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Croatian Ecological Society

4. HRVATSKI SIMPOZIJ O INVAZIVNIM VRSTAMA
s međunarodnim sudjelovanjem

4th CROATIAN SYMPOSIUM ON INVASIVE SPECIES
with International Participation

29-30. XI 2021 .
Zagreb, Hrvatska

ZBORNIK SAŽETAKA
BOOK OF ABSTRACTS

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tigrasti komarac / tiger mosquito (*Aedes albopictus)* – Lana Schmidt
signalni rak / signal crayfish (*Pacifastacus leniusculus)* – Ivana Maguire
grozdasta kaulerpa / seaweed (*Caulerpa cylindracea)* – Ante Žuljević

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BOOK OF ABSTRACTS

Zagreb, 2021.

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4. HRVATSKOG SIMPOZIJA O INVAZIVNIM VRSTAMA

BOOK OF ABSTRACTS
OF THE 4th CROATIAN SYMPOSIUM ON INVASIVE SPECIES

Urednik / Editor

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Sven D. Jelaska

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Poštovane kolegice i kolege!

Protekle dvije godine bile su obilježene SARS-CoV-2 virusom, i njegovim negativnim utjecajem na sve segmente našeg života. Mnogi od nas iskusili su te posljedice i osobno, kao i ostali bez svojih bližnjih i suradnika. Među njima je i Prof. Gábor Vétek (Szent István University, Mađarska) koji je bio sudionik i član znanstvenog odbora prethodnih Simpozija. Nedostaje nam njegova izrazita stručnost, ali i divna osobnost koja ga je krasila. Njegova predanost istraživanju invazivnih vrsta, bila nam je dodatni poticaj da se ipak odlučimo na organizaciju Simpozija u „klasičnom“ obliku, koji je nezamjenjiv u razmjeni znanja i ideja, kao i uspostavljanju budućih suradnji.
Da mnogi dijele takvo mišljenje, dokazuje i preko 100 sudionika iz 11 Europskih država prijavljenih na ovaj 4. Simpozij. Kroz dva pozvana predavanja, 34 usmena i 45 posterskih priopćenja biti će prikazane najnovije spoznaje, rezultati i smjerovi istraživanja stranih i invazivnih vrsta, te ostalih aspekata poput praćenja, kontrole, uključivanja javnosti i mnogih drugih. Želimo svima dva informativna i konstruktivna dana Simpozija, kao i sklapanje nekih novih kontakata koji će rezultirati suradnjama za pamćenje, poput one naše s Prof. Gábor Vétek-om.

U ime Organizacijskog odbora
Sven Jelaska
Predsjednik Hrvatskog ekološkog društva

Honourable colleagues!

The SARS-CoV-2 virus and its negative impacts on all segments of our lives have marked the past two years. Many of us have experienced these consequences personally, as have those who lost their loved ones and colleagues. Among them is Prof. Gábor Vétek (Szent István University, Hungary) who was a participant and member of the Scientific Committee of previous Symposia. We miss his distinct expertise, but also the wonderful personality that adorned him. His commitment to research on invasive species was an additional incentive for us to decide to organize the Symposium in a "classical" form, which is indispensable in the exchange of knowledge and ideas, as well as the establishment of future collaborations.
That many share this opinion is proven by over 100 participants from 11 European countries registered for this 4th Symposium. Through two invited lectures, 34 oral and 45 poster presentations, the latest findings, results and directions of research of alien and invasive species, as well as other aspects such as monitoring, control, public involvement and many others will be presented. We wish everyone two informative and constructive days of the Symposium, as well as making some new contacts that will result in collaborations to remember, such as was ours with Prof. Gábor Vétek.

On behalf of the Organising Committee
Sven Jelaska
President of the Croatian Ecological Society

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PROGRAMME OF THE SYMPOSIUM

Programme of the 4th Croatian Symposium on Invasive Species

Monday 29th November

08:30 – 09:30	Registration and poster setup
09:30 – 10:00	Opening of the Symposium
10:00 – 10:45	Keynote lecture Bruce Osborne *Gunnera* INVASIONS AND THEIR WIDER IMPLICATIONS
10:45 – 11:15	Coffe Break
11:15 – 12:45	Chairperson: Sven Jelaska 11:15 Daijun Liu, Franz Essl, Bernd Lenzner, Dietmar Moser, Stefan Dullinger HOW DOES LAND-USE CHANGE AFFECT THE OCCURRENCE OF ALIEN SPECIES IN LOCAL COMMUNITIES ACROSS THE GLOBE? 11:30 Petra Kutleša, Igor Boršić, Martina Cigrovski Mustafić, Ana Ješovnik, Tanja Mihinjač, Sandra Slivar THE RESULTS OF THE FIRST SYSTEMATIC MAPPING OF ALIEN SPECIES IN CROATIA 11:45 Jurica Tadić, Matea Rubinić, Lucia Perković, Nela Jantol, Ana Đanić, Zrinka Mesić RISK ASSESSMENT OF SELECTED INVASIVE ALIEN PLANT SPECIES USING NON-NATIVE RISK ASSESSMENT METHODOLOGY IN CROATIA 12:00 Kateřina Berchová Bímová, Martina Kadlecová, Martin Vojík, André Evette, Fanny Dommanget, François-Marie Martin, Josef Kutlvašr, Jan Pergl SHOULD REPRODUCTION MODE IN KNOTWEEDS CHANGE THE MANAGEMENT APPROACH? 12:15 Tim Adriaens, Jim Casaer, Lieven De Smet, Koen Devos, Frank Huysentruyt, Peter Robertson, Tom Verbeke, Nikolaas Reyns COST-BENEFIT ANALYSIS FOR INVASIVE SPECIES CONTROL: THE CASE OF GREATER CANADA GOOSE *Branta canadensis* IN FLANDERS (NORTHERN BELGIUM) 12:30 Andreja Papež Kristanc, Andrej Štembergar Zupan, Ana Dolenc, Sonja Rozman, Kaja Frlic MANAGEMENT OF INVASIVE ALIEN SPECIES IN SLOVENIA –FROM FIELDWORK TO THE NATIONAL DATABASE
12:45 – 14:30	Lunch Break
14:30 – 15:45	Chairperson: Dinka Matošević 14:30 Manuela Giovanetti, Laura Zavatta, Sergio Albertazzi, Simone Flaminio, Rosa Ranalli, Laura Bortolotti READINESS TO REDIRECT NESTING EFFORTS AS WINNING STRATEGY TO SPREAD: THE ALIEN BEE SPECIES, *Megachile sculpturalis* (HYMENOPTERA; MEGACHILIDAE) 14:45 Nikola Zorić COMBINED METHOD OF MONITORING Monochamus spp. USING TRAPS AND UNMANNED AERIAL VEHICLES

	15:00 Marina J. Orlova-Bienkowskaja, Andrzej O. Bieńkowski INVASIVE EMERALD ASH BORER (*Agrilus planipennis*) IS APPROACHING THE CAUCASUS 15:15 Nina Šajna, Mirjana Šipek, Eva Horvat A NOVEL PLANT – ANIMAL INTERACTION BETWEEN TWO ALIEN SPECIES RESULTS IN UNEXPECTED BENEFITS 15:30 Laura Pismarović, Valentina Šoštarčić, Kristina Kljak, Maja Šćepanović EFFECT OF COMBINING REDUCED DOSES OF HERBICIDES WITH PHENOLIC ACIDS TO REDUCE GERMINATION AND GROWTH *Ambrosia artemisiifolia* L
15:45 – 16:45	Poster Session & Coffe Break
16:45 – 18:15	Chairperson: Quentin Groom 16:45 Nela Jantol, Matko Čvrljak, Ivan Tomljenović, Ivona Žiža, Branimir Radun, Zrinka Mesić TESTING REMOTE SENSING METHODS FOR INVASIVE ALIEN PLANTS *Ailanthus altissima* AND *Amorpha fruticosa* 17:00 Lucija Rajčić, Sven D. Jelaska IMPACT OF SPATIAL PRECISION OF CHOROLOGICAL DATA ON SUPPOSED HABITAT AND ENVIRONMENTAL CONDITIONS PREFERENCES OF SIX INVASIVE PLANT SPECIES IN CROATIA 17:15 Robert T. Hanczaruk, Agnieszka Kompała-Bąba, Wojciech Bąba FUNCTIONAL ANALYSIS OF THE URBAN RIVER VEGETATION ALONG THE ENVIRONMENTAL GRADIENT 17:30 Danijela Poljuha, Barbara Sladonja, Mirela Uzelac, Ida Linić, Ivana Šola, Josipa Bilić, Slavica Dudaš INVASIVE ALIEN PLANT SPECIES IN CROATIA AS NEW ECOSYSTEM SERVICES PROVIDERS 17:45 Najla Baković, Dubravko Šincek, Tajana Uzelac Obradović, Sanja Žalac, Friederike Trognitz PRESENCE OF INVASIVE PLANT SPECIES ON THE GRASSLANDS IN RELATION TO THE NEARBY ROADS IN THE PLITVICE LAKE NATIONAL PARK AND SELECTED KARST POLJES (CROATIA) 18:00 Jasnica Medak, Ivana Sirovica, Sanja Perić, Nikola Zorić NEW FINDINGS OF AN INVASIVE *Prunus serotina*: A CASE STUDY FROM CROATIA
19:00 - 22:00	Beervasive evening

Tuesday 30th November

08:30 – 09:00	Registration
09:00 – 09:45	Keynote lecture Elena Tricarico AWARE AND ACTIVE CITIZENS TO TACKLE INVASIVE ALIEN SPECIES
09:45 – 10:45	Chairperson: Sven Jelaska 09:45 Quentin Groom, Helen Roy ALIEN CSI: INCREASING UNDERSTANDING OF ALIEN SPECIES THROUGH CITIZEN SCIENCE 10:00 Sandra Slivar, Ana Ješovnik, Petra Kutleša, Tanja Mihinjač, Vesna Tatalović THE SURVEY RESULTS OF THE PUBLIC OPINION ON THE IAS IN CROATIA 10:15 Lucija Novoselec, Arvena Bošnjak, Ana Depolo, Mihaela Jakopčić, Lana Židak, Sandra Hudina EXPLORING THE KNOWLEDGE AND APPLICATION OF BIOSECURITY PRACTICES IN FIELD RESEARCH AMONG RESEARCHERS IN CROATIA 10:30 Vedran Šegota, Antun Alegro, Miroslav Samardžić, Fran Rebrina, Andreja Brigić INVASIVE MOSS *Campylopus introflexus* (HEDW.) BRID. CONTINUES TO SPREAD THROUGH CROATIA
10:45 – 11:15	Poster Session & Coffe Break
11:15 – 12:30	Chairperson: Elena Tricarico 11:15 Ivana Buj, Zoran Marčić, Kazimir Miculinić, Ivanka Špoljarić et al. REMOVAL OF INVASIVE FISH SPECIES FROM THE PLITVICE LAKES WATER SYSTEM HELPS INCRESING VIABILITY OF NATIVE FISH SPECIES AND RESTORING NATURAL HABITAT CONDITIONS 11:30 Marina Piria, Tena Radočaj, Ivan Špelić, Lorenzo Vilizzi THE TRUTH BEHIND THE FISH DIVERSITY OF THE LIKA RIVER AND ITS TRIBUTARIES: ARE ALL MANAGEMENT EFFORTS WORTH IT? 11:45 Milorad Mrakovčić, Matija Kresonja, Branko Glamuzina, Juraj Petravić, Krešimira Trgovčić STRUCTURE AND CHARACTERISTICS OF THE FISH COMMUNITY IN THE NERETVA DELTA (CROATIA) AFTER THE INTRODUCTION OF LARGEMOUTH BASS, *Micropterus salmoides* (Lacepède, 1802) 12:00 Juraj Petravić, Matija Kresonja, Branko Glamuzina, Milorad Mrakovčić DIETARY COMPOSITION OF LARGEMOUTH BASS, *Micropterus salmoides* (Lacepède, 1802) IN THE LOWER COURSE OF THE NERETVA RIVER IN CROATIA 12:15 Tvrtko Dražina, Maria Špoljar, Mirela Sertić Perić, Žanet Bilić, Natalia Kuczyńska-Kippen, Ines Tkalčec INVASIVE FISH SPECIES HAVE A NEGATIVE EFFECT ON ZOOPLANKTON ASSEMBLAGES IN SHALLOW WATER BODIES
12:30 – 14:15	Lunch Break

14:15 – 15:15	Chairperson: Sandra Hudina 14:15 Leona Lovrenčić, Martina Temunović, Riho Gross, Marin Grgurev, Ivana Maguire CONSERVATION OF THE CROATIAN NOBLE CRAYFISH POPULATIONS CONFRONTED WITH INVASIVE CRAYFISH AND CLIMATE CHANGE – WHEN POPULATION GENETICS MEET SPECIES DISTRIBUTION MODELLING 14:30 Ljudevit Luka Boštjančić, Caterina Francesconi, Christelle Rutz, Lucien Hoffbeck, Laetitia Poidevin, Arnaud Kress, Japo Jussila et al. IS THE IMMUNE RESPONSE OF FRESHWATER CRAYFISH TO APHANOMYCES ASTACI INFLEUNCED BY THE HOST-PATHOGEN COEVOLUTION? 14:45 Caterina Francesconi, Ljudevit Luka Boštjančić, Lena Bonassin, Jenny Makkonen, Anne Schrimpf, Japo Jussila et al. *Aphanomyces astaci* VS FRESHWATER CRAYFISH: A STORY OF DEATH, RESISTANCE AND COEVOLUTION 15:00 Anita Tarandek, Paula Dragičević, Dorotea Grbin, Ivana Maguire, Sofija Ana Blažević, Lucija Abramović, Sandra Hudina COMPARISON OF THE IMMUNE RESPONSE OF NATIVE AND INVASIVE ALIEN SPECIES OF DECAPOD CRAYFISH OF THE KORANA RIVER
15:15 – 15:45	Coffe Break
15:45 – 16:45	Chairperson: Ivana Maguire 15:45 Paula Dragičević, Ana Bielen, Ines Petrić, Jurica Žučko, Sandra Hudina MICROBIOME OF THE SUCCESSFUL FRESHWATER INVADER, THE SIGNAL CRAYFISH, AND ITS CHANGES ALONG THE INVASION RANGE 16:00 Ana Bielen, Dorotea Grbin, Anđela Miljanović, Dora Pavić, Sandra Hudina, Jessica Rieder, Simone R. R. Pisano, Irene Adrian-Kalchhauser EXOSKELETON MICROBIAL COMMUNITIES OF CO-OCCURRING AND PHYLOGENETICALLY RELATED NATIVE AND INVASIVE CRAYFISH SPECIES 16:15 Romana Gračan, Ana Bekavac, Ana Beck, Ivana Maguire, Sandra Hudina FIRST RECORD OF IDIOPATHIC NECROTIZING HEPATOPANCREATITIS IN THE SIGNAL CRAYFISH *Pacifastacus leniusculus* (DANA, 1852) IN CROATIA 16:30 Katarina Bačnik, Denis Kutnjak, Silvija Černi, Ana Bielen, Sandra Hudina DETECTION OF DIVERSE AND DIVERGENT RNA VIRUSES OF THE INVASIVE SIGNAL CRAYFISH AND THEIR VARIATION ALONG THE HOST'S INVASION RANGE
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Damjana Levačić, Sven D. Jelaska
OVERVIEW OF PLANT LIFE TRAITS AVAILABILITY FOR INVASIVE PLANTS IN CROATIA – FIRST RESULTS

Nenad Jasprica, Sanja Kovačić, Vanja Stamenković
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ALIEN AND INVASIVE MOLLUSCS IN THE CROATIAN FRESHWATERS

Anđela Miljanović, Dorotea Grbin, Dora Pavić, Maja Dent, Igor Jerković, Zvonimir Marijanović, Sandra Pedisić, Ivana Maguire, Ana Bielen
NATURAL PRODUCTS INHIBIT THE LIFE STAGES OF *Aphanomyces astaci*, AN INVASIVE PATHOGEN OF FRESHWATER CRAYFISH

PLENARNA PREDAVANJA

KEYNOTE LECTURES

Gunnera INVASIONS AND THEIR WIDER IMPLICATIONS

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Globally, *Gunnera* invasions have a restricted, but locally significant, distribution and are limited to high rainfall super-humid environmental conditions. Whilst most of these populations are comprised of one species, *G. tinctoria*, there are records of naturalised *G. manicata,* although this is complicated by the formation of hybrids between the two species and difficulties in identification. Although the origins of the naturalised populations are not known many have persisted for over 60 years based on dating evidence and anecdotal information and are likely to have arisen as garden escapes via multiple introductions. Growth of *G. tinctoria* is almost totally dependent on its N fixing capability through a symbiotic association with cyanobacteria, and is initiated early prior to that of resident species, largely through the remobilization of nutrients from the rhizome. In contrast, young seedlings germinate late in the year when the growth of resident species has finished, and this may be supported by its N fixing capability. In areas invaded by *G. tinctoria* there are marked reductions in the standing vegetation with the elimination of most of the resident species and reductions in the abundance and biodiversity of the seedbank. Conversely, *G. tinctoria* invasions are associated with a major reduction in soil greenhouse gas emissions and an increase in earthworm abundance and diversity, as well as modifications in the microbial community. Despite these modifications there is no evidence of any significant changes in soil C and N stocks despite an almost 6-fold increase in litter inputs, which we attribute to concomitant reductions in root-associated C due to the lower below ground biomass of invasive populations. Overall, these results indicate the complexity of factors that may underlie successful plant invasions and the impacts that they have. Although there have been many attempts to make generalisations about the traits associated with successful plant invaders, these have largely been unsuccessful and the evidence from *G. tinctoria* complicates this even further. How can an unusual species, like *G. tinctoria,* that is almost totally dependent on symbiotic N fixation, with very specific ecological requirements, become a successful invader? Or could it be that most species can become successful invaders when introduced into areas outside their native range given the appropriate combination of circumstances?

Key words*: Gunnera tinctoria*, ecology, origins, ecosystem impacts, invasive success

AWARE AND ACTIVE CITIZENS TO TACKLE INVASIVE ALIEN SPECIES

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Biological invasions are rapidly increasing and the inadequate public awareness towards this problem and their mismanagement are the main constraints for prevention and mitigation of their impacts. It is thus crucial to increase public awareness on invasive alien species (IAS) through well-planned and focused communications strategies for different target groups and stakeholders. The importance of programmes related to public awareness is underlined also in the EU Regulation 1143/2014 as one of the means to favour the cooperation among Member States. Aware and active citizens can be indeed involved in tackling IAS following voluntary instruments such as the European codes of conduct on IAS, participating in citizen science initiatives (and even in some management activities) and becoming multipliers of knowledge. Some examples of communication campaigns and instruments to increase awareness present in Europe will be provided. Finally, I will focus on the project Life ASAP (Alien Species Awareness Program; GIE/IT/001039: 2016-2020), that aimed at increasing the awareness and the active participation of citizens concerning the problem of IAS in Italy and promoting their efficient management in accordance with the EU Regulation 1143/2014. The project targeted different stakeholders and actors, and produced important outputs such as technical guides, guidelines, campaigns, educational kits and materials, and laboratory for kids.

