dugo Selo in Zagreb County, where weed maintenance and removal measures are regularly implemented. Field researches were carried out during 2012 and 2016, during which 54 plots (250 × 250 m²) were explored on an area of about 3.38 km². We recorded a total of 34 and 36 invasive plants in 2012 and 2016, respectively. All observed invasive plants belong to 18 families, of which the most represented are Asteraceae (13 taxa). Most invasive taxa originate from the Americas (65.45%), and the spectrum of life forms is dominated by therophytes (60.18%). The majority of invasive plants show competitive – ruderal (44.00%) and competitive (37.45%) CSR strategies, and 42.36% of them apply more propagation methods. Most invasive plants (29.33%) have been recorded in the habitat type “residential houses in a row with back gardens–individual houses” (J.2.2.5. according to the Croatian National Habitat Classification). During the repeated research in 2016, the increase in the number of invasive plants

does not seem large, but it is worrying that a significant increase in the number of their findings was observed on all plots (increase from 343 findings in 2012 to 550 in 2016). This is especially true for the most common, unintentionally introduced weeds *Ambrosia artemisiifolia* L., *Conyza canadensis* (L.) Cronquist and *Erigeron annuus* (L.) Desf., which is a cause for concern due to their huge potential for expansion into new areas. All this indicates the need for even more intensive and organized monitoring and management of invasive alien plants in urban areas, in particular weeds, in order to prevent their spread, especially to native areas.

Keywords: mapping, non-native species, northwest Croatia, spatial distribution, urban habitats, weeds

INVASIVE ALIEN WEED *Conyza canadensis* (L.) Cronquist IN URBAN AREAS OF THE ZAGREB COUNTY

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Conyza canadensis (L.) Cronquist (Canadian fleabane) is a common and widespread alien invasive plant in Croatia, first recorded in 1847. However, systematic research on its occurrence and possible spread has not been conducted so far. Therefore, the aim of our work was to show the spatial distribution of Canadian fleabane in urban areas of Zagreb County and to detect its possible spread. Therefore, in 2012 the species was mapped in all nine towns of Zagreb County, on approximately equal plots (250 × 250 m²). Furthermore, in 2016, the survey was repeated on the same plots in the towns of Dugo Selo (eastern part of the County) and Samobor (western part of the County), in order to determine the possible spread of the species. A total of 541 plots were surveyed in all towns in 2012, and *C. canadensis* was found on 362 plots (66.9%). In Ivanić Grad, the plant was found on 44 of the 73 surveyed plots, in Jastrebarsko on 32 of 48, in Sveti Ivan Zelina on 21 of 44, in Sveta Nedjelja on 19 of 31, in Velika Gorica on 33 of 76, in Vrbovec on 24 of 48, in Zaprešić on 39 of 58, in Dugo Selo on 21 of 54, and in Samobor on 71 of 109 investigated plots. A comparative analysis of the spatial distribution of Canadian fleabane between two “opposite” towns of the County showed a significant increase in the areas covered by *C. canadensis* in a four-year period: in 2016, it was recorded in Dugo Selo on all 54 plots, and in Samobor on 87 plots. It was additionally observed that the increase in the both areas is more significant in suburban and rural parts of the towns, and less in the urban parts, probably due to more regular maintenance.

Keywords: Canadian fleabane, mapping of invasive alien plants, northwest Croatia, spatial distribution

