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Croatian Ecological Society

3. HRVATSKI SIMPOZIJ O INVAZIVNIM VRSTAMA
s međunarodnim sudjelovanjem

3rd CROATIAN SYMPOSIUM ON INVASIVE SPECIES
with International Participation

26-27. XI 2018 .
Zagreb, Hrvatska

ZBORNIK SAŽETAKA
BOOK OF ABSTRACTS

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signalni rak / signal crayfish (*Pacifastacus leniusculus)* – Ivana Maguire
grozdasta kaulerpa / seaweed (*Caulerpa cylindracea)* – Ante Žuljević

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Zagreb, 2018.

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3. HRVATSKOG SIMPOZIJA O INVAZIVNIM VRSTAMA

BOOK OF ABSTRACTS
OF THE 3rd CROATIAN SYMPOSIUM ON INVASIVE SPECIES

Urednik / Editor

Sven D. Jelaska

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Sven D. Jelaska

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Poštovane kolegice i kolege!

Zabilježen je prvi put u Hrvatskoj 2014. godine. Nakon dvije godine je uspostavio svoju prisutnost, a ove godine je još veći.
Iako bi ovo mogao izvještaj o pojavljivanju i broju neke invazivne vrste u Hrvatskoj, na sreću to je kratka povijest našeg Simpozija. Ovu godinu, s ponosom vam predstavljamo Knjigu sažetaka s još više priopćenja nego prije dvije godine. Tri pozvana predavanja, 30 usmenih i 49 posterskih priopćenja, koja obrađuju različite aspekte teme invazivnih vrsta. Teme, koja bi zasigurno mogla biti jedna od ključnih riječi koje karakteriziraju ovu epohu, koju još nazivamo i Antropocen.
Iako kratkog postojanja, ovaj Simpozij je svjedočio evoluciji pristupa i fokusa u istraživanju invazivnih vrsta: rano opažanje; njihova ekologija i rasprostranjenost; uklanjanje i podizanje svijesti javnosti; uloga u ekosustavima; uključivanje javnosti; prepoznavanje mogućih koristi od njihove prisutnosti, itd. Raznolikost tema koja može samo i dalje rasti, te koja traži udruživanje sudionika iz što više zemalja. Ove godine, preko 120 sudionika iz 15 Europskih država podiže letvicu, koju ćemo pokušati sljedeći put podići još više.

Sven Jelaska
Predsjednik Hrvatskog ekološkog društva

Honourable colleagues!

In the 2014, it was observed for the first time in Croatia. Two years later, it was already established, while this year it is even bigger.
This might be a report of some invasive alien species population in Croatia. Luckily, it is the short history of our Symposium! This year, we can proudly present you this Book of abstracts with even more contributions than two years ago. Three keynote lectures, 30 oral and 49 poster presentations, tackling various aspects of invasive species topic. Topic, which for sure can be nominated as one of the keywords of the Anthropocene.
Even in its very short history, this Symposium witnessed evolution of approaches and focus on dealing with invasive species: early detection; their distribution and ecology; eradication and public awareness activities; their position in the ecosystems; citizen science; searching for potential benefits of invasive species presence, and many more. Diversity of topics that can only grow, and to be able to cope with it, gathering of participants from as many countries as possible is needed. This year, over 120 participants from 15 European countries attended the Symposium, setting the benchmark that we will try to raise next time even higher.

Sven Jelaska
President of the Croatian Ecological Society

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Programme of the 3rd Croatian Symposium on Invasive Species