Keywords: awareness, management, code of conduct, stakeholders

USMENA PRIOPĆENJA

ORAL PRESENTATIONS

HOW DOES LAND-USE CHANGE AFFECT THE OCCURRENCE OF ALIEN SPECIES IN LOCAL COMMUNITIES ACROSS THE GLOBE?

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Human-driven land use changes and species invasion are among the major threats to biodiversity worldwide. However, how land use changes affect the degree of invasion in local species assemblages has not yet been assessed at the global scale. We analyze the relative richness of alien species (i.e., the ratio of alien to all species) of local terrestrial species assemblages in relation to land use types by compiling the PREDICTS dataset with five global alien species distribution datasets for ants, birds, mammals, spiders and vascular plants. Across all taxonomic groups, we find that 10% of local assemblages include alien species occurrences. Additionally, islands and coastal regions emerge as regions with high alien ratios. The site alien probabilities are significantly different among the taxonomic groups, with highest for spiders (0.19) and lowest for vascular plants (0.05). Highly modified land-use types like plantations, croplands, pastures and urban areas have higher alien ratios compared to primary and secondary vegetation. Our results highlight that the degree of invasion of a local community is related to the land use type prevailing at a specific site.

Keywords: Land use pressure, species invasion, local biodiversity, alien ratios,

THE RESULTS OF THE FIRST SYSTEMATIC MAPPING OF ALIEN SPECIES IN CROATIA

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In Croatia, there is more than 900 alien species of animals, plants, fungi and other groups of organisms. As part of the project "Establishment of the National Monitoring System for Invasive Alien Species" from May 2019 to February 2021 the Institute for Environment and Nature has conducted first systematic field survey at the national level on selected alien and invasive alien species (IAS). We have collected data for freshwater macrozoobenthos, freshwater crayfish, freshwater fishes, amphibians and reptiles, mammals and vascular plants. Methodologies for collected field data were based on the known distribution and biology of priority species from the Union list and the presence of suitable habitats with lack of data in the territory of Croatia. Through two years of field survey, there was around 27.000 records for 116 alien species. Beside field survey, we have also collected literature data for marine species and pest species in forestry and agriculture. All of the collected data are publicly available through the IAS information system, which is a part of the Croatian Nature Protection Information System. Collected data are the basis for monitoring of IAS and preparation of action plans on the pathways of invasive alien species and management measures of invasive alien species of Union concern that are widely spread. The data will also be used for public awareness on IAS and citizen science programs to prevent further spread of IAS and introduction of new alien species. In this presentation, we will present the results of the mapping of alien species with focus on the efficacy of conducted field survey to collect data for specific taxonomic groups and species.

Keywords: invasive species, IAS, field survey, information system, data collection

RISK ASSESSMENT OF SELECTED INVASIVE ALIEN PLANT SPECIES USING NON-NATIVE RISK ASSESSMENT METHODOLOGY IN CROATIA

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Invasive alien species (IAS) are introduced naturalized species with high rate of reproduction and spread that have destructive effects to native ecosystems, human health, and economy. Nevertheless, each introduced species will not become invasive, nor will every population of the IAS show invasive character. The procedure for assessing the risk of introduction and spread of IAS identifies species with high probability of showing invasive character in the area outside its natural range, identifies related risks and determines mitigation measures to prevent or reduce these risks. Risk assessment was carried out for Croatia according to the "*non-native nisk assessment*" methodology for the following species: *Amorpha fruticosa*, *Reynoutria japonica*, *Reynoutria sachalinensis*, *Reynoutria* x *bohemica*, *Solidago canadensis* and *Solidago gigantea*. This risk assessment methodology was chosen as the precise tool for assessing the individual species potential for entry, establishment and spread, as well as possible environmental, economic, and social impacts. It is based on extensive literature review including species biology and ecology, data on natural and potential range, pathways of introduction and spread, climate change effects, and impacts on human health, safety, and economy in the assessment process and enabling evaluation of impact probability in the risk assessment area and level of uncertainty. Assessment objectivity was ensured by content quality control carried out by two independent experts. Results show that in Croatia all analyzed species, except *R. sachalinensis*, show high invasive character with estimated high probability of their introduction, high potential for spread, and consequently their impact was assessed as high. The species *R. sachalinensis* is considered to be less invasive because of its lower potential for spread and moderate probability of introduction and establishment.

Keywords: IAS, NNRA, false indigo-bush, knotweed, goldenrod

SHOULD REPRODUCTION MODE IN KNOTWEEDS CHANGE THE MANAGEMENT APPROACH?

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Alien knotweeds (*Fallopia* ssp., *Reynoutria* ssp. complex) are one of the most invasive species in Europe and cause serious problems in nature protection. Once established, they form vast stands and almost completely outcompete native species. Besides human-made habitats, knotweeds mainly occupy riparian vegetation where periodical disturbance occurs. Such habitats enable both generative and vegetative reproduction. Vegetative reproduction prevails in all knotweed taxa and the overwhelming majority of localities. However, there are several localities in Europe with high cytological and genetic variability, which suggests ongoing generative reproduction. In this study, we describe cytological and genotype variability (using Simple Sequence Repeats, SSRs) from localities in France, Germany, the Czech Republic, and Croatia. In addition, we studied the seed production of particular clone variants and seedling vitality. The localities differ in number of cytotypes and genotypes in particular taxa, as well as in seed production and germination of particular genotypes (octoploid seeds showed about 10% higher germination compared to hexaploids). At specific localities, which we assume as invasion hot spots, octoploid cytotypes of the hybrid *F.* × *bohemica* (2n = 88) and high genotype variability of octoploids were found. In the Czech Republic, genotype variability was mainly found in hexaploid hybrids. Low variability was found in German and Croatian populations. In addition, seedlings of specific parental combinations reveal high fitness and vitality. Our results stress the importance of cytological and genotype variability observed in the field which is obviously the result of generative reproduction. Hybridisation, backcrossing, and polyploidization are therefore considered as important driving forces in the invasive process. We suggest the general approach to knotweed management should change based on the knowledge of generative mode of reproduction presence. The presence of hybrids increases the competitive and invasive ability of knotweeds, and native vegetation in such localities can be completely destroyed as was repeatedly described.

Keywords: cytology, genotype variability, microsatellites, generative reproduction, seedlings fitness, germination

COST-BENEFIT ANALYSIS FOR INVASIVE SPECIES CONTROL: THE CASE OF GREATER CANADA GOOSE *Branta canadensis* IN FLANDERS (NORTHERN BELGIUM)

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Sound decisions on control actions for established invasive alien species (IAS) require information on ecological as well as socio-economic impact of the species and of its management. Cost-benefit analysis provides part of this information, yet has received relatively little attention in the scientific literature on IAS. We applied a bio-economic model in a cost-benefit analysis framework to greater Canada goose, an IAS with documented social, economic and ecological impacts in Flanders (northern Belgium). We compared a business as usual (BAU) scenario which involved non-coordinated hunting and egg destruction with an enhanced scenario based on a continuation of these activities but supplemented with coordinated capture of moulting birds. To assess population growth under the BAU scenario we fitted a logistic growth model to the observed pre-moult capture population. Projected damage costs included water eutrophication and damage to cultivated grasslands and were calculated for all scenarios. Management costs of the moult captures were based on a representative average of the actual cost of planning and executing moult captures. Comparing the scenarios with different capture rates, different costs for eutrophication and various discount rates, showed avoided damage costs were in the range of 21.15 M€ to 45.82 M€ under the moult capture scenario. The lowest value for the avoided costs applied to the scenario where we lowered the capture rate by 10%. The highest value occurred in the scenario where we lowered the real discount rate from 4% to 2.5%. The reduction in damage costs always outweighed the additional management costs of moult captures. Therefore, additional coordinated moult captures could be applied to limit the negative economic impact of greater Canada goose at a regional scale.

Keywords: Management costs, Moult capture, Damage costs, Present value, Logistic growth model

MANAGEMENT OF INVASIVE ALIEN SPECIES IN SLOVENIA –FROM FIELDWORK TO THE NATIONAL DATABASE

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Invasive Alien Species (IAS) are one of the major threats to biodiversity and its related ecosystem services, making IAS management a crucial part in an attempt to diminish its impact. In Slovenia, IAS management is conducted by several institutions, societies/associations, NGOs, local communities and individuals. Here we present the IAS management experiences coordinated by the Institute of the Republic of Slovenia for Nature Conservation (IRSNC), and solutions developed for field actions monitoring in Slovenia. Since 2019, IRSNC has been systematically organising field actions, although prior to this, some smaller scale events were carried out in biodiversity hotspots. In recent years the focus has shifted towards managing IAS listed on 'the Union list' IAS, based on the Regulation (EU) 1143/2014 which outlines the prevention and management of the introduction and spread of invasive alien species and species that have shown increased dispersion potential in Slovenia. In order to develop long-term solutions for IAS management, a cooperation between different government sectors, such as water management and forestry, has been established in the interim. The in-situ work organised by the cross-sector cooperation has been financed through a number of different projects. Due to a lack of coordination among different actors, crucial information is difficult to locate and often lost. As the continuation of IAS management is pivotal, the IRSNC has made a database layer on the widely available online nature conservation information platform. The database ensures all in situ work data is gathered in that one location. It is presented in the form of geographical metadata and includes key information about the site manager, location, managed species, methods of management and the consequent success.

Keywords: IAS management, cross-sector cooperation, geographical metadata, long-term monitoring

READINESS TO REDIRECT NESTING EFFORTS AS WINNING STRATEGY TO SPREAD: THE ALIEN BEE SPECIES, *Megachile sculpturalis* (HYMENOPTERA; MEGACHILIDAE)

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Animal species success is linked to a combination of suitable ecological conditions coupled with behavioural plasticity. The latter is certainly a key element especially for the spread of alien species. *Megachile sculpturalis* is an East-Asian solitary bee accidentally introduced in France that quickly spread in many European countries. While numerous publications refer to its distribution, crucial aspects of its reproductive biology are still poorly known. In 2020, we carried out focal observations on marked individuals nesting in an artificial structure (beehotel) in the city of Bologna. During one month of daily observations, we individually marked 52 females and followed their activity across 10583 records. We assigned behavioural patterns to nest or foraging activities and verified the recurrence of behavioural schemes linked with the nesting cycle and, possibly, with this alien bee species successful expansion. We depicted main behavioural sequences at nest and recorded inter- and intraspecific aggressions. Unexpectedly, we also witnessed a relatively readiness of females in redirecting their nesting activity towards new nests, following previous nest closure, usurpation or apparently in absence of direct stimuli. This aptitude in starting new nests may have resulted crucial in establishing at new sites and in contrasting nesting interruptions, successfully completing more cells with progeny. This information will impact future measures of rapid eradication of new introductions and management of established populations.

Keywords: solitary bees, range expansion, life history traits

COMBINED METHOD OF MONITORING *Monochamus spp.* USING TRAPS AND UNMANNED AERIAL VEHICLES

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Quarantine pest pose great threat to our forest stands. Researchers of Croatian Forest Research Institute are conducting surveys of quarantine pest threatening Croatian forests, and those are funded by European Commission in 75% extent. Monitoring of *Monochamus spp.* as potential vector of invasive *Bursaphelenchus xylophilus that causes very serious* pine wilt disease is being performed in Croatia since 2010. Main tool for monitoring the pest are still pheromone traps focused on forest stands with major host trees of the pest, equipped with various kind of lures. European food safety authority (EFSA) is recommending usage of unmanned aerial vehicles (UAVs) as a versatile remote sensing-based toolkit for monitoring forest health and occurrence of forest pests. Forests are being inspected with lightweight UAV equipped with high quality RGB camera with which we can inspect up to 15 ha with one battery. Data collected with UAV is processed with software that georeferences images, meaning that the image can be related to geographic coordinate system, and from those we can easily detect potentially infested trees with *Monochamus* spp.

Keywords: quarantine pest, *Monochamus* spp. , trapping, unmanned aerial vehicle

INVASIVE EMERALD ASH BORER (*Agrilus planipennis*) IS APPROACHING THE CAUCASUS

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Emerald ash borer (*Agrilus planipennis*) (Coleoptera, Buprestidae), an invasive pest of ash trees, is spreading in Eastern Europe. It has occupied the vast territory in Russia and is established in Ukraine. It has killed millions of ash trees in urban and roadside plantings of *Fraxinus pennsylvanica* introduced from North America. The only native ash species *F. excelsor* is rare in the forests in the regions occupied by the pest in Russia. Therefore, cases of damage of forest trees are also rare. But *A. planipennis* is spreading to the south and could soon reach the Caucasus, where *F. excelsior* and *F. angustifolia* are native and common forest species. It is a serious threat to the Caucasian forests. The aim of our study was to determine if the pest has spread to the Caucasus or adjacent regions. In 2021 we surveyed about 1000 ash trees in the south Russia outside the previously known pest range: Krasnodar Territory (Anapa, Novorossijsk, Temryuk), Stavropol Territory (Mineralnye Vody, Pyatigorsk), Republic of Dagestan (Makhachkala), Rostov Region (Azov, Rostov-on-Don). At least 100 trees were examined in each locality. The pest was detected only in Azov, on 10 trees in a public park. This is first record of *A. planipennis* in Rostov Region and the most south-western record in Europe. Azov is situated far from all previously known localities of this species, about 250 km from the Caucasus.

Keywords: invasive pest, *Fraxinus*, Russia, spread

A NOVEL PLANT – ANIMAL INTERACTION BETWEEN TWO ALIEN SPECIES RESULTS IN UNEXPECTED BENEFITS

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The constantly increasing number of alien species introductions worldwide leads eventually to encounters among species that are all alien to a region. The extent of those novel interactions can result in intriguing relationships. Interactions on the same trophic level are often recognized as competition. However, when comparing interactions of alien species on one another between trophic levels, the outcomes can sometimes turn out to be positive, adding to invasional meltdown. Here we present a study of a newly formed plant-herbivore interaction between two alien invasive species in Europe: a North American ornamental tree *Gleditsia triacanthos* L. and a non-native Asian seed beetle *Megabruchidius dorsalis* (Fåhræus 1839). Expectedly, the seed beetle would destroy the seeds and decrease the chances for plant to propagate with seeds. However, our results based on germination experiments show that in certain circumstances the beetle larva acts as a dormancy breaking agent, improving seed imbibition, delaying germination, and enabling asynchronous germination. We discuss that novel interaction established can consequently provide better opportunities for seedling establishment and can therefore act as mutual facilitation in which each species aids the other to exist and even to increase their invasion success.

Keywords: beetle, herbivory, invasional meltdown, seeds germination, tree

EFFECT OF COMBINING REDUCED DOSES OF HERBICIDES WITH PHENOLIC ACIDS TO REDUCE GERMINATION AND GROWTH *Ambrosia artemisiifolia* L

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Phenolic acids, a major source of allelochemicals can inhibit weed germination and growth. The aim of this study was to determine germination, radicle and hypocotyl length, seedling weight, chlorophyll a and b, carotenoids, and aboveground dry mass of *Ambrosia artemisiifolia* treated with dissolved *p-hydroxybenzoic acid*, *coumaric acid*, *ferulic acid*, and *vanillic acid* in aqueous solution of reduced doses of the herbicide Adengo (thiencarbazone-methyl, 90 g L^{-1}, isoxaflutole 225 g L^{-1}). The strongest inhibitory effect on germination and initial growth of *A. artemisiifolia* was observed by the addition of *p-hydroxybenzoic* acid and *ferulic* acid in reduced doses of herbicide. In the greenhouse experiment, *hydroxybenzoic* acid (22.3 and 177.8 µg mL^{-1}) and *ferulic* acid (110.4 µg mL^{-1}) were added at linearly decreasing herbicide doses of 1/8 - 1/128 (x) (x = 0.44 L h^{-1}). Visual damage to the aboveground mass of *A. artemisiifolia* treated with *ferulic* and *p-hydroxybenzoic* acid was observed at 1/8 and at 1/16 of the herbicide dose, respectively, when ferulic acid was added. The estimated ED_{90} for the herbicide plus ferulic acid is 0.031 L ha^{-1}, compared to 0.052 L ha^{-1} (Adengo alone). At 1/8 x Adengo plus ferulic acid, the occurrence of generative organs on treated plants was not observed. Carotenoid content was lower at reduced herbicide doses, but the addition of phenolic acids to reduced herbicide doses did not show lower carotenoid content compared to herbicide application alone, so a more relevant indicator of herbicide efficacy is visual assessment of aboveground mass damage and ragweed dry matter reduction. The results show that the herbicide dose can be significantly reduced by the addition of *ferulic* and *p-hydroxybenzoic* acid. Since the herbicide efficacy depends on a number of biotic and abiotic factors, the further studies should be conducted in maize cultivation under different pedoclimatic conditions and different stages of ragweed development.

Keywords: p-hydroxybenzoic acid, ferulic acid, thiencarbazone methyl, isoxaflutole, allelopathy

TESTING REMOTE SENSING METHODS FOR INVASIVE ALIEN PLANTS *Ailanthus altissima* AND *Amorpha fruticosa*

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Remote sensing is widely used for the vegetation and habitat mapping. Therefore, using remote sensing can be useful for detailed mapping and monitoring dynamics of spread of invasive species. It can supplement research while being affordable and easy to use. Overview with examples of different remote sensing methods in detection of the invasive alien plants (IAP) will be presented. The remote sensing was used to test the possibilities of mapping IAP *Ailanthus altissima* as part of the development of monitoring program. Two drone surveys were made in Zagreb and Istria in locations with significant coverage with the *Ailanthus altissima*. Images were processed with Agisoft Metashape Professional program and resulted in 3D models, DEM and multispectral orthomosaics which showed the best detection of the species in Red Edge spectral channel (735nm ± 10nm). In addition, non-supervised automatic classification with eCognition program was tested. Both methods showed that using drone imagery is suitable in projects where IAP has to be detected, especially in bigger or unapproachable areas or detailed spread has to be documented. Second example is related to the estimation of *Amorpha fruticosa* biomass in Nature Park Lonjsko polje. The biomass estimation was needed for detection of priority areas for its removal and potential use as energy material. The estimation of biomass was based on the interpretation of Sentinel 2 satellite images, LiDAR data and the field measurements in 42 plots. The best biomass model was based on Sentinel 2 data with August 2019 images in Red Edge, NIR and SWIR bands. In conclusion, the remote sensing could be useful in cost-effective detailed detecting and monitoring of IAP as well as various applications at larger scales.