EFFECT OF PROTEINS, CARBOHYDRATES AND OILS ON PHYTOCHEMICAL BIOAVAILABILITY AND BIOACTIVITIES OF GINKGO LEAF EXTRACT

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The main goal of our study was to evaluate the effect of proteins (40 g/L casein), carbohydrates (25 g/L glucose) and oils (5% olive oil) on phytochemical bioavailability, antioxidant, antidiabetic and weight loss activity of ginkgo leaves standardized extracts after *in vitro* gastrointestinal digestion. Spectrophotometric methods were used to determine the concentration of total phytochemicals (TP: total phenols, TF: total flavonoids, TPA: total phenolic acids, TFLA: total flavanols, TFLO: total flavonols, TPAN: total proanthocyanidins and TTL: total triterpene lactones), antioxidant (DPPH and FRAP), antidiabetic (inhibition of α -glucosidase and BSA glycation) and weight loss (inhibition of lipase) activity. Ginkgo olive oil formulation had the highest TFLO, TFLA, TPAN and TTL bioavailability after *in vitro* gastrointestinal digestion. The highest TF and TPA bioavailability had ginkgo casein formulation. In the ginkgo water formulations, the highest TP bioavailability was detected. All ginkgo formulations had high (>70%) antioxidant activity (DPPH and FRAP), high (>70%) enzyme (α -glucosidase and lipase) inhibitory activity and high (>70%) inhibition of BSA glycation after *in vitro* digestion. According to our results, ginkgo formulation with olive oil has proved to be the formulation with the highest bioavailability of polyphenolic groups and terpene lactones after *in vitro* gastrointestinal digestion.

Keywords: antidiabetic activity, antioxidant activity, bioactive compounds, *Ginkgo biloba* L., weight loss

INFLUENCE OF PHOSPHORUS NUTRITION ON LEAF FUNCTIONAL TRAITS OF COMMON BEECH AND SESSILE OAK SAPLINGS

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This research was conducted on five-year-old saplings of common beech (*Fagus sylvatica* L.) and sessile oak (*Quercus petraea* (Matt.) Liebl.) originating from two mature mixed beech-oak stands from Croatia. One stand is from the Slavonski Brod provenance and one from the Karlovac provenance. These two provenances are characterized by similar orographic and edaphic (chemical composition and mechanical soil structure) conditions, but differ in climate, especially in precipitation. In Slavonski Brod average total annual precipitation is 770 mm (dry provenance) and in Karlovac 1112 mm (wet provenance). The aim of this study was to examine the influence of different phosphorus concentrations in the substrate on leaves' functional traits (phosphorus concentration in leaves, leaf dry matter content (LDMC), leaf mass per area (LMA), etc.) in beech and oak saplings originating from dry and

wet provenance. During 2021, after the establishment of field trial, the saplings grew into two types of substrates. One type of substrate was a treatment with an increased phosphorus concentration (+P) and another type of substrate was a treatment with a lower phosphorus concentration (-P). The results showed that in the +P treatment there was a significant increase in the concentration of phosphorus in the leaves of both species originated from both provenances. However, LDMC and LMA in the +P treatment were significantly higher than the -P treatment in common beech, while LDMC and LMA in sessile oak were the same in both treatments. Saplings originating from dry provenance had a significantly higher LDMC and LMA than saplings from wet provenance. Research has shown that different phosphorus concentrations have different effects on the leaves' functional traits depending on the species and provenance.

Keywords: Croatia, *Fagus sylvatica*, LDMC, LMA, provenance, *Quercus petraea*

ANALYSIS OF COWSLIP POPULATIONS (*Primula veris* L.) IN THE MUNICIPALITY OF MRKOPALJ (GORSKI KOTAR)

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The cowslip growing in grassland areas and forest edges is widely recognized as a threatened species due to the continuous extinction of these valuable habitats. It is a perennial, herbaceous plant with green elongated leaves up to 20 cm long, multiple stems, and flowers with orange dots, blooming in clusters of 5-16. The cowslip is heterostylous, occurring as S-morph (short female reproductive organ and longer male reproductive organs visible from above) and L-morph (visible long female and shorter male reproductive organ). The aim of the study conducted in May 2022 was to determine the state of cowslip populations and frequency of S- and L-morph at the three study sites - Mrkopalj, Matić Poljana, and Begovo Razdolje in the Mrkopalj municipality. The municipality of Mrkopalj is located in the southeastern part of Gorski kotar (Croatia). The area is covered with fertile arable land (today mostly uncultivated), as well as with forests, pastures, and meadows rich in biodiversity. In recent years, the natural overgrowing of arable lands and grasslands in this area has become more pronounced and expressed in the loss of species and landscape diversity. The cowslip populations were found in meadows, usually mown for hay. A total of 350 cowslips were counted. The frequencies of the S- and L-morph (S / L) at the studied sites were 59.09% / 40.90%, 59.66% / 40.33% and 42.97% / 57.02%, respectively. The results indicated variations in the development and frequency of S- and L-morphs at studied sites, which may lead to the population decline.

Keywords: Croatia, heterostyly, meadows, *Primula veris*, semi-natural grasslands

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