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10:45 – 11:15	Coffe Break
11:15 – 12:45	Chairperson: Nenad Jasprica 11:15 Zrinka Domazetović, Una Mršić DEVELOPMENT OF A SYSTEM TO MANAGE AND CONTROL INVASIVE ALIEN SPECIES IN CROATIA 11:30 Sandra Slivar, Igor Boršić, Martina Cigrovski Mustafić, Sonja Desnica, Ana Ješovnik, Petra Kutleša, Tanja Mihinjač MAPPING AND MONITORING OF ALIEN SPECIES IN CROATIA 11:45 Zrinka Mesić, Edin Lugić, Sonja Sviben, M. Mikulčić, Ana Ostojić, Marko Augustinović, Monika Petković, V. Slijepčević, Goran Gužvica1 METHODS FOR MAPPING AND MONITORING ALIEN INVASIVE FRESHWATER MAMMALS IN CROATIA 12:00 Sandra Hudina, Ivana Maguire, Petra Kutleša HOW TO ASSESS THE EFFECTIVE MANAGEMENT OF INVASIVE ALIEN SPECIES LISTED ON LIST OF SPECIES OF UNION CONCERN (EU REGULATION NO. 1143/2014) – A CASE STUDY ON INVASIVE CRAYFISH 12:15 Anže Japelj, Andrej Verlič, Judita Malovrh, Jana Kus Veenvliet, Maarten DeGroot PUBLIC PREFERENCES OF SLOVENES FOR CONTROLING INVASIVE ALIEN SPECIES 12:30 Neven Šlopar THE LIFE PROGRAMME AND IAS
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19:00 - 22:00	Beervasive evening

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	OF THE ALIEN INVASIVE OAK LACE BUG (*Corythucha arcuata*) IN THE CLONAL SEED ORCHARD 'PETKOVAC'
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PLENARNA PREDAVANJA

KEYNOTE LECTURES

UNRAVELLING THE ECOLOGY OF NON-NATIVE SPECIES TO INFORM STRATEGY

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Biological invasions are large-scale processes and cross-boundary collaborations are critical to ensure knowledge on invasive non-native (=alien) species (INNS) is shared between countries. This not only advances understanding of invasions but also enables successful implementation of strategies to manage INNS. Indeed there have been a number of policies developed across Europe which recognise the importance of INNS as a driver of biodiversity loss. Most notably the European Commission has addressed the threat of invasions in their Regulation 1143/2014. At the heart of the Regulation is the development of a list of INNS of EU Concern which explicitly focuses on potential future invaders, derived through horizon scanning, that require management. Species inventories are recognised as critical for the management of biological invasions, informing horizon scanning and surveillance, and underpinning prevention, control and elimination of INNS. There have been major developments in the availability of high quality data INNS. Here I will provide an overview of the ways in which this information can be used to inform science, policy and ultimately conservation. I will specifically focus on our research that has underpinned the GB INNS Strategy and the European Regulation including insights into invasion ecology from broad patterns and processes to approaches in surveillance and monitoring, particularly involving citizens and highlighting the importance of collaborations. Networks established through these collaborative initiatives have benefits for people, science, and nature.

Key words: monitoring, citizen science, transdisciplinarity

ASSESSING AND MANAGING LIVELIHOOD IMPACTS OF WOODY INVASIVE ALIEN SPECIES IN EASTERN AFRICA

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Several of the hundreds of exotic woody plant species that were introduced throughout Africa during the last century to provide benefits to rural people, including income, firewood and charcoal, wind shelter and soil protection have escaped cultivation and become some of the most important invasive alien species (IAS). These threaten fodder production for livestock, water availability and other key ecosystem services for rural livelihoods. We study impacts of woody IAS, in particular Prosopis juliflora, on ecosystem services and on people, the resulting conflicts as well as the spatio-temporal dynamics of these processes in case study areas in Eastern Africa. This presentation will highlight some of the impacts on individual socio-economic and ecological parameters and the upscaling thereof using remote sensing techniques. We will emphasize that developing sustainable land management (SLM) strategies for woody IAS requires a thorough understanding of the environmental, social and economic components of this complex social-ecological system. Management of IAS in social-ecological systems must be adapted to the invasion stage, local conditions and stakeholder preferences. Thus, we will also discuss approaches to incorporate stakeholders with potentially competing interests in a structured decision process to select SLM technologies that help mitigating the negative impacts of woody IAS.

Key words: Invasive woody species, Prosopis, transdisciplinarity, social-ecological system, sustainable land management

COMPARING IMPACTS OF ALIEN SPECIES: WHY AND HOW?