Keywords: UAV, LiDAR, eCognition, Sentinel-2, biomass model

IMPACT OF SPATIAL PRECISION OF CHOROLOGICAL DATA ON SUPPOSED HABITAT AND ENVIRONMENTAL CONDITIONS PREFERENCES OF SIX INVASIVE PLANT SPECIES IN CROATIA

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Previous studies show that low spatial precision of chorological data negatively affects the accuracy of species distribution models which are used to determine the distribution of invasive species and develop management strategies. In this study spatial records of various spatial precisions (from GPS coordinates to 5 km^2 accuracy) were acquired for six invasive plant species in Croatia – *Ailanthus altissima, Ambrosia artemisiifolia, Echinocystis lobata, Erigeron annuus, Robinia pseudoacacia,* and *Veronica persica*. Using GIS, data on habitats and environmental conditions (climatic and land surface parameters) were joined to chorological records. Environmental conditions preferences were analyzed using descriptive statistics and ANOVA followed by Tukey post-hoc test. Habitat preferences were tested using Friedman ANOVA followed by the Wilcoxon Matched Pairs test. ANOVA detected significant differences in preferences for environmental conditions, while the Tukey post hoc test showed that most differences were present among climatic variables. More differences were present in annual than in quarterly variables. Friedman ANOVA also detected significant differences in habitat preferences in *A. artemisiifolia*, *E. annuus, R. pseudoacacia,* and *V. persica*. Wilcoxon Matched Pairs test showed that differences were predominately present between the dataset of lowest spatial precision and the dataset of highest spatial precision but there were also some exceptions to this trend. According to our results, lower spatial precision affects the obtained ecological profile and habitat preferences although it differs across species and variables and depends on the sample size. More consistent results were obtained for species with a more specialized distribution (*A. altissima* and *E. lobata*) than for ones with a broad distribution. Lastly, we recommend testing the consistency of chorological data of different spatial accuracy before choosing the entry data for environmental modeling.

Keywords: spatial accuracy, uncertainty, invasive plants, Croatia

FUNCTIONAL ANALYSIS OF THE URBAN RIVER VEGETATION ALONG THE ENVIRONMENTAL GRADIENT

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The study was carried out along the Kłodnica, main river of Silesian Upland (southern Poland). Kłodnica has been under antropopressure for 200 years. As a result, rush, ruderal, nitrophilous fringe communities were created. In some of them, the dominant role play alien species. This study aimed at examining the selection of species functional traits along the environmental gradient. For analysis we took 157 sample plots and 94 vascular species. The RLQ analysis made it possible to distinguish five functional groups of species in the gradient connected with moisture and light (along I RLQ axis), productivity and pH along the II RLQ axis. The first group included 28 species. Among them are *Aster novi-belgii, Bromus inermis, Eupatorium cannabinum, Alopecurus pratensis, Filipendula ulmaria.* They are mainly hemicryptophytes with a longer flowering period from June to September, with lower average specific leaf area (SLA), reproducing both vegetatively (high lateral spread) and generatively. The second group included 12 species, among them *Reynoutria japonica, Phragmites australis, Clematis vitalba, Partenocissus inserta*. They are mainly geophytes, hemicryptophytes and lianas, high plants, with flowering period (June-October), with lower SLA reproducing mainly vegetatively, rarely by seeds. The third group included 14 species, among them *Impatiens parviflora, Impatiens glandulifera. Heracleum mantegazzianum*. They are terophytes and hemicryptophytes intermediate in height, with higher SLA, higher seeds, reproducing mainly by seeds, rarely vegetatively (low lateral spread), dispersed via epizoo-, endozoo- and anemochory. The fourth group included 28 native species, among them *Arrhenatherum elatius, Dactylis glomerata, Deschampsia caespitosa*. They are hemicryptophytes intermediate in height, with lower SLA, light seeds, reproducing mainly by seeds and by seeds and vegetatively, dispersed via epizoo-, endozoo- and anemochory. The fifth group included 14 species, among them *Calamagrostis epigejos, Solidago canadensis, Solidago gigantea*. They are geophytes and hemicryptophytes intermediate in height, with lower SLA, reproducing by light seeds and vegetatively (low lateral spread), dispersed via anemochory and epizoo-, endozoochory. Data on species functional traits can be crucial in planning revitalisation of river valleys in urban areas.

Keywords: invasive alien species, plant functional traits, response groups, RLQ analysis

INVASIVE ALIEN PLANT SPECIES IN CROATIA AS NEW ECOSYSTEM SERVICES PROVIDERS

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Preventing invasive alien plant species (IAPS) introduction and spread is the most efficient strategy to avoid costs arising from IAPS. However, given the current rate of species invasion, IAPS management based mainly on eradication is neither completely effective nor economically viable. Although the economic cost of ecological damages caused by IAPS is significant, their positive influence on human activities and sites is also relevant. One of the positive aspects of some IAPS is their possible use as a source of pharmaceutically active compounds. The research project "NATURe as an ALLY: Alien invasive plants as phytopharmaceuticals – NATURALLY" (IP-2020-02-6899), funded by the Croatian Science Foundation, investigates the phytopharmaceutical potential of extracts of four invasive alien species (*Ailanthus altissima*, *Robinia pseudoacacia*, *Helianthus tuberosus*, and *Solidago canadensis*) found in Istria (Croatia) as a basis for new ecosystem services. A final goal of the project (2021-2025) is to propose a model for exploring new IAPS provisioning (medicinal) ecosystem services on the pilot territory of Istria. The model will be based on the following elements: a) phytochemical profiling of plant extracts and isolation of specific fractions by liquid chromatography-mass spectrometry (LC-MS); b) determination of their antioxidative, antimicrobial, antiproliferative, genotoxic, and cytotoxic properties by functional tests; c) assessment of the effects (both negative and positive) of selected IAPS using existing and newly developed assessment tools. Preliminary results of RP-HPLC phytochemical profiling indicate the abundance and diversity of bioactive compounds in 70% ethanol extracts of the analysed species. The most commonly detected compounds were: vitamin C, phenolic acids (gallic, benzoic, chlorogenic, vanillic, caffeic, p-coumaric, synapic, and ferulic acid), and flavonoids (quercetin, kaempferol, and isorhamnetin). Antioxidant capacity values expressed as the percentage of reaction inhibition relative to Trolox of the same concentration as the extracts varied from 93.9 to 101.8% for ABTS, 98.4 to 99.1% for FRAP, and 41.4-62% for DPPH assay. Obtained results suggest the potential of invasive plant species as a source of natural antioxidants in medicine and the food industry.

Keywords: antioxidants, ecological balance, HPLC, phenolics, phytochemical profiling

PRESENCE OF INVASIVE PLANT SPECIES ON THE GRASSLANDS IN RELATION TO THE NEARBY ROADS IN THE PLITVICE LAKE NATIONAL PARK AND SELECTED KARST POLJES (CROATIA)

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The roads represent important path of introduction of invasive alien species (IAS). In case natural near-road habitats have been disturbed, they are easily invaded by IAS. Still, the data on this problem in Croatia are scarce. Primary goal of this study was to identify IAS present on the grasslands and IAS developed near their access roads. Secondary goal was to determine drivers of potential ability of grasslands to resist invasion. Research was performed on 40 sites mainly in the National Park Plitvice Lake and surrounding karstic poljes from May till August 2021. It included dry, mesic, and wet grasslands that were maintained by mowing and grazing as well as plots submitted to the succession processes. Presence of invasive plant species was assessed by using the Braun-Blanquet approach. Additionally, data on IAS present on access roads to the grasslands was recorded. Invasive species *Erigeron annuus* (L.) Desf. was found in grassland complexes on 34 (or 85 %) locations, while *Epilobium ciliatum* Raf. was found only in one location (Drakulić Rijeka, northern Lika). Invasive species observed near roads were dominantly *E. annuus* (L.) Desf and *Ambrosia artemisiifolia* L., while species *Conyza canadensis* (L.) Cronquist, *E. ciliatum* Raf., *Cuscuta campestris* Yunck. and *Chenopodium ambrosioides* L. were occasionally present. Highest IAS abundance was recorded in grasslands developed on former agricultural plots, in plots where natural grassland was damaged (by vehicles, cattle, wild boars and bears etc.) and in sections of grasslands that were omitted from usual maintenance practice on the site. Greatest ability to resist invasion was noted on stabile plots that were subjected to specific long-term practice. Results of this research imply that future fight against IAS should be focused on maintaining natural conditions on the grasslands, thus enhancing their ability to resist invasion. This approach could be useful not only to existing IAS on the site, but also on future IAS.

Keywords: *Erigeron annuus*, grassland maintenance, habitat disturbances, new invasive alien species, resistance to invasion

NEW FINDINGS OF AN INVASIVE *Prunus serotina*: A CASE STUDY FROM CROATIA

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American black cherry (*Prunus serotina* Ehrh., *Rosaceae*) is a widespread invader of the continental European lowlands, often reaching high abundance and an invasive status. Unlike in many European countries, in Croatia, *P. serotina* is still not on the invasive species list. The individuals of *P. serotina* were found in the Pedunculate oak (*Quercus robur* L.) forest regeneration area of Jastrebarsko forest management unit in 2019. This alerted us to start to monitor the spreading area, status and its impact on the native plant species. In order to investigate the habitat characteristics phytosociological approach was applied. In addition, area was surveyed using an unmanned aerial vehicle (UAV) DJI Mavic 2 Pro and DJI Ground Station Pro, both on regeneration area and the surrounding forest area from April 2019 to August 2021. The results showed that *P.serotina* has been spreading considerably in the regeneration area. While regeneration area was covered with the high shrub layer of the american black cherry, not a single specimen was found in the surrounding forest area. Fast initial expansion of *P. serotina* in 2019 in the estimated area, was slowed down in next 2 years due to performed tending activities. This suggests that mechanical measures potentially are a solution of its further spreading. We recommend to continue monitoring survey of *Prunus serotina* in order to help *prevent* its *spread* in the future.

Keywords: American black cherry, regeneration area monitoring, spreading control, phytosociology, invasiveness, forest management

ALIEN CSI: INCREASING UNDERSTANDING OF ALIEN SPECIES THROUGH CITIZEN SCIENCE

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Alien-CSI is a four year networking action funded by the European Commission's COST Office to create a network of researchers concerned with the use of citizen science to study, monitor and raise awareness of invasive alien species. Alien-CSI funds workshops, training, short-term scientific missions, dissemination and other forms of outreach to connect researchers together, support their studies and be a force-multiplier for other research funding. The Action consists of five working groups, Engaging people in citizen science; Approaches to citizen science; Data management and standards; Analysis and visualisation and Cross-cutting citizen science initiatives for IAS across Europe. Some examples of the activities the working groups have been doing include, examining how citizen science can inform risk assessments through collecting biotic interaction data; conducting a metaanalysis of how the "bioblitz" method can be used as a research and engagement tool and others have been looking at the data publishing practises of European citizen science projects. Also, in collaboration with the EuroScitizen and The Citizen Science COST Actions we have examined how to promote scientific literacy of evolution through citizen science. Like so many in the last two years, we have had to be creative to keep activities going though travel bans and lockdowns. Nevertheless, the Action has run a series of webinars, virtual networking events and promotional videos to keep people engaged. Even citizen science events went Covid safe with home safaris and other forms of virtual and contact-free events being organised. In 2022 we hope that in person events can resume and we welcome suggestions for activities and topics for short-term scientific missions.

Keywords: Public engagement, networking, invasive species

THE SURVEY RESULTS OF THE PUBLIC OPINION ON THE IAS IN CROATIA

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The Institute for Environment and Nature (IEN) in the Ministry of Economy and Sustainable Development started the project „LIFE CONTRA Ailanthus“ financed through the LIFE programme of the European Commission. Project partners are the Public Institution National Park Krka, the Public Institution for the Management of Protected Natural Areas of Dubrovnik-Neretva County, and Vrtlar d.o.o. The project duration is from October 2020 to April 2025. The aim of the project is to establish control of invasive tree species *Ailanthus altissima* (Mill.) Swingle in targeted areas of the Mediterranean region in Croatia: Natura 2000 SCI sites (HR2000918 Šire područje NP Krka, HR2001364 JI dio Pelješca) and historic sites (City of Dubrovnik, Ston and Mali Ston). One of the actions of the project is to evaluate public awareness on invasive alien species (IAS) by conducting a nationwide survey at the start and at the end of the project, to evaluate the success of public awareness-raising activities. The first survey was conducted in May 2021 using the Computer Assisted Web Interview method. The survey consisted of 27 questions on alien species definition, public perception on IAS as a threat to biodiversity and public opinion of possible management to control IAS. Part of the survey was also related to *Ailanthus altissima* (Mill.) Swingle as widespread IAS in Croatia. The sample consisted of 406 respondents (Croats over 18 years of age) representative of the Croatian population according to age, gender ratio, education, and regional distribution. According to the survey, 43% of respondents know the meaning of the term alien species, 45% have heard for IAS, 34% know at least 3 invasive alien species and 83% of respondents recognize *Ailanthus altissima* (Mill.) Swingle if they see it in the photo. In this presentation, we will present the results of the public opinion survey in detail.

Keywords: public survey, *Ailanthus altissima*, invasive species, LIFE programme, Natura 2000

EXPLORING THE KNOWLEDGE AND APPLICATION OF BIOSECURITY PRACTICES IN FIELD RESEARCH AMONG RESEARCHERS IN CROATIA

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Invasive alien species (IAS) are among the main drivers of biodiversity loss and negatively impact ecosystem services, human health and economy. A high percentage of IAS has been introduced unintentionally, as a result of activities such as transport, trade, recreation and work-related activities, which can also include field activities of researchers. The aim of this research was to evaluate biosecurity practices of researchers during their field work, as well as their knowledge of IAS, biosecurity and the risks imposed by the spread of IAS. We carried out our research through an anonymous online *Google Forms* questionnaire distributed to over 63 institutions and groups. The results based on 172 received responses show a general insufficient knowledge of biosecurity practices, while the most relevant identified issues are the lack of cleaning transport vehicles and the application of most basic and least efficient cleaning approaches for field equipment and clothes (removal of residuals). Students were identified as a high-risk group due to a high number of field visits to multiple locations and high frequency of equipment use, but with low scores regarding equipment cleaning. Due to these identified high risks of field work practices posed by the youngest analysed group, we propose that a better formal education regarding IAS and biosecurity should be included in the academic curriculum. Moreover, we suggest that biosecurity campaigns on this important but neglected topic should be conducted in Croatia and should focus on increasing the frequency and number of equipment and clothing cleaning approaches, on including cleaning procedures into biosecurity practices and on the importance of fieldwork planning for minimization of biosecurity risks.

Key words: accidental IAS introductions, Croatia, fieldwork, questionnaire

INVASIVE MOSS *Campylopus introflexus* (HEDW.) BRID. CONTINUES TO SPREAD THROUGH CROATIA

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Invasion patterns of bryophytes have been largely neglected in invasion biology for a long time. *Campylopus introflexus* (Hedw.) Brid, originating from the Southern hemisphere, is one of only three invasive immigrant bryophyte species recorded in Europe so far. Due to its biological features (numerous small spores and abundant vegetative propagation) it is considered an aggressive invader in western and central Europe and shows tendency to expand towards the east. Its pioneer arrival to the frontiers of the southeastern Europe in two Croatian geografical regions – the Dinaric (karst field Vrhovinsko polje, Lika) and the peri-Pannonian (Mt Papuk, Slavonia) has been observed between 2013 and 2015. Subsequently the further spread of the species in Croatia has been registered by mere chance while studying various vegetation types. In the peri-Pannonian region the species has been additionaly found within rare sand dune vegetation of the Đurđevački peski Botanical Reserve. In the Dinaric region two new populations occupying different habitats were registered. The first one has covered managed beech and fir forest clearings highly disturbed after extreme snowbreaks and windthrows (near Lividraga in Gorski Kotar), while the second one occupied transitional habitats between peatbog vegetation and spruce forests affected by severe, climate change induced water drainage (Trstenik mire, Gorski Kotar). The vegetation analyses of affected localities in Croatia indicates the species adaptation to acidic and nutrient-poor, often disturbed habitats with sparse vegetation cover, which is in accordance with the known invasive patterns of *C. introflexus* across the Europe. No sexual propagation was found in any of rather disjunct populations, thus the introduction and expansion dynamics of the species in Croatia has not yet been fully elucidated.

Keywords: alien, bryophyte, habitats, invasion,

REMOVAL OF INVASIVE FISH SPECIES FROM THE PLITVICE LAKES WATER SYSTEM HELPS INCRESING VIABILITY OF NATIVE FISH SPECIES AND RESTORING NATURAL HABITAT CONDITIONS

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Native fish community of the Plitvice Lakes is not rich in species, but comprises some interesting elements and important genetic diversity. It contains only four species: the Danube trout (*Salmo labrax*), minnow (*Phoxinus* sp.), Italian spined loach (*Cobitis bilineata*) and Italian golden loach (*Sabanejewia larvata*). Previous investigations proved that the Danube trout in the Plitvice Lakes National Park is still presented with 'pure' populations, which have become rarity throughout most of Europe. Moreover, ancient haplotypes are very important for the viability of the whole species. At the same time, several threats to survival of the Danube trout have been noticed, invasive species being one of the most problematic. The fish community of the Plitvice Lakes water system have been severely altered in the 20th Century and today the alien species dominate in the lakes and are also present in rivers and streams of this water system. The negative effects of those alien species on the native fish community could be observed on several levels: predation on larval and adult stages of individuals of native species, competition for resources, and significant alteration of habitat conditions. In order to reduce negative effects of the alien species and help restoring populations of the native fish species, we have designed and implemented a programme for removal of invasive fish from the Prošćansko Lake, as well as from the rivers and streams where the Rainbow trout (*Oncorhynchus mykiss*) have been recorded. Intensive removal has been conducted from May to October 2021., with different methods employed in various habitats. More than 700 kg of non-native fish were removed. Results of this project, as well as plans for future activities in the Plitvice Lakes are discussed.

Keywords: competition, predation, habitat alteration, non-native fish species removal, Prošćansko Lake

THE TRUTH BEHIND THE FISH DIVERSITY OF THE LIKA RIVER AND ITS TRIBUTARIES: ARE ALL MANAGEMENT EFFORTS WORTH IT?

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The River Lika basin is characterised by karst sinking water courses several of which have become perennial as a result of recent human intervention, whereas others still remain intermittent. Based on recently published data, the River Lika and its tributaries are inhabited by 14 fish species of which three are native, ten naturalised non-native or translocated, and one of unknown origin (note that translocated species are those introduced from one part of a geographical area/country in which they are native to another part of the same country in which they are not native). Also, all translocated species in the River Lika basin, where sport fishing clubs are active, originate from the Danube basin of Croatia. Similar to introduced species, translocated species can rapidly adapt to newly-colonised habitats, thereby posing a threat to native species. The aim of this study was to determine changes in the ichthyocenoses of the Lika River and its tributaries Jadova, Bogdanica and Novčica during the last two centuries, as well as to present current anglers' management practice and determine how the recent Croatian Regulation on invasive alien species recognises the problem of translocations. There is evidence that the true native and endemic stygophile fish are restricted to the narrow upper part of the River Jadova, and the fish fauna of the rivers Lika, Novčica and Bogdanica has become similar to the middle rithron rivers of the Danube basin. Anglers' management plans are based on restocking with 'native' cyprinid fish species, which in fact have never been native to the region. Restocking by cyprinids is a regular practice in Croatia and is considered to be legal according to national legislation.

Keywords: ichthyofauna, translocation, perennial, intermittent, karst river

STRUCTURE AND CHARACTERISTICS OF THE FISH COMMUNITY IN THE NERETVA DELTA (CROATIA) AFTER THE INTRODUCTION OF LARGEMOUTH BASS, *Micropterus salmoides* (Lacepède, 1802)

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Invasive species are one of the leading causes of biodiversity loss. Sport fishermen have recently introduced the largemouth bass (*Micropterus salmoides*) in the Neretva delta, which raises great concern about the possible impact on the endemic ichthyofauna. Largemouth bass has been introduced to many regions and countries due to its extreme popularity as a species for sport fishing. As early as 2011, it was discovered that in the streams and rivers of Spain and Portugal, it can adapt its eating habits allowing it to be a successful invasive species even in relatively stable aquatic food webs. Its reproductive traits, such as early maturation, relatively high fertility, group spawning, and parental care, are believed to facilitate successful settlement in various conditions. The largemouth bass was first recorded in the Neretva delta in 2016. Individuals reach sexual maturity in the Neretva delta at the age of one year. Spawning takes place in spring when the water temperature reaches 15.5˚C. The difference in the structure and abundance of the fish community after the invasion of largemouth bass in the Neretva delta habitat was investigated. Changes in stable food chains, reduction or disappearance of indigenous ichthyofauna, evident plasticity of the diet, as well as changes in the composition of benthos have been found in many places. The greatest issue in verifying the differences before and after largemouth bass introduction is information about the previous state of the ichthyofauna. In the case of the Neretva delta, we have had a good analysis of the ichthyofauna available twenty years before the invasion. In the year 2004 a field research in the lower course of the Neretva River and its tributaries, on the border of fresh and brackish biotopes, has recorded 38 fish species, of which 30 species are native and eight species are alien. The identified fish belong to 22 families, with the most numerous being the family Cyprinidae with 18 species, followed by the family Salmonidae with six species, Gobiidae and Mugilidae each with three species, and Petromyzontidae and Percidae each with two species. The remaining families are represented with only one species. In comparison with previous results, this study indicates that the number of most small fish species has drastically decreased.

Keywords: alien species, invasive species, fish community, introductions of new species

DIETARY COMPOSITION OF LARGEMOUTH BASS, *Micropterus salmoides* (Lacepède, 1802) IN THE LOWER COURSE OF THE NERETVA RIVER IN CROATIA

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The aim of this study was to determine the composition of the diet of the largemouth bass (*Micropterus salmoides*) in the lower course of the Neretva River and whether this species feeds on any endemic fish . The research was conducted at the beginning of May 2021. Samples were collected from a boat by electrofishing from Krvavac near Opuzen to the mouth of the Neretva River into the Adriatic Sea near Rogotin. Ten locations were sampled and the length of each transect was 100 m. In the laboratory, the digested material was separated and determined to the lowest possible taxonomic group. In the processing of prey, the percentage of abundance (N%) and frequency of occurrence (F%) were determined. In total, 37 largemouth bass were sampled, with their diet including prey from Decapoda, Amphipoda, Coleoptera and five fish species. The results on relative abundance shows: decapods of the suborder Caridea with 46.9%, fish with 37.5%, Coleoptera with 12.5% and amphipodes represented by *Gammarus balcanicus* with 3.1%. In regard to frequency of occurrence, the most significant are fish with 40%, followed by Caridea with 35%, Coleoptera with 20% and *G. balcanicus* with 5%. The endemic fish species *Orsinigobius croaticus* and *Ninnigobius canestrinii* are determined in the diet of largemouth bass. The largemouth bass in the lower course of the Neretva River also feeds on non-native fish species *Gambussia hoolbrooki* and *Lepomis gibossus*; cannibalism has also been recorded. Due to its fast adaptability, predation and food choice the largemouth bass could have a significant negative impact on the ichthyofauna in the lower course of the Neretva River in the future, in particular on endemic species from the Gobidae family.

Keywords: abundance, prey, endemic species, *Orsinigobius croaticus*, *Ninnigobius canestrinii*

INVASIVE FISH SPECIES HAVE A NEGATIVE EFFECT ON ZOOPLANKTON ASSEMBLAGES IN SHALLOW WATER BODIES

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Freshwater zooplankton (Rotifera, Cladocera, and Copepoda) is an essential component of the biocoenosis in lentic ecosystems as it has a key role in transfer of energy, nutrients, and primary food particles (detritus and phytoplankton) to higher trophic levels (fish). Both "bottom-up" and "top-down" regulations can influence zooplankton species composition, density, and biomass. Here we present results of our investigation conducted in different shallow water bodies in the Mediterranean region of Croatia (Europe): Vrana Lake near Biograd na Moru, and twenty-one permanent and semi-permanent ponds along the coast and islands of the Adriatic Sea. We sampled zooplankton together with macrozoobenthos, fish, macrophytes, and physico-chemical parameters. The main aims were to determine the impact of top predators (fish) and other biotic and abiotic factors on zooplankton structure in the investigated shallow lakes and ponds. Overall, rotifers dominated in zooplankton, followed by cladocerans and copepods. In habitats with invasive fish species, zooplankton density, biomass, and diversity were strongly reduced. Fish presence negatively affected Cladocera and Copepoda. Rotifers were not under direct fish predation, and their assemblage was shaped by other biotic (e.g., macrophyte stands) and abiotic (e.g., increased salinity) factors. Our results indicate strong "top-down" regulation of zooplankton in shallow water bodies harbouring invasive fishes, primarily by excluding large-bodied algivorous cladocerans. Thus, invasive fishes promote phytoplankton growth, preventing zooplankton from maintaining a clear water state of investigated habitats, and deteriorating ecological functioning of shallow water bodies, particularly in warmer climate.

Keywords: Rotifera, Cladocera, Copepoda, "top-down" factors

CONSERVATION OF THE CROATIAN NOBLE CRAYFISH POPULATIONS CONFRONTED WITH INVASIVE CRAYFISH AND CLIMATE CHANGE – WHEN POPULATION GENETICS MEET SPECIES DISTRIBUTION MODELLING

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Astacus astacus is a native European freshwater crayfish species with recorded population declines caused mainly by spreading of non-native invasive crayfish species (NICS), anthropogenic pressure onto its habitats and climate change. In order to mitigate further losses in populations' numbers and genetic diversity of this vulnerable species, effective conservation that will ensure crayfish long-term survival is needed. In this research we merged population genetics and species distribution modelling (SDM) to reveal impact of two NICS and climate change onto *A. astacus* aiming to direct future conservation programs of the current populations in Croatia. Obtained results indicated that *A. astacus* populations in Croatia possess high genetic diversity, comprising a significant genetic reservoir on the European level. Results of SDM forecasted that, under pessimistic RCP 8.5 scenario, by 2070 only 13% of this species currently suitable habitat is predicted to remain stable, and populations that are predicted to be lost are populations possessing high genetic diversity. The SDM results for NICS predicted that their projected future distributions will be wider compared to current ones, but with severe decrease in habitat suitability values for both NICS distributed in Croatia. Further, our results indicated that *A. astacus* will be more endangered by climate change than by future NICS spreading. In conclusion we may say that conservation of present *A. astacus* diversity in areas that are predicted as suitable (climate refugia) will require assisted migration/relocation in order to preserve their maximum genetic variability. Our research emphasizes once again the importance of multidisciplinary studies in the modern approach to biodiversity conservation.

Keywords: invasive species, *Faxonius limosus*, *Pacifastacus leniusculus*, *Astacus astacus*, habitat suitability, climate change, freshwaters

IS THE IMMUNE RESPONSE OF FRESHWATER CRAYFISH TO APHANOMYCES ASTACI INFLEUNCED BY THE HOST-PATHOGEN COEVOLUTION?

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Aphanomyces astaci is an Oomycete pathogen listed amongst the 100 worst invasive species worldwide. It was first introduced into Europe with invasive North American crayfish species and caused the collapse of numerous native freshwater crayfish populations. It is hypothesised that some of the first *A. astaci* strains to reach Europe, belonging to haplogroup A, have started to coevolve with the native European crayfish, resulting in reduced virulence of the pathogen and/or increased resistance of the host. To test this hypothesis, we exposed noble crayfish, a susceptible native European species, and marbled crayfish, an invasive disease-resistant species, to a haplogroup A strain (isolated form a latently infected noble crayfish population) and a haplogroup B strain of *A. astaci*. Following the RNAseq, gene expression profiles were studied in hepatopancreas. We detected 412 differentially expressed genes (DEGs) in the noble crayfish and 257 DEGs in the marbled crayfish across all challenge groups. In the noble crayfish, a clear immune response was detected to haplogroup B-strain but not to the supposedly coevolving haplogroup A strain. On the other side, in the marbled crayfish we detected an immune response to the haplogroup A strain, but not to the haplogroup B strain, more recently introduced into Europe. For the first time, we showed that the hepatopancreas has a role in the response to *A. astaci* infections in freshwater crayfish. Furthermore, the immune response crayfish mount to fight the pathogen is strongly influenced by the coevolution of the crayfish and specific strains of *A. astaci,* with both crayfish species being able to build up the immune response to the pathogen. Lastly, a clear distinction between the innate immune response in marbled crayfish and noble crayfish is the capability of the marbled crayfish to mobilise a higher variety of innate immune response effectors.

Keywords: crayfish plague, *Astacus astacus*, innate immunity, *Procambarus virginalis,* differential gene expression analysis

Aphanomyces astaci VS FRESHWATER CRAYFISH: A STORY OF DEATH, RESISTANCE AND COEVOLUTION

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The introduction of North American freshwater crayfish and their hitchhiking pathogen *Aphanomyces astaci* into Europe has led to several mass mortalities among native European crayfish populations. However, several studies have indicated a great variability of pathogen virulence and host resistance, possibly indicating host-pathogen adaptation. This knowledge is of importance to inform invasive species management actions. With this study we first compared the response of plague-sensitive European noble crayfish (*Astacus astacus*) and invasive marbled crayfish (*Procambarus virginalis*) to an *A. astaci* challenge with strains of high and low virulence. The results showed that neither of the *A. astaci* strains caused signs of disease in the marbled crayfish, which is remarkably resistant against the disease and could thus potentially act as carriers of highly virulent *A. astaci* strains. Furthermore, while all the high virulent-challenged noble crayfish were moribund, the low virulent-challenged noble crayfish showed only light symptoms of disease. Our results provide evidence for the adaptation of one specific *A. astaci* strain to its novel European host, supposedly through reduced virulence. Second, we aimed to characterize the virulence of our *A. astaci* strain collection through challenges of noble crayfish. Highly standardized controlled infection experiments involving 15 *A. astaci* strains showed a wide range of virulence, with the percentage of mortality among challenged noble crayfish ranging between 0% and 100%. This high variability in the virulence seems independent from the previous tentative virulence classification based on genetic data. The virulence characterization will be integrated with data on growth speed and on the entity of the spore production. Prospectively, genome-wide association studies of all strains will identify associations between genetic regions in the *A. astaci* genome with its respective phenotype (virulence), to infer whether or not variation in strain virulence is coded within the pathogen´s genome. This knowledge will support advanced management strategies.

Keywords: crayfish plague, *Astacus astacus*, *Procambarus virginalis,* noble crayfish, marbled crayfish , new records

COMPARISON OF THE IMMUNE RESPONSE OF NATIVE AND INVASIVE ALIEN SPECIES OF DECAPOD CRAYFISH OF THE KORANA RIVER

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The immune response is among the major drivers of an individual's health since it is responsible for protecting organisms against pathogens. Consequently, it is one of the drivers of the invasion success of a species. This study aimed to compare the immune response of the resistant native species, the narrow-clawed crayfish (*Pontastacus leptodactylus*) and the successful invasive alien species, the signal crayfish (*Pacifastacus leniusculus*) from the Korana River, at three sites where these species co-occur in mixed populations. We have performed between-species comparisons of specimens caught with LiNi traps in September 2020. The standard immune response parameters, frequently reported in crayfish, were compared: total hemocyte count, the strength of the encapsulation response and enzyme activity of phenoloxidase (PO) and total prophenoloxidase (proPO). Also, since the immune response is considered an important fitness component, we have compared it to the body condition parameters (hepatosomatic index and Fulton's condition factor) of each species. Compared to native narrow-clawed crayfish, invasive signal crayfish had significantly higher values of two immune response parameters (encapsulation response and total prophenoloxidase) and exhibited an overall better immune response. We discuss our findings in the context of the potential contribution of these differences in the immune response to the observed displacement of the narrow-clawed crayfish by the signal crayfish from mixed populations in the Korana River.

Keywords: immune system, signal crayfish, narrow-clawed crayfish, freshwater ecosystems

MICROBIOME OF THE SUCCESSFUL FRESHWATER INVADER, THE SIGNAL CRAYFISH, AND ITS CHANGES ALONG THE INVASION RANGE

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Invasive species are among the major drivers of biodiversity loss and impairment of ecosystem services worldwide, but our understanding of their invasion success and dynamics still has many gaps. For instance, although it is known that host-associated microbial communities may significantly affect an individual's health and fitness, the current studies on invasive species are mainly focused on pathogenic microbes. In contrast, the effects of the remaining majority of microbial communities on the invasion process are almost completely unexplored. We have analyzed the microbiome of one of the most successful crayfish invaders in Europe, the signal crayfish in the Korana River, Croatia. Using a 16S rRNA gene amplicon sequencing approach, we analyzed the microbiomes of different crayfish tissues (exoskeleton, hemolymph, hepatopancreas, and intestine) and explored their changes along the invasion range. Exoskeletal, hepatopancreatic, and intestinal microbiomes varied between invasion core and invasion front populations, indicating that they may be partly determined by population density, which was higher in the invasion core than in the invasion front. The highly diverse microbiome of exoskeletal biofilm was partly shaped by the environment (due to the similarity with the sediment microbiome) and partly by intrinsic crayfish parameters (due to the high proportion of exoskeleton-unique amplicon sequence variants [ASVs]). Our findings offer an insight into microbiome changes during dispersal of a successful invader and present a baseline for assessment of their contribution to an invader's overall health and its further invasion success.

Keywords: *Pacifastacus leniusculus*, 16S rRNA gene, range expansion

EXOSKELETON MICROBIAL COMMUNITIES OF CO-OCCURRING AND PHYLOGENETICALLY RELATED NATIVE AND INVASIVE CRAYFISH SPECIES

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Microbial communities can impact the invasion success since it is known that they can be beneficial to the host and, in the case of pathogenic microbes, can adversely affect their health and fitness. We aimed to determine the potential differences in the exoskeletal microbial communities of co-occurring and phylogenetically related native and invasive crayfish species, using the native narrow-clawed crayfish, *Pontastacus leptodactylus*, and the invasive signal crayfish, *Pacifastacus leniusculus*, from the recently invaded Korana River, Croatia, as a model. The high-throughput 16S rRNA sequencing results showed that the exoskeleton microbiome of both species is highly diverse, significantly influenced by the local environment, and dominated by Proteobacteria and Actinobacteria. However, significant differences in community structure and the presence of low abundance microbial taxa were found between the crayfish species, suggesting that the exoskeleton microbiome is species-specific despite the shared habitat. Furthermore, we used qPCR/ddPCR to quantify the selected oomycete pathogens, *Aphanomyces astaci*, and *Saprolegnia parasitica*, on the crayfish exoskeleton. Despite their contrasting life strategies, where *A. astaci* is highly virulent and has a relatively narrow host range (mainly native European crayfish), and *S. parasitica* is an opportunist with a broad host range, low pathogen loads were found for both pathogens and both crayfish species. This suggests that the co-occurring invasive and native crayfish are resistant to and share the quantified pathogens. Although the literature has pointed outspreading of *A. astaci* from the invasive to the susceptible native crayfish as the main reason for the decline of native species populations, our results suggest that this is not the case for *P. leniusculus* and *P. leptodactylus* in Korana River. Other mechanisms, such as competitive exclusion, probably play a more important role in the successful invasion of signal crayfish.

Keywords: *Aphanomyces astaci*, invasion success, narrow-clawed crayfish, *Saprolegnia parasitica*, signal crayfish

FIRST RECORD OF IDIOPATHIC NECROTIZING HEPATOPANCREATITIS IN THE SIGNAL CRAYFISH *Pacifastacus leniusculus* (DANA, 1852) IN CROATIA

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As the most successful crayfish invader and possible reservoir of new pathogens, signal crayfish *Pacifastacus leniusculus* (Dana, 1852) is among the major drivers of native crayfish species decline in Europe. We present data on lesions and frequency of idiopathic necrotizing hepatopancreatitis along the invasion range of signal crayfish in the Korana River in Croatia. We sampled and histologically analysed 73 signal crayfish individuals collected during three consecutive years (2018-2020). Our results show a very high prevalence of the lesions in hepatopancreas of signal crayfish (>91%), with 14% of individuals displaying heavy and 51% moderate changes within tubular and interstitial structures of the organ. Recorded lesions were more frequent in females and within the invasion core where population density is higher. Heavy histopathological changes in hepatopancreas were correlated with lower hepatosomatic index which indicates that this disease affects the individual condition and may affect invasion success. Our preliminary screening of co-occurring native narrow-clawed crayfish *Pontastacus leptodactylus* (N=3) showed similar hepatopancreatic lesions and highlighted the susceptibility of native crayfish populations to this newly detected disease. Aetiology of necrotizing hepatopancreatitis and potential new pathogen in Korana River are still unknown, and need to be further investigated.

Keywords: signal crayfish, narrow-clawed crayfish, invasive species, hepatopancreas, Korana River

DETECTION OF DIVERSE AND DIVERGENT RNA VIRUSES OF THE INVASIVE SIGNAL CRAYFISH AND THEIR VARIATION ALONG THE HOST'S INVASION RANGE

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Crayfish are successful invasive species and keystone species of freshwater ecosystems, however, their pathogens, including viruses, remain understudied. The aim of this study was to analyze the virome of one of the most successful invader in European freshwaters, the signal crayfish (*Pacifastacus leniusculus*), and to elucidate the potential differences in viral abundance along its invasion range in the Korana River, Croatia. By high-throughput sequencing of total RNA, isolated from the crayfish hepatopancreas and subsequent sequence data analysis, we identified novel and divergent RNA viruses including signal crayfish associated reo-like, hepe-like, toti-like and picorna-like viruses, phylogenetically related to viruses previously associated with crustacean hosts. The patterns of reads abundance and calculated nucleotide diversities of the detected viral sequences varied along the invasion range, which could indicate the possible influence of different factors and processes on signal crayfish virome composition: e.g., the differences in signal crayfish population density, non-random dispersal of host individuals from the core to the invasion fronts, and transfer of viruses from the native co-occurring and phylogenetically related crayfish species. The study reveals a high, previously undiscovered diversity of divergent RNA viruses associated with signal crayfish and set foundations for understanding the potential risk of virus transmissions as a result of this invader's dispersal.