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Alien species can cause a broad range of significant changes to recipient ecosystems; however, their impacts vary greatly across species and the ecosystems into which they are introduced. There is therefore a critical need for a standardised method to evaluate, compare, and eventually predict the magnitudes of these different impacts. I will demonstrate a straightforward system for classifying alien species according to the magnitude of their environmental impacts (Environmental Impact Classification of Alien Taxa EICAT), based on the mechanisms of impact used to code species in the International Union for Conservation of Nature (IUCN) Global Invasive Species Database. The EICAT system uses five semi-quantitative scenarios describing impacts under each mechanism to assign species to different levels of impact — ranging from Minimal Concern to Massive — with assignment corresponding to the highest level of deleterious impact associated with any of the mechanisms. The scheme also includes categories for species that are Not Evaluated, have No Alien Population, or are Data Deficient, and a method for assigning uncertainty to all the classifications. EICAT is applicable at different levels of ecological complexity and different spatial and temporal scales, and embraces existing impact metrics. Apart from environmental impacts, many alien taxa are also known to cause socio-economic impacts by affecting the different constituents of human well-being (security; material and immaterial goods for a good life; health; social, spiritual and cultural relations; freedom of choice and action). Attempts to quantify socio-economic impacts in monetary terms are unlikely to provide a useful basis for comparing impacts of alien taxa because they are enormously difficult and may ignore important aspects of human well-being. In the second part of my talk, I propose a novel standardised system based on the capability approach from welfare economics for classifying alien taxa in terms of the magnitude of their impacts on human well-being (Socio-Economic Impact Classification of Alien Taxa SEICAT). The core characteristic of this approach is its focus on how alien taxa change people's activities. Like in EICAT, impacts are assigned to one of five impact levels, from Minimal Concern to Massive, according to semi-quantitative scenarios of impact descriptions. Classification of a taxon is according to the highest level of deleterious impact caused by it through effects on any constituent of human well-being. SEICAT provides a consistent procedure for translating the broad range of impact types and measures into ranked levels of socio-economic impact, assigns alien taxa on the basis of best available evidence of their most severe documented deleterious impacts, and is applicable across taxa and at a range of spatial scales. Both EICAT and SEICAT are designed to align closely with the Red List and could therefore be readily integrated into international practices and policies. In fact, EICAT was recently adopted by the IUCN.

Key words: impact assessment, environmental impacts, socio-economic impacts, comparing impacts, EICAT, SEICAT

USMENA PRIOPĆENJA

ORAL PRESENTATIONS

DEVELOPMENT OF A SYSTEM TO MANAGE AND CONTROL INVASIVE ALIEN SPECIES IN CROATIA

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The Ministry of Environment and Energy is implementing a project financed from the Operational Program Competitiveness and Cohesion, which aims to contribute to the development of a system to manage and control invasive alien species in the Republic of Croatia. In February this year, the *Act on the Prevention and Management of the Introduction and Spread of Alien and Invasive Alien Species* entered into force. It regulates risk assessment of alien species invasiveness, restrictions on the use of alien and invasive alien species and related controls. In addition, *Regulation (EU) 1143/2014 of the European Parliament and of the Council on the prevention and management of the introduction and spread of invasive alien species* obliges Croatia to adopt planning documents for the management of invasive alien species of Union concern. Part of the project activities is to develop management plans for signal crayfish (*Pacifastacus leniusculus*), small Asian mongoose (*Herpestes javanicus*) and sliders (*Trachemys scripta*), as well as action plans for pathways of unintentional natural ways of introduction of invasive alien species and transport-related pathways. Additionally, capacity building activities for management and official controls of alien species are foreseen, as well as activities to raise awareness of the general public on the issue of invasive alien species. The projected duration is 49 months. Its implementation will fulfil part of the obligations the Republic of Croatia has as a member state of the European Union in relation to common legislation on invasive alien species.

Keywords: management plans,, invasive alien species,, action plans,, pathways,, unintentional introduction,

MAPPING AND MONITORING OF ALIEN SPECIES IN CROATIA

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There are about 14,000 alien species currently known in Europe out of which 10–15% is estimated to be invasive. Invasive alien species (IAS) are recognized as a threat to biodiversity at the global, European and national level, and goals and legal obligations of Croatia regarding management and mitigation of IAS adverse impacts are defined in EU and national legislation, as well as in international conventions and treaties. In order to meet those goals and legal obligations, we need the knowledge of the current distribution of alien species in Croatia, their pathways of introduction and spread, and their impact on biodiversity and related ecosystem functions, human health and economy. Therefore, the purpose of the ongoing project "Establishment of the National Monitoring System for Invasive Alien Species" is to increase the knowledge about IAS in Croatia through literature review, data analysis, field survey at the national level, and the establishment of monitoring and citizen science programs. All of the collected data, including species' distribution maps, will be publicly available through the IAS information system, planned as a part of the Croatian Nature Protection Information System. Also, one of the aims of the project is to raise the public awareness on IAS in order to prevent their further spread and introduction of new alien species. In this presentation, we will present the project activities in detail.