Keywords: signal crayfish virome, invasive alien species, invasion range, high-throughput sequencing

POSTERSKA PRIOPĆENJA

POSTER PRESENTATIONS

FROM EARLY WARNING TO RAPID RESPONSE: SET UP OF AN EMERGENCY TASK FORCE TO SUPPORT ACTION AGAINST INVASIVE SPECIES

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Objectives: Following the entry into force of Regulation (EU) No 1143/2014, EU member states needed regulatory and technical tools for its implementation. In Italy, under Legislative Decree no. 230/2017, regional agencies and National Parks are responsible for monitoring and implementing management measures. The surveillance system seems able to detect invasive alien species quite efficiently; however, great difficulties remain in rapidly implementing removal measures. For this reason and for squirrels in particular, an Alien Squirrel Emergency Team (ASET) was set up at national level in the framework of the LIFE U-SAVEREDS Project. *Methods:* The Team consists of researchers and technicians from several Italian universities and ISPRA, experts in the biology, ecology and management of Sciurids. When alien squirrels are detected through an Early Warning network involving both citizens and institutions, the ASET supports the local authorities to ensure a rapid response. It helps with the administrative procedures and provides directions on equipment and methods to monitor and trap squirrels, estimating the effort required under different scenarios. If necessary, the ASET provides direct support for field activities. *Results:* Since 2018, ASET provided operational guidance for 10 nuclei of alien squirrels (two species of union concern; *Sciurus carolinensis*, *Callosciurus erythraeus, Callosciurus finlaysonii*, and *Callosciurus prevostii*), in 7 different regions. Field activities were carried out for alien squirrels in four regions (Veneto, Piedmont, Friuli-Venezia-Giulia and Emilia-Romagna). When necessary, ASET provided camera traps for confirming the presence and trained local staff for removing the animals. *Conclusion:* Local agencies often face difficulties starting to act against new alien species. They often lack the knowledge and technical expertise to act and remove them quickly. ASET is an operational structure that provides an effective support to local administrations in the initial implementation of removal activities. Its operational scheme can be transferred and applied to other species.

Keywords: alien squirrels, Alien Squirrel Emergency Team, eradication, invasive alien species, operational scheme

AWARENESS OF PROBLEMS OF INVASIVE SPECIES IN PRIMARY EDUCATION

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One of the biggest challenges today is the control of invasive alien species (IAS) and the reduction of their impact on native species and ecosystems. It is therefore necessary to increase public awareness of the IAS problem. One of the main tools for solving this problem is the earliest possible education. Therefore the aim of our study was to detect the knowledge of primary school students about the problem of invasive species. The research was conducted on a sample of 177 upper grade students from two elementary schools in the cities of Samobor and Zagreb. The participation in the survey was voluntary, and consisted of completing a questionnaire. It was mostly attended by sixth-graders (62%) and eighth-graders (33%). The results showed that the students were introduced (75%) to the term "invasive species" via the Internet (30%), schools (28%), the media - TV / radio (23%) and newspapers / press (10, 4%). The concept of biodiversity loss under the influence of IAS was determined by the majority of students (63%) to be correct. In the open-ended question about the ways of introducing IAS into a new area, most students (75%) state different correct answers. A high percentage of students recognize ragweed through the attached photo (83%), and as the most suitable way of removal they recognized plucking the plant before flowering (65%) and mowing before flowering (13%). When recognizing invasive / native animal species, most students (24%) did not recognize the grey squirrel as an invasive species. The students mostly answered correctly (74%) that the red-eared turtle should not be released into the wild, but they also stated the wrong reasons for that. Most students marked the danger of invasive species (80%) as high and very high.

Key words: alien species, education, primary school student, questionnaire

INVASIVE ALIEN PLANT SPECIES MANAGEMENT PLANNING – *Asclepias syriaca* L. AND *Impatiens glandulifera* ROYLE

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The spread of invasive alien species (IAS) is one of the drivers of ecosystem change that has a great impact on biodiversity on a global scale. EU Regulation 1143/2014 on Invasive Alien Species (the IAS Regulation) enlists invasive alien species that are of European Union concern, known as the "Union list". According to the IAS Regulation, every EU Member State is obliged to implement management measures for those IAS included in the Union list that are widespread in the Member State. Invasive alien plant species take over the area that native plant species naturally inhabit, changing the ecosystem structure and composition. *Asclepias syriaca* L. (common milkweed) and *Impatiens glandulifera* Royle (Himalayan balsam) are spreading alongside highways, railroads, riverbanks, marginal forest habitats and crop lands in Croatia, as well as in many other parts of Europe. Their presence has a negative impact on ecosystem, species, and genetic diversity, causing disruption in natural environment and community composition. Wide distribution in Croatia, as well as their propagation ways, makes their complete eradication impossible. Due to pervasiveness of *A. syriaca* and *I. glandulifera,* management plans with measures for population control and spread limitation were developed. To ensure effective and feasible measures, site-specific removal activities envisaged in management plans were discussed and elaborated in multi-stakeholder workshops. When developing control and removal approach, it was taken into consideration that the activities do not cause significant harm to the natural environment, especially in protected areas, Natura 2000 sites and rare habitats of special importance.

Keywords: IAS, Union list, plant species, management planning, control

MANAGEMENT OPTIONS FOR THE NUTTALL'S WATERWEED (*Elodea nuttallii*) IN SLOVENIA

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According to regulation (EU) 1143/2014, member states shall prepare effective management measures for widespread Invasive Alien Species (IAS) of Union concern in their territory. Nuttall's waterweed is an IAS included on the Union list and it is widely spread in Slovenia. Guidelines for the management of Nuttall's waterweed have been prepared in 2021. Its distribution in nature, impact on biodiversity and the possible management options for Slovenia have been analysed and presented in this document. Based on past experiences, *E. nuttallii* has the potential to cause major problems for hydropower plants. This aquatic IAS is widely spread in the eastern part of Slovenia, predominantly in the Drava river. Other scattered locations have been recorded in the tributaries of the Mura and Sava rivers, too. Nuttall's waterweed poses a threat to high value conservation areas such as Natura 2000. Endangered Natura 2000 freshwater habitats include: Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoeto-Nanojuncetea* (HT-3130), Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation (HT-3150) and Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation (HT-3260). Due to its characteristics as an aquatic plant, its fast growth rate and reproduction potential, the eradication of already established populations is not possible. Our main focus is therefore on preventing further colonisation and its spread to new locations, while prioritising its management in protected areas. Already established populations can be managed through various methods such as hand weeding, mechanical methods, shading and nutrient reduction. We suggest that the management of Nuttall's waterweed in Slovenia should focus on early detection and rapid response, as well as preventative measures. Freshwater ecosystems have high levels of biodiversity and as such preventing the introduction and spread of IAS in these ecosystems is a crucial part of nature conservation.

Keywords: invasive alien species, early detection and rapid response, Natura 2000, aquatic plants, protected areas

TWO SHADES OF GREY: XEROPHYTES FROM GARDEN BEDS AS INVADERS OF NATIVE VEGETATION?

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Our study describes germination and cytological variability in two popular ornamental and potentially invasive species, lamb's ear *Stachys byzantina* and rose campion *Lychnis coronaria*. Both xerophytic species have the potential to invade natural habitats across Europe and create viable naturalised populations, with subsequent impacts on native vegetation. To assess the species' invasiveness, seeds were collected from naturalised populations and germination rate recorded under different temperature regimes. Flow cytometry, used to record cytological variability, indicated that all populations of both species were cytologically homogeneous. Germination success, a key spreading factor in both species, was significantly influenced by temperature, with final germination of *L. coronaria* being extremely high at temperatures > 15°C (98.5 %) and extremely low at temperatures < 10°C (2.9 %). In comparison, final germination in *S. byzantina* highest at 22°C (55.6%), reducing to 40.3% at 15°C and just 0.3% at temperatures < 10°C. No significant differences in germination rate were observed between escaping and non-escaping populations, though there were differences between particular populations. Our results indicate germination temperature limits between species consistent with sizes of primary distribution and distance between primary and secondary distribution borders. However, the observed germination rates allow for successful generative reproduction of both species over their secondary distribution areas, suggesting that these species are likely to become invasive species of European grasslands soon.

Keywords: alien species, generative reproduction, genome size, ornamental plants

ARE THE OLD FORESTS IN THE URBAN AREAS RESISTANT TO PLANT INVASIONS?

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Old forests in the cities are considered as a local center of biodiversity and provide many valuable ecosystem services. We conducted our study in „Las Dąbrowa" Forest Reserve, located in the western part of the Upper Silesia (southern Poland) and existing in the local landscape since at least the 1st half of the 18th century. We excepted that the diverse vegetation of „Las Dąbrowa" will be resistant to invasion, despite that in the surroundings of the reserve, we predicted a high level of propagule pressure of IAS. Obtained results were opposite to our assumptions. Number of IAS has increased from 1 to 12 and the number of the localities of IAS increased from 1 to 118 between 1992 and 2020. *Quercus rubra* (42 loc.), *Padus serotina* (18 loc.), and *Reynoutria japonica* (16 loc.) were the most widespread IAS in the forest. The increasing level of invasion had a statistically significant effect on the species richness and species diversity of reserve vegetation. Between 1992 and 2020 mean number of species per single study plot decreased from 30.67 to 19.03 ($Z = 6.21$; $p = 0.00$), whereas average value of Shannon-Wiener diversity index decreased from 2.46 to 2.05 ($Z = 4.04$; $p = 0.00$). In the immediate vicinity, the changes in land cover between 1990 and 2018 were identified according to CORINE Land Cover. The cover of urban development (+4.87%), industrial zone (+4.38%), and allotment gardens (1.10%) increased, while the share of arable land decreased (-17.52%). The highest propagule pressure occurred in the urban development (341 loc.), allotment gardens (161 loc.), industrial zone (62 loc.).

Keywords: invasive alien species, CORINE Land Cover, landscape metrics, species diversity, woodlands

COMPARISON OF FITNESS TRAITS BETWEEN TWO COMPETITORS, NATIVE *Glechoma hederacea* AND INVADER *Duchesnea indica*, ACROSS CONTRASTING HABITATS

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Glechoma hederacea L. and *Duchesnea indica* (Andrews.)Focke. are globally widespread plants and in many countries considered as invasive and hard to eradicate. Plants share several similar traits including overwintering leaves, rapid vegetative reproduction by runners, fidelity to nutrient rich sites and tolerance to wide range of environmental conditions. In studied area both plants coexist in semi-shaded habitats (e.g. forest edge), however they also grow in understory and open (disturbed) habitats. Sharing similar traits and their coexistence imply competition between them thus studying their populations might shed light into traits crucial for their invasiveness and competitive success. We studied performance of both plants in terms of eco-physiological status and fitness related traits *in situ* across understory, forest edge and open habitats. We studied 17 and 18 populations of *G. hederacea* and *D. indica*, respectively. We explored plants reaction norms across habitats as mean trait value estimated from 10 plants per population. Our results confirm *G. hederacea* preference for nutrient rich and edge habitats. Edge plants showed the best eco-physiological status and reached the highest biomass, however open habitat plants produced more seeds but had otherwise poorer performance. Higher nitrogen levels in the soil resulted in higher fitness of *G. hederacea* but did not affect fitness of *D. indica*. On the other hand, *D. indica* outcompete *G. hederacea* in all fitness related traits and across all habitats showing tolerance to various environmental conditions. Moreover, if *G. hederacea* showed decline in performance in open habitat, *D. indica* maintained similar or had even better performance in such habitats. Results indicate not only the competitive strength of *D. indica* to outcompete native plants but also the ability of rapid vegetative reproduction and abundant production of seeds. The obtained field data fill gaps in the knowledge of the ecology of both species and may help to improve the predictions of the invasive potential of species before they establish in the introduced range, spread and become invasive.

Key words: alien plant, invasive potential, eco-physiological performance, reproduction

AERIAL MAPPING OF FLOWERING JERUSALEM ARTICHOKE: A COMPARISON OF TWO METHODS

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Invasive plant species are a major threat to biodiversity, and their introduction can negatively impact the environment, the economy and human health. Once established, invasive species must be monitored which can be demanding and expensive. Therefore, methods for early detection and monitoring of the spread of invasive species are crucial. Aerial mapping methods can make the detection of invasive species faster than traditional ground-based visual methods. It is convenient for mapping large or inaccessible habitats, especially for anthropogenically disturbed habitats such as roads, riverbanks, roads and railways. Aerial detection of invasive plants can be useful when a particular growth stage (e.g., flowering, ripening) of a plant can be easily identified or for those species with recognizable features. We have chosen the Jerusalem artichoke (*Helianthus tuberosus* L.) because of its bright, yellow-coloured flowers during the flowering season. This study aimed to test methods for more efficient data collection for invasive species. In particular, to measure and compare the economic and labour effort for mapping invasive species by two methods: aerial mapping and traditional field mapping. Aerial mapping was performed using an unmanned aerial vehicle (UAV), commonly known as a drone. In the two-year research, we have tested the possibilities of the two drone models for aerial mapping. In the first year, several drone shots were taken at different altitudes to detect the altitude from which the Jerusalem artichoke is recognizable. In the second year, different technological possibilities of drones for mapping were tested and compared to traditional field mapping methods. The lack of this method is the possible application on a limited number of species while for others it is still necessary to apply the classical mapping method. The results suggest that the use of drones in the mapping of some invasive species is beneficial in reducing economic and labour effort, and the best drone protocol for Jerusalem artichoke mapping is proposed.

Keywords: drone protocol, mapping, *Helianthus tuberosus*, remote sensing

OVERVIEW OF PLANT LIFE TRAITS AVAILABILITY FOR INVASIVE PLANTS IN CROATIA – FIRST RESULTS

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Due to the spread of invasive alien species (IAS), European (including Croatian) landscapes are changing, while certain mechanisms that promote realization of invasive potential, are still unknown. Plant traits underpin species' tolerance to environmental stressors and disturbances as well as their contributions to ecosystem properties, so they can provide insights in functional diversity analyzes between invaded and (yet) not invaded areas. With this ambition, we set out to review publicly available data on plant traits for 77 invasive plant species in Croatia. In this research we focused on numerical plant trait variables that describe persistence, regeneration and dispersibility – key features of plant dynamics, by investigating one whole plant trait (canopy height), four leaf traits (leaf size and mass, SLA, LDMC) and nine seed traits (seed length, width, height, number, number per shoot and longevity, releasing height, buoyancy and terminal velocity). Firstly, we examined LEDA Traitbase – an open Europe-wide database that gathers several sources of knowledge, and identified 4 species (5.2 %) represented with all 14 examined traits, 19 species (24.7%) represented with 11 or more traits and 22 species (28,6 %) represented with no traits. Measurements for canopy height, seed length and releasing height were contained for more than 50% of species with seed length being the most common. Least amount of information (measured for less than 30% of species) was available for seed buoyancy and terminal velocity, with buoyancy being represented for only 8 species. Our plan is to expand the search for 14 selected plant traits by collecting data from the TRY Plant Trait Database, after which we will be able to identify Croatian plant IAS whose traits are not available and have to be measured by ourselves, in order to complete the data set needed for further analyses (e.g. functional diversity). Authors will carry out all the tasks, gathering the information on previously available traits until vegetation season of 2022, when the measuring of missing traits is planned to begin.

Keywords: IAS, functional traits, LEDA Traitbase, numerical variables

VEGETATION OF A *Ailanthus altissima* STANDS ALONG THE CROATIAN COAST AND ISLANDS

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Ailanthus altissima (Mill.) Swingle ("Tree of Heaven"), native to China, has become invasive all over the world. In Croatia it is present in all administrative regions, where it can form dense forest communities. Although there are several ecological studies on this species, there is a lack of floristic-vegetational data for Croatia. We present the results of a preliminary floristic-vegetational investigation on *A. altissima* stands along the Croatian coast and islands, based on a dataset consisting of 56 phytosociological relevés, carried out according to the Braun-Blanquet approach. In focus was the area from the island of Krk in the north, to the Prevlaka peninsula (Konavle region) in the south of the Croatian coast. Classification of the dataset was carried out by TWINSPAN, run under the JUICE software. To check the differentiation of the obtained vegetational groups Non-Metric Multidimensional Scaling (NMDS) was performed on a dissimilarity matrix of Bray–Curtis. In our study, two types of stands were defined: (i) those with stratified structure and high canopy density on the dry soils and low anthropic disturbance, and (ii) paucispecific stands with a monolayered structure typically found in agricultural and peri-urban areas with high anthropogenic disturbance. Furthermore, our results also showed the floristic and physiognomic similarity of *A. altissima* stands with the recently described plant associations *Asparago acutifolii-Ailanthetum altissimae* and *Aro italici-Ailanthetum altissimae* from the Italian sub-Mediterranean and Mediterranean areas. According to the current state of knowledge, the attribution of these stands to the *Robinietea* class seems to be the only way forward. Future studies, both in the Mediterranean and Continental regions in Croatia, will better clarify the syntaxonomic position of the *A. altissima* stands, as well as the syntaxonomic framework of the *Robinietea* class.

Keywords: invasive alien species, Mediterranean climate, plant landscape, *Robinietea* class, syntaxonomy

USAGE VALUE OF INVASIVE PLANT SPECIES IN THE RIJEKA AREA

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Invasive species create numerous direct and indirect damages in urban areas. The city of Rijeka is located at the Adriatic coast and it is principal seaport in Croatia, which makes it susceptible to the spread of invasive flora. In this work, invasive flora was recorded at 70 localities in the area of the city of Rijeka and its surroundings. For each taxa were provided information on life form, life duration, floral element, flowering time, habitat and region of occurrence. For each species the negative effects were determined, as well as their usage possibilities. Twenty (20) different plant species were found and categorised into eleven (11) families. The most represented family was Asteraceae. The most common species was *Robinia pseudoacacia*. Species *Erigeron annuus* and *Ailanthus altissima* were also recorded at a large number of sites. The majority of the invasive plant species in the area of the city of Rijeka and its surroundings are of American origin. Invasive species can cause great damage to indigenous flora, but also to agricultural production. Also, invasive species could have a negative impact on human health. However, some of this species have certain usage value and can be very useful. Invasive plant species could potentially be used for food, medicinal, melliferous and ornamental purposes, but also as animal feed or as antierosive species. The most common potential ways of usage of recorded invasive flora are for medicinal purposes, as decorative plants, for honey production and as antierosive species.

Keywords: food, medicinal, melliferous, decorative, allelopathy

CHANGE OF VISUAL HISTORICAL IDENTITY OF THE CITY OF DUBROVNIK CAUSED BY INVASIVE AND POTENTIALLY INVASIVE PLANTS

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The research determines the extent of changes in the visual character of the landscape from the aspect of vegetation, in the administrative area of the City of Dubrovnik in the last two centuries. The aim was to make inventarisation of invasive and potentially invasive plant species that permanently changed the visual historical identity of the landscape in the observed period. As methods analysis of historical literature and graphic documents, as well as field survey have been applied. The second half of the 19th century and the entire 20th century were marked by numerous introductions of exotic plants, mostly for aesthetic reasons, caused by the development of tourism which conditioned a paradigm shift in the experience of the Mediterranean landscape. Although today there is an awareness of allochthones especially invasive species that permanently change the character of the landscape of the City of Dubrovnik, some plant species are widespread to such an extent that the possibility of their eradication is questionable. This is especially true of *Ailanthus altissima* (Mill.) Swingle, but also *Robinia pseudoacacia* L. and *Broussonetia papyrifera* (L.) Vent. The process of transformation of the landscape, i.e. the change surface cover in the observed area, was dominantly transformed from the beginning of 20th century onwards. Over time, parts of natural stands have been cleared and repurposed into agricultural land. Olive groves and vineyards were especially in 19th century located on the terraced slopes in the public landscaping spaces of the City of western and southern exposure and were forming a specific visual identity. By abandoning agricultural activity, stronger urbanization and changes in the economy structure during 20th century, much of the cultivated area is left again to natural succession processes. Therefore, on many cultivated areas during the natural vegetation succession, a *Pinus halepensis* Mill. forests are developed. For example, on the slopes of protected park-forest Petka, until the 19th century were olive groves. By the end of 19th century these slopes were already covered with *P. halepensis.* Nowadays on these slopes many *A. altissima* stands can be traced. In conclusion, we emphasize the necessary regular maintenance of City's greenery, the need of autochthonous vegetation planting, also wearing the visual historical identity of the City area.

Keywords: native plants, exotics, flora inventarisation, historical map

INVASIVE ALIEN PLANT SPECIES IN PROTECTED AREAS OF THE CITY OF ZAGREB

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This research was conducted as part of the monitoring of invasive alien plant species (IAP) in protected areas of the City of Zagreb. The aim was to determine the distribution and abundance of IAP, to compare the data obtained with the data collected during the last monitoring in 2017 and to propose future monitoring and/or eradication activities. The fieldwork was carried out in August 2018 at 15 locations. Smaller areas (urban parks) were divided into microlocations (unambiguous and clearly marked monitoring sites), while their boundaries were determined following existing pathways and/or vegetation units. In the larger areas several 5+5 m wide transects were defined and split into 100 m long segments (microlocations) using the Jenks' method of natural breaks, while aiming to include sites with the largest number of previously recorded IAP and the most favourable habitats for their development and spreading. At each microlocation all present IAP were recorded and their abundance was estimated using the DAFOR scale. Alltogether, 34 IAP were recorded, of which five species were not previously recorded (e.g. *Broussonetia papyrifera* and *Angelica archangelica*), while six previously recorded species were not found (e.g. *Impatiens glandulifera* and *Juncus tenuis*). The most common species were *Erigeron annuus* and *Robinia pseudoacacia*. The abundance of recorded IAP is, however, relatively small - 61.06% of observations were assessed as rare, while no species was assessed as dominant. Due to intensive mowing of sites in the city centre, habitats favourable for the growth and spread of IAP are limited, while in larger areas, where maintenance in not as intensive, a larger number of IAP was generally recorded. Due to the methodology applied and field work period, the likelihood of presence of additional IAP is not excluded. Therefore, further monitoring is necessary to increase understanding of the current state, as well as the possibility of controlling IAP in protected areas of the City of Zagreb.

Keywords: Ecological network, monitoring, microlocations, transects, urban parks

Bidens frondosa STANDS IN THE RAMSAR SITES OF THE SOUTHERN PANNONIAN PLAIN, IN SERBIA

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The highly invasive therophyte *Bidens frondosa* L. (devil's beggarticks) is not restricted to disturbed habitats but can also invade natural vegetation, especially riparian areas. In its country of origin (North, Central and South America), it inhabits the same natural habitat types as in the allochthonous areas: moist forests, meadows, coppices, drained riverbeds, along streams, ponds and wetlands. Hence, the occurrence of this invasive species was studied in ecologically very important and valuable wetlands in the southern region of Pannonian Basin (northern part of Serbia). These habitats are known to be rare and fragile, and are internationally protected, including as Ramsar sites. Research on selected Ramsar sites was conducted over a five-year period (2011-2015). Vegetation sampling was made at sites where the presence of the studied invasive species was determined according to the Braun-Blanquet methodology. The species *B. frondosa* was found in 158 plots in 4 of the 6 Ramsar sites. Field research and data collection were performed on the entire surface of each investigated area during the flowering period of the investigated invasive plant. The results of numerical analyzes revealed a group of relevés characterized as a plant community with the informal name *Mentha aquatica-Bidens frondosa* comm. dominated by devil's beggarticks. Stands of this community develop within 2 habitat types (according to EUNIS classification codes): Water-fringing reedbeds and tall helophytes other than canes (C3.2) and Periodically inundated shores with pioneer and ephemeral vegetation (C3.5). Stands occur in open hydrophilous and hygrophilous habitats with a negligible presence of shrub species. Due to the fact that the data on distribution and abundance of invasive plant species, unique checklists and recording of their status for the whole Europe are missing, this article contributes to reducing this lack.

Keywords: beggarticks, habitat types, invasibility, wetland.

DISTRIBUTION OF INVASIVE ALIEN PLANT SPECIES ALONG RAILWAYS IN CROATIA

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Since 19th century a network of railways have expanded intensively and become a distinctive part of the landscape. Nowadays, the railway infrastructure represents one of the main corridors for the introduction and spread of the plant invasive alien species (IAS) into new areas. Disturbed habitats within railway areas create an ideal environment for establishment of IAS. The aim of the research is to show which IAS most often occur along the railway infrastructure. During field research conducted as part of the project "Mapping of foreign and invasive foreign plants development, finishing and testing of the monitoring program" a numerous sampling points were visited along the railways throughout Croatia. All data collected during field research in the period from July 2019 to October 2020 were analyzed. The collected data are overlapped with the spatial basis of the railway network of the Republic of Croatia. For the analysis of the data, a narrower and wider zone of 5 and 50 m from the railways was determined, which gave a list of IAS that occur within these zones. The most frequently IAS from the list were compared to biogeographical regions, and the ratio of railway-related species findings was determined in relation to all species findings collected during field research. Some of the most common IAS that occur along the railways are: *Ambrosia artemisiifolia*, *Conyza canadensis*, *Erigeron annuus*, *Solidago gigantea*, *Sorghum halepense*, *Robinia pseudoacacia* and *Amaranthus retroflexus*. These species are also widely distributed in other habitats. The species *Lepidium virginicum*, *Parthenocissus quinquefolia*, *Euphorbia maculate* and *Acer negundo* occurred more frequently along railways than in other researched areas.

Keywords: disturbed habitats, transport, trains, mapping, GIS analysis

DISTRIBUTION OF INVASIVE ALIEN PLANT SPECIES NEAR AQUATIC HABITATS IN CROATIA

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Invasive alien plant species (IAS) are usually distributed in anthropogenic habitats where native vegetation has been disturbed. However, aquatic habitats are also favorable for the spread of some IAS which can endanger native vegetation. The aim of this research is to show which IAS are spreading along aquatic habitats (streams and water bodies) in Croatia. All findings of IAS were collected by field research for the project Analysis of existing data on foreign types and IAS with elaboration of mapping methodology, mapping of foreign species and IAS with elaboration, testing and completion of the IAS tracking program and analysis of IAS entry and spreading methods, Group 17: "Mapping of foreign and invasive foreign plants development, finishing and testing of the monitoring program". Field research took place from July to October during 2019 and 2020. Collected data was overlapped with spatial data of streams and water bodies with a buffer zone of 10 m for streams and 20 m for water bodies. The analysis resulted with a list of IAS which grow along aquatic habitats. Most commonly recorded IAS from the list were analyzed in more detail, i.e., the ratio of species findings in aquatic habitats was determined in relation to all species findings in other habitats. Number of individuals on site was also analysed. Some of the species analysed in more detail (*Ambrosia artemisiifolia, Erigeron annuus, Solidago gigantea, Sorghum halepense, Conyza canadensis, Robinia pseudoacacia* and *Amaranthus retroflexus*) are not specific to aquatic habitats and are widespread in other habitats. Species *Amorpha fruticosa, Echinocystis lobata, Bidens frondosa, Xanthium strumarium* ssp. *italicum*, *Acer negundo*, *Asclepias syriaca* and *Reynoutria* x *bohemica* were more frequently recorded in aquatic habitats compared to other habitats. Some less common IAS that grows only in aquatic habitats recorded are *Ludwigia peploides, Egeria densa*, and *Elodea canadensis*.

Keywords: streams, water bodies, GIS analysis, mapping

MAPPING OF THE ALIEN AND INVASIVE ALIEN PLANT SPECIES IN BARANJA REGION (NE CROATIA)

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Ministry of Environmental Protection and Energy had implemented the project: Establishment of the National Monitoring System for Invasive Alien Species, financed by the Operational Program Competitiveness and Cohesion 2014-2020. Project activities set up in Group 17 comprised mapping of the selected alien and invasive alien plant species in the priority areas, and creation, revision and testing of the monitoring programmes. Field investigations had been undertaken with an aim to collect data on distribution of selected 82 species and two genera at national level, in the periods: July-October 2019, and June-October 2020. The mapping area comprises total 356 mapping quadrants with surface 10x10 km and 10-18 localities have to be visited in each of them. For data recording in the field a smartphone device is used with a special GIS/GPS application that enables simple data entry about locality, habitat, species recorded, estimation of size and cover, with entry of photos of habitats and selected plants. During August 2019, field investigations were carried out in eight quadrants, covering most of the area of Baranja region, including Nature Park Kopački rit. Total of 28 alien and invasive alien plant species were recorded, mostly members of the weed and ruderal flora. The most frequent were species: *Abutilon teophrasti, Ambrosia artemisiifolia, Asclepias syriaca, Conyza canadensis, Datura stramonium, Erigeron annuu*s and *Solidago canadensis*. Rare species were *Azolla filiculoides*, *Broussonetia papyrifera, Duchesnea indica*, *Eleusine indica, Elodea nuttallii, Impatiens parviflora*, *Reynoutria* x *bohemica* and *Xanthium spinosum*. Significant spreading was observed for the species *Phytolacca americana* and *Reynoutria japonica* in parts of the Nature Park Kopački rit.

Keywords: biodiversity, flora, nature protection, threats

MAPPING OF INVASIVE ALIEN PLANT SPECIES IN VIROVITICA-PODRAVINA COUNTY AS PART OF A COUNTRYWIDE PROJECT IN CROATIA

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During the course of a national project "Mapping of allochthonous and invasive alien plant species, including modelling, adapting and testing the monitoring programme" (in Croatian), comprehensive field surveys of such plants were conducted in Croatia under the capacity of Oikon Ltd. – Institute of Applied Ecology. As a fundamental part of the project, it was necessary to gather the following data in the field: site name and GPS coordinates, list of invasive plant species (including abundance and coverage), habitat type, observed anthopogenic impact and an estimate of its severity. For the purpose of the project, the overall territory of Croatia was divided into 10x10 km squares. A minimum of 10 sites per square, rich in invasive alien plants, were then selected based on the field expert's evaluation. Considering the amount of field data, a digital mapping application was available to all researchers as a means to expedite the data inputs. Additionally, a field manual with identification keys was specifically created for this project. Field research was conducted during the period of 2019-2020 and the results hereby presented belong to the larger part of the Virovitica-Podravina County (eastern Croatia). Consequently, a total of 40 invasive plant species have been recorded, with the more frequent ones being: *Abutilon theophrasti*, *Amaranthus retroflexus*, *Ambrosia artemisiifolia*, *Asclepias syriaca*, *Bidens frondosa*, *Conyza canadensis*, *Echinocystis lobata*, *Erigeron annuus*, *Helianthus tuberosus*, *Panicum dichotomiflorum*, *Phytolacca americana*, *Robinia pseudoacacia*, *Solidago gigantea*, *Sorghum halepense* and *Veronica persica*. The greatest diversity of invasive plants was related to poorly managed roadsides and arable land, including post-harvest areas. According to the obtained results, invasive plants are commonly dispersed throughout the researched area, sometimes with 10 different taxa growing within a single locality. New field data will contribute to the knowledge regarding diversity, abundance and spatial distribution of invasive alien plants in Croatia, while at the same time designing more effective ways to monitor and support their eradication.

Keywords: abundance, diversity, field research, spatial distribution, Virovitica-Podravina County

Rosa multiflora Thunb. – A NEW ALIEN SHRUB AND POSSIBLE NOXIOUS WEED IN CROATIA

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Rosa multiflora (family Rosaceae) is native in East Asia and invasive in Australia, Pakistan, and the USA. In Europe, it was recorded for the UK, Poland and Slovakia, but without a defined level of invasiveness. The plant colonises roadsides, old fields, prairies, open woodlands, forest edges, abandoned areas etc. So far, this species has not been recorded for Croatia, but recently we discovered it at two localities in the city of Zagreb: during 2020 at the area of Savica lakes and in 2021 in the city park Maksimir. Therefore, the aim of this work was to present the description and invasion ability of the new alien plant in the flora of Croatia, as well as features of its discovered habitats. *R. multiflora* is easy to determine due to its pinnatifid stipules and hairless styles. The leaves are toward 10 cm long with 5–11 leaflets, each with serrated edges. The flowers form large corymbs (blossom in late spring or early summer), each flower is small (about 2 cm), white or pink. The hips are reddish to purple, around 6 mm in diameter. Large plants produce numerous seeds, mostly dispersed by birds. In observed habitats in Zagreb it mostly colonises the shores of the lakes. While the presence of the plant in Maksimir is still negligible, it is much more widespread on the Savica lakes. In some places, it is a dominant plant within the alliances *Berberidion vulgaris* and *Chelidonio-Robinietalia pseudoacaciae*. This area is the ornithological reserve, and birds probably contribute to rapid spread of *R. multiflora,* which indicate an invasive potential of this plant at the area. Most often *R. multiflora* grows in the form of a bush, but on the Savica lakes we also observed it as a climbing plant reaching a length of more than six meters.

Keywords: city of Zagreb, non-native plant, ornamental plant, Rosaceae

CURRENT KNOWLEDGE ABOUT THE ALIEN PLANT KUDZU (*Pueraria montana* var. *lobata* (Willd.) Maesen & S.M.Almeida) IN CROATIA

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According to the Flora Croatica database (FCD) kudzu (*Pueraria montana* var. *lobata* (Willd.) Maesen & S.M.Almeida ex Sanjappa & Predeep), an alien plant of concern in the EU, in Croatia is relatively rare. It was first recorded in 2003 in the city of Split (Dalmatia), and for a long time, it was the only record in Croatia. However, only since 2019, two new sites along the Adriatic coast have been recorded: arboretum Trsteno (Dubrovnik coast) in 2019, and Malinska (island of Krk) in 2021. The aim of our work was to present another new locality of kudzu in Dalmatia, as well as its biology and habitat features at that site. Namely, also in 2021, we discovered this taxon in the town of Gradac, near the hotel complex, close to the beach (coordinates of the site: 43º 06 '27 "N 17º 20' 23" E; FCD ID 69630). The population was growing outside of cultivation, on a ruderal area with a strong anthropogenic influence, covering an area that increased from 15 to 20 m^2 over three months of monitoring. Kudzu is a climbing vine which climb in Gradac on vertical stone blocks and various waste materials, but we noticed that it spreads on the ground as well. Further description of the plant individuals on this site, observed invasive features and a complete list of plants with which it grows (e.g. *Cynodon dactylon, Lolium perenne, Cichorium intybus, Oxalis corniculata*, etc.) will be presented. A comparison of our results with available data on previous localities shows that the taxon is currently present in Croatia only in anthropogenically affected habitats of urban areas. However, it is probably present in a number of localities along the Adriatic coast, and requires our caution and possible monitoring before it becomes a serious invasive plant in Croatia.

Keywords: *Pueraria thunbergiana*, Flora Croatica database, Gradac, Dalmatia

NEW CHOROLOGICAL AND ECOLOGICAL DATA ON ALOCHTONOUS *Thladiantha dubia* (CUCURBITACEAE) IN CROATIA

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Thladiantha dubia Bunge (*Cucurbitaceae*) is a dioecious, perennial climbing vine native to the northern parts of China. So far, it has been recorded as an alien in many European countries, western states of the USA and Canada, and in several Asian countries outside its native range. This species is usually reported growing in shrubs, along railways, riverbanks, in maize fields, on the borders of vineyards and landfills. In Croatia, it was recorded for the first time in 1985 in the immediate vicinity of Botanical Garden of the Department of Biology (Zagreb County), however, the first published Croatian record, is relatively recent (marshland area Savica in Zagreb). Both previously known localities in Zagreb were confirmed and four new localities, all in continental Croatia were recorded between 2015 and 2020 – a single locality at Stara Savica (Zagreb) and in the vicinity of Vrbova (Brod-Posavina County) and two localities near Slatina (Virovitica-Podravina County). Although the species was not considered a garden plant earlier, two of our new records are most likely of garden origin. Introduction pathways on other localities might be through railroads, watercourses or embankment maintenance. The majority of the Croatian populations are female, which is quite rare in Europe, wherefrom mostly male plants were reported so far. Female populations of *Th. dubia* were recorded while in bloom or bearing seedless fruits in the summer months. Since no mixed populations were found and specific pollinators of this entomophilous species are absent from Europe, the fruits are most likely parthenocarpic (e.g. developed without fertilisation, resembling normally produced fruits but are seedless). According to the Croatian classification of alien flora, *Th. dubia* can be classified as a naturalized, non-invasive alien weed in Croatia.

Keywords: neophyte, alien species, naturalized species, parthenocarpy

NEW LOCALITIES OF ALIEN PLANT SPECIES *Senecio angulatus* (ASTERACEAE) IN CROATIA

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Senecio angulatus L. f. is a perennial climbing plant species originating from South Africa, classified as a naturalized alien in the southern and western Europe. After its first reported in Croatia in 2005, about twenty new populations (mostly in Northern Dalmatia) have been found, either as garden plants or rarely as garden escapees, and reported within Flora roatica Database. Here we report new localities along the Croatian coast recorded from 2019 to 2021. For the first time, the species has been found on the central Dalmatian islands of Hvar and Lastovo. Several populations were found in the city of Hvar – three cultivated in gardens and graveyard, and two garden escapees along the roads above the seashore (the latter two were the only populations recorded in bloom), and one garden escapee near the city of Jelsa. On the island of Lastovo (Middle Adriatic) only one cultivated and one escaped population were noticed in the Skrivena Luka Bay. In Northern Adriatic new planted and naturalised populations were found on the island of Lošinj (Veli and Mali Lošinj), and the island of Ilovik. In all localities, it was obvious that the plants have been eventually realised into the wild as an excess of plant material left after garden maintenance, which is a negative practice common in both rural and urban areas of Croatia. In addition, the species was noticed also in continental Croatia as ornamental plant planted in planters (jardinières) in Eastern Croatia (Lipovac) and sold in pots on farmer's market in the city of Karlovac. However, since the species has low frost resistance, its naturalisation in continental Croatia is not anticipated. On the other side, in the coastal region and on islands, the species obviously circulates among gardeners and plant lovers, thus its further spread through garden waste/escape is highly plausible.

Keywords: central Dalmatia, climber, garden escapee, islands, naturalised species

FLIGHT PROPENSITY AND PERFORMANCE OF INVASIVE BOX TREE MOTH

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Box tree moth *Cydalima perspectalis* (Walker) (Lepidoptera: Pyralidae) is an invasive moth originating from East Asia and present in Croatia since 2012. Its natural dispersal velocity of up to10 km per year is of particular concern. Understanding flight characteristics of insect pests is essential for designing effective strategies and programs for their management. The aim of this research was to use a flight mill to test flight propensity, performance and flight patterns of the box tree moth. The flight-testing mill consisted of a flight mill, a testing chamber and a data logging and processing unit. Flight characteristics such as duration and number of flights as well as velocity and distance of individual flights were monitored by four flight mill chambers in a *C. perspectalis* population under naturally occurring conditions. In 24-hour experiments, *C. perspectalis* flew a maximum distance of 15.6 km (virgin females) and spent a maximum time in flight of 241 minutes (4 hours). The average speed of *C. perspectalis* ranged from 1.1 m/s (the slowest flying/virgin females) to 1.6 m/s (laboratory males). The performed flight-testing systems proved to be efficacious and useful tools in unveiling essential flight characteristics of invasive flying insects. Flight mills contribute to the understanding of physiological traits and provide important insights into migratory activities; this is of particular importance for the highly invasive *C. perspectalis*.

Keywords: flight mill, flight characteristics, physiological traits, *Cydalima perspectalis*

SPREAD OF THE SCULTPURED RESIN BEE, (*Megachile sculpturalis*), IN CROATIA

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Sculptured resin bee, *Megachile sculpturalis* (Hymenoptera: Apoidea: Megachilidae), is a bee species native to East Asia (Korea, Japan, China, and Taiwan) that was introduced to France in 2008, and since then spread successfully across Europe. So far, it has been recorded in Italy (2009), Switzerland (2010), Hungary (2015), Germany (2015), Austria (2017), Slovenia (2016), Serbia (2017), Spain (2018), Crimea (2019), and Liechtenstein (2020). For Croatia, the first record was in 2019 in Split. Sculptured resin bees are distinctively large - among the largest bees in Europe, the length of females is 22-27 mm, and of males 14-19 mm. We report new occurrences of this species in Croatia in 2021: Pula (23 June), Makarska (7 July), Barać Caves (24 July), Zagreb (26 July), and National park Plitvička Jezera (26 July). These new records are from different habitats, including urban environment, and coastal and mountainous region (altitude of the highest find is 724 m). Additional research and monitoring of this species are needed to estimate its potential impact on native bee fauna and other native pollinators. In particular, we need more data about its behaviour, ecology, and interactions with plants it uses as a food source.

Key words: *Megachile sculpturalis*, invasive species, spread, monitoring

SPREAD OF *Aedes japonicus* IN THE ISTRIA COUNTY, CROATIA

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The first finding of invasive Asian bush mosquito *Aedes (Finlaya) japonicus* (Theobald, 1901) in Croatia was in 2013 on the Slovenian-Croatian border. In the following years, the species has occupied the northwest part of the country. As part of the National Monitoring System for Invasive Mosquito Species in the Republic of Croatia, the species was first recorded in 2016 in the Istria County within the settlement of Bale. In the following years, the species spread to other parts of Istria. The research was conducted in two ways: by setting oviposition traps and finding larvae from found mosquito breeding sites (barrels, tires, etc.). Every year, three traps were set in more than twenty cemeteries, which were changed regularly every forthnight. Collected eggs and larvae were left for further development. Determination of the species was performed mostly in the fourth instar of the larva, while some number of the larvae is derived to the adult form. To date, the expansion of the species' range to about twenty locations in Istria has been confirmed (Bale 2016, Premantura, Kanfanar and Završje 2018, Motovun and Karojba 2019, Motovun, Gračišće, Grožnjan, Kršete, Momjan, Oprtalj, Oskoruš and Županići 2020, Gorenja Vas, Petrovija, Sv. Marija na Krasu, Buje, Kaštel, Karojba, Oprtalj, Buzet, Hreljići, Ladrovići, Baderna, Bonaci, Umag, Višnjan, Brgudac, Roč, Barban, Grožnjan, Stari Pazin, Mihatovići, Sv. Lovreč, Oskoruš, Premantura and Lanišće 2021) which speaks of the extremely rapid spread of the species. Since the same reference locations were not always observed during monitoring, the number of species per location and the capacity of the environment were not monitored. In this paper, repeated findings at sites during more than one monitoring season are considered places where the population has become stable (Bale, Premantura, Motovun, Karojba, Grožnjan, Oprtalj, Oskoruš, Momjan).

Keywords: *Aedes japonicus*, invasive species, mosquito, Istria, oviposition traps

A FIVE-YEAR STUDY ON THE PRESENCE AND SPREAD OF INVASIVE MOSQUITO SPECIES IN BROD-POSAVINA COUNTY, CROATIA

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The monitoring of invasive mosquito species, which has been carried out since 2016 in Brod-Posavina County, Croatia represents a systematic surveillance of the invasive *Aedes* mosquito abundance and distribution. The purpose of monitoring is the early detection of alien mosquito species at entry points as well as rapid response actions and control measures. All obtained data were collected in a single national database and used to predict the risk of vector diseases. The research was conducted by oviposition traps at several different habitat categories that represent potential mosquito breeding sites. During the five-year study, special attention was paid to border crossing and tyre shop yards. The continuous appearance of eggs of the genus *Aedes* at these locations, as well as the fact that 40% of total number of eggs belong to these stations, confirm their importance as hot spots for the introduction and spread of invasive mosquito species. These results support the need for improved control of entry points in a wide range of activities, such as: obligatory control of imported goods and the validity of their storage, appropriate disinsection methods in accordance with the biology and ecology of invasive *Aedes* mosquito species and systematic public information and education.

Keywords: *Aedes albopictus, Aedes japonicus,* focal points, national monitoring

Drosophila suzukii RECORDED IN MEDITERRANEAN OLIVE ORCHARDS IN CROATIA

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Drosophila suzukii (Matsumura, 1931), native to Eastern and South-eastern Asia, nowadays has spread across North America and Europe. This Dipteran species is an invasive pest that causes economic damages due to its infestation on different fruit crops. It was first reported in Croatia in 2010 across various fruit orchards in Istria, and since then, it has spread across the country's territory including the capital city Zagreb and the Dalmatian region. In this study, we report the record of *D. suzukii* from an olive orchard in Zadar County, Croatia, with integrated pest management (IPM) system, surrounded by autochthonous sour cherry var. Marasca (*Prunus cerasus* var. marasca. To monitor the presence and abundance of flying pests, yellow sticky traps were set up from mid-July to late September 2018 and September and October 2019, within two olive orchards. Additional sampling for biodiversity assessment was done using a beating stick with a net. Examination of yellow traps did not confirm the presence of this invasive pest species. On the other hand, the DNA barcoding method of individuals sampled with a net confirmed the presence of *D. suzukii*. Earlier research in the area confirmed spider predation on *Bacterocera olea*, common dipteran pest species. Following mentioned results, we applied gut content analysis using e-DNA method to see potential biocontrol on *D. suzukii*. Here we present the result of gut content analysis of common predators for biocontrol of *D. suzukii*. The spread of this invasive fruit pest demonstrated the need to further research and implement environmentally friendly and sustainable pest control within agroecosystems, including biocontrol.

Keywords: biocontrol, DNA barcoding, monitoring, pest species

EARLY DETECTION AND RAPID RESPONSE ON THE INVASION OF *Takahashia japonica* IN THE CITY OF PULA

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The Asiatic string cottony scale *Takahashia japonica* (Hemiptera, Coccomorpha, Coccidae) is a newly discovered invasive alien species in Croatia. Its first and only report in Croatia is from Pula in 2019. *T. japonica* was found on six trees belonging to genera *Acer*, *Morus*, and *Albizia*. Some of the trees have completely lost their leaves (*Albizia*), others have a tendency to defoliate. The species was spotted early enough for eradication. The method applied in 2020 included two chemical treatments. For winter spraying against overwintering forms of pests 3% OVITEX (active substance paraffin oil 80%) was used. Treatment during the growing season (June, July) was performed with a combination of contact and systemic insecticides (e.g. acetamiprid + pyrethroids + paraffin oil as a moisturizer) at intervals of 15 days. The achieved effect was infestation reduction on most trees, but not complete disappearance of the pest. Monitoring and treatment should be continued until eradication. If *T. japonica* continues to spread, it will be necessary to assess whether the species poses a low or high risk to indigenous flora and whether it affects native hosts in other Mediterranean countries with similar climatic conditions. If the eradication process proves insufficient, it will be necessary to establish a control system to reduce the number and density of this invasive alien species and keep its negative effect on flora below an acceptable threshold.

Keywords: monitoring, suppression, *Takahashia japonica*

SUSCEPTIBILITY OF THE *Eucalyptus* spp. TO THE RED GUM LERP PSYLLID (*Glycaspis brimblecombei*)

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The presence of the species *Glycaspis brimblecombei* (Hemiptera, Psyllide), a native Australian psyllid, was first recorded in Croatia in 2020. The species was found on Pelješac Peninsula and in the Botanical Garden of the Institute for Marine and Coastal Research (University of Dubrovnik) on the island of Lokrum on several *Eucalyptus* spp. Its attack is recognized by the presence of conical white coverings (lerps) secreted by the preimaginal stages. Damages consist of leaf sap subtraction and visible leaf wilting. The symptomatic *Eucalyptus* spp. leaves were collected during the summer and analysed. The level of infestation was established for each species. In the case of light infestations, there was discolouration and wilting of the foliage, whereas heavy infestations caused extensive discoloration leading to leaf necrosis and defoliation, which reduced tree vigour. *E. blakelyi*, *E. camaldulensis*, *E. rudis*, *E. scoparia* and *E. tereticornis* showed significant susceptibility to the attack of the red gum lerp psyllid while *E. andrewsii*, *E. bridgesiana*, *E. cephalocarpa*, *E. globulus* subsp. *bicostata*, *E. leucoxylon*, *E. macarthurii*, *E. mannifera*, *E. mannifera* subsp. *maculosa*, *E. melliodora*, *E. nicholii* and *E. viminalis* showed light to moderate susceptibility. The red gum lerp psyllid is considered a serious pest that may cause reduction of the photosynthetic area of affected leaves, severe defoliation and reduction in plant growth. With repeated severe psyllid attack, tree susceptibility to other insects and diseases may increase, eventually leading to the death of the weakened plants. Also, honeydew and lerps cause inconveniences and could present a threat to ornamental values in urban areas or in special forest vegetation reserves such as Lokrum Island and its botanical gardens.

Keywords: invasive alien species, Lokrum Island, infestation symptoms

INVASION OF THE BEAUTY RAT SNAKE, *Elaphe taeniura* Cope, 1861 IN BELGIUM

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We report on the establishment of the beauty rat snake, *Elaphe taeniura* Cope, 1861, a large, oviparous colubrid native to Southeastern Asia, in Belgium. The snakes have invaded a railroad system next to the city of Hasselt in the northeast of the country (Limburg province), successfully reproduce and spread. Our report is based on validated citizen science observations, supplemented with targeted surveys performed on site. The species has been recorded in the wild since 2006, most probably following an introduction linked to the pet trade. Genetic identification, based on the COI gene, confirms that the sampled individuals belong to *E. taeniura*. In addition, the snakes recorded in Belgium phenotypically match *E. t. taeniura*, a Chinese subspecies. So far, only the Taiwanese subspecies *E. t. friesi* was reported to be invasive and have an impact on endemic mammals and birds, in Japan. Exact date of introduction, spatial extent and population size are currently unknown, but the number of observations increased in recent years. Sightings exist from an area as large as 208 km², yet the core distribution is currently estimated to be no more than 2 km². Based on what is known on its ecology and distribution, we classified the species as a watchlist species with moderate environmental risk, currently occurring in isolated populations. However, the species' distribution and invasive potential in Belgium remain largely unknown, and a full risk assessment would require more data on its ecology. As management of more widely established snake populations is notoriously difficult, we advocate rapid eradication as the most appropriate risk management strategy. As experience with the species is limited, this would require testing a combination of removal methods (hand capture, specific traps) in an adaptive management strategy. The conditions of an active railway, inaccessible to the public, pose a particular management challenge. Dedicated snake surveys to determine invasion extent are urgently needed to inform such response.

Keywords: reptiles, pet trade, risk analysis, ISEIA protocol

DISTRIBUTION AND POPULATION DENSITY OF NUTRIA (*Myocastor coypus*) IN CROATIA

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Nutria, a species naturally distributed in South America, was regularly bred on fur farms in the former Yugoslavia. Outside farms, nutria was for the first time recorded in 1936 in the swamps near Donja Dubrava (Međimurje), and then in 1959 individuals were observed in the wild in the area of Kopački rit. Later, the nutria spread to the entire area of continental Croatia and all major rivers of the Black Sea river basin, but also Mirna river in the Adriatic river basin. Nutria has been on the European Union's list of species of concern since 2014 and the aim of this study was to determine the current population distribution and relative density in Croatia for the purpose of further population monitoring and management. The nutria distribution was determined by a combination of three methods: survey mapping, visual census and camera traps. The relative population density was established by recording all nutria tracks on 10x10 km grid squares and line transects according to predefined criteria. Nutria was distributed on the upper flow of the Sava River to Stara Gradiška, on the rivers Lonja, Stara Lonja, Odra, Kupa, Kupčina, Dragonja, Mirna, Raša, Pazinčica, Boljunšćica and surrounding canals and tributaries, and on Lake Butoniga and the Crna Mlaka pond. In the continental part of Croatia, i.e. on the Kupa and Sava river, the relative population density of 0.8 ± 0.03 tracks per km was significantly lower compared to the Mirna River with 50 ± 0.07 tracks per km (Dunn Kruskal Wallis, $p < 0.05$). In Istria, given the damage present on crops, it is possible to speak of a very high population density, while in other parts of Croatia damage on natural ecosystems was not observed during the period of the survey, and hence the population density was not estimated as high.

Keywords: semi-aquatic invasive rodent, Croatia, visual census survey, camera trap survey

DISTRIBUTION AND POPULATION DENSITY OF MUSKRATS (*Ondatra zibethicus*) IN CROATIA

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The muskrat is a semi-aquatic species native to North America. The species was introduced to Europe in the early 20th century for fur farming. Individuals escaped from fur farms or were deliberately released into the wild. Thanks to a high reproductive potential and a nomadic lifestyle this highly adaptable species quickly established new wild populations. The muskrat was first recorded in the Republic of Croatia in 1932, where it probably spread from Hungary and Austria across the Mura River. Due to its invasiveness and negative impact on native aquatic vegetation and habitat structure the muskrat has been on the List of Invasive Alien Species of European Union concern since 2017 and the Republic of Croatia has an obligation to monitor and control the population. The aim of this study was to determine the muskrat distribution and the relative population density in Croatia as a basis for further population monitoring. The current distribution of muskrat was determined by a combination of survey mapping, visual census and camera traps. The relative population density was determined by recording active muskrat lodges according to predefined criteria for a line transect selection in preselected squares in a 10x10 km square grid. The muskrat was distributed in Croatia on all rivers of the Black Sea river basin including tributaries and ponds. The species was also present on the Krka River in Adriatic river basin. The relative population density was 1.8 ± 0.03 SD lodges per km. The relative population density differed significantly between water body types (Kruskal - Wallis, $p < 0.05$), and was significantly higher on the Sava River and its tributaries compared to the Drava River (Dunn's test $p < 0.02$). Population densities also differed significantly between selected squares (Anova, $p < 0.05$) and is generally low compared to studies conducted in the Netherlands, France, and the United States.

Keywords: semi-aquatic invasive rodent, Croatia, visual census survey, camera trap survey

PRESENCE OF LESEPSIAN FISH MIGRANTS IN THE ADRIATIC SEA: A BRIEF OVERVIEW

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The "Lessepsian migration" is the largest marine biological invasion in the world. Hundreds of species have already passed the Suez Canal and settled in the Eastern Mediterranean Sea. The marine biodiversity of the Mediterranean Sea is nowadays facing substantial the structural changes in flora and fauna. Such changes were also recorded in the Adriatic Sea, as well. During the last few decades, various factors including climate change, anthropogenic activity and lessepsian migration have altered the composition of Adriatic ichthyofauna. Extensive investigations carried out in the last decades allowed us to recognize species previously not recorded or reported in this area. Among these, 13 Lessepsian fish migrants were recorded in the Adriatic sea: *Pampus argenteus,, Saurida lessepsianus , Sphyraena chrysotaenia, Epinephelus coioides, Leiognathus klunzingeri, Stephanolepis diaspros, Siganus rivulatus*. *Terapon theraps, Fistularia comerssonii, Lagocephalus sceleratus, Abudefduf saxatilis, Abudefduf sp., Bregmaceros nectabanus* and *Pterois miles*. Two species (*Paraexocoetus mento* and *Hemiramphus far*) were excluded from the previous lists because the records were not scientifically confirmed, while three species *F. commersonii*, *L. sceleratus* and *S. luridus* proved to be successful invaders especially in its southern part. The situation with the records of species of the genus Abudefduf is particularly interesting and should be discussed. The lionfish *P. miles* was observed on four locations: Santa Cesarea Terme (Lecce, Italy), Torre Canne-Fasano (Brindisi, Italy), Dherme beach (Albania) and Komiža, island Vis (Croatia).

Keywords: Fish, lesepssian migration, Adriatic Sea

WILL THE LIONFISH (*Pterois miles*) CONQUER THE ADRIATIC SEA?

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The scorpaenid fish *Pterois miles* (Bennett, 1828), originating from the Indo-Pacific, is considered one of the worst invasive species in the Mediterranean Sea. Once established, its populations can have damaging effects on native communities, resulting in biodiversity loss, habitat degradation, and economic effects on the fishing industry and marine-based activities as evidenced in the Eastern Mediterranean (e.g. Cyprus and Greece). Their biological traits and ecological habits: early maturity, high growth rate and fecundity, long-range larval dispersion, venomous spines, generalist diet, and habitat flexibility, combined with lack of native predators facilitate their spreading and establishment success. In the Adriatic Sea the lionfish was recorded for the first time in summer of 2019 along the Italian and Albanian coasts (in the Strait of Otranto) and in summer 2020 ca. 90 km northwest from the Otranto Strait in Apulia. Here we report a single spotting of *P. miles* in August 2021, on the Island Vis near Komiža, more than 250 km northwest from the previous (2020) sighting in the Adriatic Sea. The fish was approx. 13 cm long, spotted at 15 m depth, on a rocky bottom covered with algae. Contrary to prediction models, this finding shows that the species could spread even further to the north than expected. Despite the efforts of Croatian scientists to warn about the possible danger, no proper actions of relevant national authorities have been initiated to date to tackle the issue. Monitoring and population controlling actions are urgently needed as a rapid response following early detection of invasive species is considered the best approach in potential damage mitigation. Although the number of individuals found at particular locations in the Adriatic so far was small (1 or 2 fish), there is an urgent need to educate divers, fishers and the wide public about the matter and to develop legal protocol for eradication. Moreover, a Croatian network for collecting and exchanging information about the fish spotting targeted for divers and fishers should be established. Due to climate change it could be expected that the sea temperature of the Adriatic will rise in the future making it more suitable for the establishment of the lionfish and formation of dense populations.

Keywords: invasive species spreading, new finding, Vis Island, Mediterranean

THREE INVASIVE SPECIES OF SOUTH ADRIATIC, DUSKY SPINEFOOT (*Siganus luridus*), BLUESPOTTED CORNETFISH (*Fistularia commersonii*) AND LIONFISH (*Pterois miles*)

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In the area of the East side of the southern Adriatic, in recent years we have noted numerous specimens of allochthonous organisms. There are different ways of arrival of these species, but most often it is active migration to the north. Some new species pose potential threat to native species and fisheries in general. These are the dusky spinefoot (*Siganus luridus*), the bluespotted cornetfish (*Fistularia commersonii*) and the lionfish (*Pterois miles*). Species were recorded in the southern Adriatic, as part of fishing or by notification of sport divers. The dusky spinefoot was recorded for the first time in the Adriatic in 2010 near island of Mljet. In the area of the southern Adriatic, where a significant numbers are present, it is hunted in Donji Molunat. In three samples taken with trawler net we noted 121 specimens during October 2016. It is an herbivorous species that drives domestic species such as salema (*Sarpa salpa*) into deeper waters. The bluespotted cornetfish was first recorded in 2006 near the island in front of Dubrovnik (Island of Sv. Andrija). It is a carnivorous species that feeds on small fish and juveniles. Till now we have received six specimens from fishermen. The lionfish was first observed in August 2021 near island of Vis (Middle Adriatic) and along the Konavle coast near Dubrovnik. It is a carnivorous species that does a great damage in the areas where it occurs by feeding on juveniles. Up to now, the number of finds is dominated by dusky spinefoot and trumpeters, while the lionfish has been recorded twice. With the change of conditions in the habitats caused of climate changes and possible establishment of their population, it is possible that the number of individuals of these species will increase. That is the reason why it is necessary to organize the informing of the public and the fishermen about those invasive species.

Keywords: fish species, Adriatic Sea, new records

TWO NEW RECORDS OF INVASIVE COPEPOD *Pseudodiaptomus marinus* IN THE ADRIATIC SEA

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Free-living pelagic copepod species *Pseudodiaptomus marinus* Sato, 1913, indigenous to the North western Pacific Ocean, is one of the most well-known zooplankton species considered to be introduced to new environments by human activities. It is generally introduced into coastal areas, primarily into ports by ballast water release. From the first observation of this species in the Adriatic Sea in November 2007 near Rimini (Northern Italy), its presence has additionally been documented along the northern and eastern Adriatic ports with a stably increasing number of records updates on its distribution. We present here additional records of *P. marinus* in the zooplankton samples from the two cruises in the Adriatic Sea. The first record originated from the Middle/South Adriatic western coast, in December 2015, where this invasive calanoid was found at two stations near Gargano and one station near Bari in low abundances (< 1 ind. m^{-3}). Samples were taken with a Nansen net (250 µm mesh size) during the ESAW cruise. Average temperatures of the sampling layers (0-100 m) ranged between 14.86 °C and 15.82 °C and salinity between 37.22 and 38.61. The second record was in the coastal area (Boka Kotorska Bay, Montenegro) of the eastern South Adriatic, in October 2018. Samples were taken during the night with Nansen net (125 µm mesh size). Abundances of *P. marinus* were 1.44 ind. m^{-3} (0-61 m sampling layer) and 3.73 ind. m^{-3} (32-62 m), with an average temperature of 18.09 °C and salinity of 37.45. Given the large number of mega cruise ships in the area, a ship's fouling is probably a vector of *P. marinus* entrance and dispersion in the Boka Kotorska Bay. Further research on ballast water composition as well as studies on the fine distribution of this species for a longer period along the Adriatic coast are needed to estimate the possible establishment of this species in the area and its consequences for local planktonic populations.

Keywords: Adriatic western coast, ballast water, Boka Kotorska Bay, Copepoda, plankton

SPREADING OF NON-INDIGENOUS CRAB *Percnon gibbesi* (H. MILNE EDWARDS, 1853) IN THE CROATIAN PART OF THE ADRIATIC SEA

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Percnon gibbesi (H. Milne Edwards,1853) (Decapoda, Percnidae), is one of the most widely distributed marine crustaceans in the world. It is native to the Pacific and Atlantic coasts of South and North America and the Atlantic coast of Africa. Since its first record in the Mediterranean Sea in 1999 (Italy, Linosa Island), the population of *P. gibbesi* has rapidly expanded. It has been speculated that *P. gibbesi* was introduced through shipping or by larval drift by the Atlantic surface current entering the Mediterranean Sea. At present, due to its rapid spread, it is considered the most invasive species introduced into the Mediterranean basin. Following the first record of *P. gibbesi* in Croatia in 2014 (Molunat Bay, South Adriatic Sea), its geographical range continues to expand toward north. In this study we present all of our spatial records of *P. gibbesi* in Croatia as well as results of the DNA barcoding of the collected specimens. Information on its distribution were collected during target field research or as incidental records. Important set of data was obtained through public awareness and collecting information from different sea stakeholders. Molecular phylogenetic analyses were made using mitochondrial DNA (mtDNA) sequences (COI region). *P. gibbesi* has been found so far on numerous locations that includes: 1) costal area in the south with the most-northern records on Pelješac Peninsula and 2) South and Middle Adriatic Islands Mljet, Korčula, Lastovo, Palagruža and Vis. The species inhabits narrow subtidal zone (at depths of 0-5 m), mainly on vegetation free boulders, usually solitary but sometimes in greater density reaching 5 individuals per m^2. Molecular analyses confirmed species identification and provided the first sequences of *P. gibbesi* from the Adriatic Sea. Phylogenetic analyses reveal high simillarity with the specimens from the Azores, Atlantic ocean.

Keywords: *Percnon gibbesi*, invasive, Adriatic Sea, mtDNA

RECENT OCCURRENCE OF *Pyrosoma atlanticum* (THALIACEA, PYROSOMATIDA) IN THE SOUTH ADRIATIC

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Gamulin (1979), during his investigations of thaliacean abundance and distribution in the Adriatic Sea in the period from 1947 to 1952, found only larvae of *Pyrosoma atlanticum*, most commonly in the tetrazooid form, and in the greatest abundance near the Vis island. Nevertheless, he states that *Pyrosoma atlanticum* is common in the South Adriatic were it is occasionally caught by the fishermen in the fishing nets. For the period 1974-1975 Katavić (1976) states that he found 7 tetrazooids and 3 small adult colonies in the South Adriatic. In the period from 2007 to 2020 only few tetrazooid colonies were caught by zooplankton nets and adult colonies were never observed on the surface. In 2021, during zooplankton sampling trip in the open South Adriatic on 9th and 10th of September, we observed 13 adult colonies of *P. atlanticum*. Three of them were caught by hand nets and their identity was confirmed by inspection under the binocular. At the time of collection the surface salinity was extremely high (39.3) and surface temperature was 25.4°C. It seems that *P. atlanticum* is not as common in the Adriatic now as it was in the past. It occurrence seems to vary and it is possible that it is governed by circulation changes in the Ionian Sea, most notably BiOS (Bimodal Ocillating System). Due to the termophilic nature of *P. atlanticum* and on-going climate changes it is possible that *P. atlanticum* will become more common in the Adriatic Sea than it was in last decades.

Keywords: *Pyrosoma atlanticum*, climate change, Thaliacea, Adriatic Sea

A NEW SPECIES OF THE GENUS *Paracytaeis* (CNIDARIA, HYDROZOA) FROM THE ADRIATIC SEA

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An unknown hydromedusa species belonging to the genus *Paracytaeis* (Anthoathecata, Cytaeididae) is collected from the open sea of the southern Adriatic in winters of 2016., 2020. and 2021. Only two species from this genus are known, *P. octona* and *P. meteoris*. So far, only medusa stage of both speies are described. The last one is doubtfoul species due to inadequate description of only single specimen from near the Cape Verde Islands (Atlantic Oceans). However, our species can be distinguished from its congeners, among others features, by the number of oral tentacles in adult specimens. Specimens were sequenced (COI, 16S) and the obtained sequences were searched against the GenBank database using the Blast tool. The search showed that no identical sequence existed in GenBank. However, no data of any of two *Paracytaeis* species existed in the Genbank. Nevertheless, this analysis confirm that species belong to the family Cytaeididae. Relatively high number of specimens (~1.0 ind/m^3) were occurred in a situation with high salinity conditions (38.8 - 39.3) in all years when they are registered. High salinity condition indicates strong inflow of Eeast Mediterranean water into Adriatic Sea. Therefore, our *Paracytaeis* species might be a Lessepsian migrant of Indo-Pacific origin.

Keywords: Hydromedusa, *Paracytaeis*, new species, Adriatic Sea

Abudefduf cf. *saxatilis*, A NEW RECORD IN THE EASTERN ADRIATIC SEA

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Alien fish species have been increasingly observed in recent years in the Mediterranean and Adriatic Seas. Beside Lessepsian migrants which enter in the Mediterranean Sea through the Suez Channel and constitute a major part of the Mediterranean assemblages of non-native species, many species have been introduced by various anthropogenic vectors such as shipping, aquarium release, aquaculture etc. Damselfishes (Pomacentridae) are represented by 423 valid species and *Chromis chromis* is the only native member of this family in the Mediterranean Sea. In the last decades, several pomacentrid fish have been recorded in the Mediterranean Sea, among which, species of the genus *Abudefduf* are the most numerous. In recent years many records of two species, namely *Abudefduf saxatilis* and *Abudefduf vaigiensis* have been published. These two species are native to two distinct marine realms, *A. vaigiensis* being Indo-Pacific and *A. saxatilis* Atlantic species. They also display very high resemblance and can be easily misidentified. However, some morphological distinguishing characteristics are predominately, but according to recent studies, not exclusively, associated with particular species. Therefore, it is suggested that the species of Abudefduf genus recorded in the Mediterranean should be reported with precaution. Here we present a new record of *Abudefduf* cf. *saxatilis* observed on 2nd October 2020 in Cavtat, Croatia (42°35′12′′N; 18°12′40′′N). Specimen was filmed by GoPro camera during the yearly MSFD monitoring of non-indigenous fish species in Croatia. Our finding represents the third record of *Abudefduf* sp. in the Adriatic Sea. The first record was in Split in September 2018, while the second record was in August 2019 at Punta Sottile near Trieste.

Keywords: alien species, non-indigenous species, Damselfishes, sergeant major

DEPTH DISTRIBUTION OF THE INVASIVE ALGA *Caulerpa cylindracea* Sonder IN THE MARINE PROTECTED AREAS IN THE EASTERN ADRIATIC SEA

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One of the recent goals for marine biologists is to understand the factors that determine the invasive success of introduced species. Exotic algae are one of the major threats to coastal marine habitats as they often have negative effects on the structure and diversity of native benthic communities. The green alga *Caulerpa cylindracea* (Sonder) has a strong invasive character and was identified as being one of the most invasive species of the genus *Caulerpa* in the Mediterranean Sea. Light is one of the factors influencing macrophyte communities and key in regulating its productivity, abundance and distribution. Thanks to the large capacity of photoacclimation, this green alga can colonize habitats within a broad range of light regimes. This has been linked with significant changes in community characteristics of receiving habitats. Many studies show the effects of this seaweed on benthic communities, but the relevance of depth, seawater movement and herbivores in the dispersal dynamic of this invasive alga are still not clear. This study aimed to evaluate the spread and depth distribution of the invasive green alga *C. cylindracea* in the protected areas in the eastern part of the Adriatic Sea and understand the factors influencing its spread. Fifteen sites (five sites per three protected areas) have been investigated. Our results provide evidence of a wide invasion of this alga in investigated marine protected areas. The present study showed that invasions of alien alga *C. cylindracea* could represent a serious threat for Mediterranean coralligenous and maerl assemblages.

Keywords: *Caulerpa cylindracea*, coralligenous, maerl, Adriatic Sea

Asparagopsis taxiformis (BONNEMAISONIALES, RHODOPHYTA) TETRASPOROPHYTE CONFIRMED BASED ON MOLECULAR MARKERS IN CROATIAN PART OF THE ADRIATIC SEA

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Two species of marine red algae of the genus *Asparagopsis* (Bonnemaisoniales) are found in the Adriatic Sea, *A. armata* Harvey and *A. taxiformis* (Delile) Trevisan de Saint-Léon. These tropical-subtropical species are considered non-native to the Mediterranean Sea. The species of the genus *Asparagopsis* have a heteromorphic life history with an erect gametophyte and a filamentous tetrasporophyte phase, which has even been considered as a separate species named *Falkenbergia*. Due to morphological differences between the gametophytes of *A. armata* and *A. taxiformis*, they have been easily distinguished. Contrary, their tetrasporophytes are morphologically similar and cannot be easily determined without accurate morphological and genetic studies. In the Adriatic Sea, the gametophyte of *A. armata* has been recorded only once, while the gametophyte of *A. taxiformis* is becoming common in the south and middle area of the Croatian part of the Adriatic. So far, all *Falkenbergia* specimens collected from the Adriatic Sea have been assigned to *A. armata*. The aim of this study was to investigate whether tetrasporophytes developing near gametophytes of *A. taxiformis* possibly belong to this species. To achieve our objective, we used DNA barcoding based on mitochondrial COI-5P and chloroplast rbcL regions. We indeed determined that the collected *Falkenbergia* belonged to the terasporophyte of *A. taxiformis*. Although the gametophyte of *A. taxiformis* was discovered in the Adriatic Sea in 2000, this is the first time that presence of its tetrasporophyte has been detected. Until now, most *Falkenbergia* records were determined *a priori* as *A. armata* because morphological identification is highly problematic. Therefore, our result suggests that some of the earlier *Falkenbergia* records may have been misidentified. Due to the apparent presence of the tetrasporophytic phase, *A. taxiformis* is probably much more widespread species in the Adriatic Sea than we previously assumed based only on its gametophytic phase records.

Keywords: macroalgae, *Falkenbergia*, rbcL, COI-5P

ALIEN CRUSTACEANS AND MOLLUSCS IN MACROINVERTEBRATE ASSEMBLAGES OF CROATIAN LARGE RIVERS

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Alien crustaceans and molluscs have heavily invaded Croatian large rivers, but their impact on macroinvertebrate assemblages has been poorly studied. The aim of this study was to assess the biocontamination in the Croatian large rivers, particularly the contribution (number and abundance) of alien crustaceans and molluscs to the total species richness and abundance of macroinvertebrate assemblages. The sampling occurred on two occasions (2015 and 2016/2017) in the main course of four major rivers: the Danube (at 4 sites), Drava (18 sites), Mura (3 sites) and Sava (21 sites). Replicative quantitative (20x0.0625 m^2) samples were collected at each site following the AQEM sampling protocol. In total, 22 alien macroinvertebrate species were recorded, with 11 crustacean and six molluscs species. A site-specific biocontamination index (SBCI) was calculated at the family level for all sites from two metrics: Abundance Contamination Index (ACI) and Richness Contamination Index (RCI). The biocontamination at most sites was high (19 sites, 41.3%) and severe (13 sites, 28.3%), and alien macroinvertebrates were not found only at seven most upstream sites in the Drava, Mura and Sava Rivers. The two crustacean (Amphipoda) genera, *Chelicorophium* and *Dikerogammarus*, had the highest abundance and proportions among the alien taxa. The biocontamination indices ACI (r_s=0.74, $p<0.001$, n=69) and SBCI-Fam (0.57, $p<0.001$, n=69) were positively and statistically significantly correlated with densities of the alien crustaceans. The mean number of native taxa (38) at the sites without alien crustaceans was significantly higher than at the sites with alien crustaceans (27). The species *Corbicula fluminea* and *Dreissena polymorpha* were the most widespread and abundant invasive molluscs. The alien crustaceans (Amphipoda and Isopoda) were the largest contributor to the biocontamination of the macroinvertebrate assemblages in the Croatian large rivers, and their future spread upstream could cause a decline of native taxa in the upstream reaches of the Drava and Sava rivers.

Keywords: invasive macroinvertebrates, Crustacea, Mollusca, biocontamination, large rivers

ALIEN AND INVASIVE MOLLUSCS IN THE CROATIAN FRESHWATERS

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Alien molluscs have heavily invaded the European freshwater ecosystems. Knowledge on distribution of alien molluscs in Croatia is limited and a complete inventory of their distribution in the Croatian freshwaters has never been conducted. The aim of this study was to collect data on distribution, origin, pathways and impacts of alien freshwater molluscs in this country. A database was built based on literature data and the authors' published and unpublished data. In total, eight alien molluscs species have been recorded in the Croatian freshwaters (Bivalvia: *Corbicula fluminea, Dreissena polymorpha*, *Dreissena rostriformis bugensis*, *Sinanodonta woodiana*, and Gastropoda: *Ferrissia californica*, *Physella acuta*, *Planorbella duryi, Potamopyrgus antipodarum*). The areas of their origin are North America (3 spp.), European Ponto-Caspian region (2 spp.), Asia (2 spp.) and New Zealand (1 sp.). The most important pathways of unintentional primary introductions of these species are transport as contaminant (fish stocking) and stowaway (shipping). Seven alien molluscs species were found in the Black Sea Basin (Danube Basin) and six of these were also recorded in the river catchments of the Adriatic Sea Basin. The most important invasive species with possible impact on ecosystem processes and native species are the mussels *C. fluminea*, *D. polymorpha*, *S. woodiana* and the snail *P. antipodarum*. The detailed information from this study about the distribution of invasive molluscs could be used for prioritisation of measures which would reduce the further spread of such invaders and their ecological and economic impact in the Croatian freshwaters.

Keywords: non-indigenous species, Bivalvia, Gastropoda, origin, pathways of introduction

NATURAL PRODUCTS INHIBIT THE LIFE STAGES OF *Aphanomyces astaci*, AN INVASIVE PATHOGEN OF FRESHWATER CRAYFISH

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Aphanomyces astaci (Oomycota), the causative agent of crayfish plague, is listed among the 100 worst invasive alien species in the world due to its detrimental effects on native European crayfish populations. It also causes significant economic losses in crayfish aquaculture, and chemicals harmful to humans and the environment are currently used to control it. Our aim was to explore environmentally safe methods for its control, i.e. we tested the potential of propolis and essential oils of selected Mediterranean plants to inhibit mycelial growth, and the motility and germination of secondary zoospores of *A. astaci*. The tested substances were found to be rich in bioactive volatile components, mainly monoterpenes, by GC-MS. The propolis samples were also rich in non-volatile polyphenols, with chrysin and apigenin being the most abundant, as shown by UPLC-MS/MS. All the natural products tested showed strong inhibitory potential against mycelial growth and zoospores, with mycelial growth being the most inhibited by the propolis samples, while the strongest inhibition of zoospore germination was achieved by the application of sage essential oil. The demonstrated inhibitory effect could be partly explained by the activity of certain dominant components such as camphor or chrysin, but it is more likely to be due to the synergistic activity of many compounds present in propolis or essential oil mixtures. In conclusion, our results can serve as a basis for further *in vivo* experiments and the development of environmentally friendly methods to control *Aphanomyces astaci* infections in aquaculture.

Keywords: antioomycete activity, crayfish plague, propolis, sage, wild Mediterranean plants

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INDEX OF KEY WORDS

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