Keywords: invasive species, IAS, pathways, information system, citizen science

METHODS FOR MAPPING AND MONITORING ALIEN INVASIVE FRESHWATER MAMMALS IN CROATIA

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The most common alien invasive freshwater mammal species in Europe are: nutria (*Myocastor coypus*), muskrat (*Ondatra zibethicus*) and American mink (*Neovison vison*). In Croatia, nutria and muskrat are reported, but only 7 literature and few recent reports exist of those species (21 reports for both species). So far, there are no reports of American mink in Croatia. Thus, there is a huge deficiency of research and monitoring of these species. We evaluated the following survey methods for monitoring nutria, muskrat and American mink: stakeholder query, mobile-phone application, camera traps, visual surveys. A stakeholder query was tested for three weeks on the Google Form platform and with intensive social network activities among the recognised stakeholders (i.e. hunters, anglers). Altogether 52 reports of nutria and muskrat were collected in this way and the distribution map is updated with new areas. Visual surveys and camera-traps were tested in the Zagreb City area and some previously known localities of nutria have been confirmed with stakeholder query, visual survey and camera traps. A priority map for future surveys was developed taking into account suitable habitats, evaluation of the accuracy of each report and the deficiency of research in some areas. The American mink has been reported in neighbouring countries and we suggest to conduct regular monitoring of nine main points of potential entry.

Keywords: *Myocastor coypus, Ondatra zibethicus, Neovison vison,* Zagreb

HOW TO ASSESS THE EFFECTIVE MANAGEMENT OF INVASIVE ALIEN SPECIES LISTED ON LIST OF SPECIES OF UNION CONCERN (EU REGULATION NO. 1143/2014) – A CASE STUDY ON INVASIVE CRAYFISH

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The Article 19 of the EU Regulation No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species (EU IAS regulation) states that for the widespread invasive alien species listed on the list of species of Union concern Member States will need to develop effective management measures. These effective management measures will have to be established so that the impact of listed species on biodiversity, ecosystem services and/or human health and economy is minimized. While management options will vary across Member states, ecosystem type, population characteristics and local climate conditions, it is of paramount importance to define general and measurable baselines for assessing what 'effective management' should represent and develop a framework that would enable comparisons of effectiveness among different measures options and countries. The aim of this presentation is to discuss these issues, focusing on listed invasive crayfish species, which represent 14% of all listed EU concern species.

Keywords: evaluation framework, effective management, dispersal, population growth, impact

PUBLIC PREFERENCES OF SLOVENES FOR CONTROLING INVASIVE ALIEN SPECIES

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Invasive alien species (IAS) are a significant environmental, economic and a societal threat, which can effectively be managed only with strong public support and active citizen involvement. Within the ARTEMIS project such system – early warning and rapid response (EWRR) –, was proposed, however public perception needed to be established. Thus, a choice experiment was designed by using five attributes, four of them representing characteristics of different IAS controlling measures and one being a payment vehicle. Control measures characteristics were type of removal (mechanical, chemical and biological), completeness of removal (partly and completely), place of removal (forest lands, urban areas) and implementation of EWRR system (yes or no). Choice experiment was a central part of the questionnaire, which was administered by a web survey in January of 2017 on a sample of 255 Slovenes. By analysing choice data, we established that the sample could be segmented into four classes, each holding a specific set of preferences towards different IAS control measures. Respondents in the first class expressed positive willingness to pay for all four measures (20.6 EUR/person year for biological removal, 22.2 for mechanical, 13.3 for complete removal, 6.5 for removal in urban areas and 13.9 for having EWRR), those in the second class for all measures except for removing IAS in urban areas compared to only forest land (40.0 for biological and 45.1 for mechanical removal, 4.1 for complete removal and 12.7 for having EWRR). Both, respondents from the third and those from the fourth class held positive willingness to pay (7.4 and 1.8 respectively) for having EWRR implemented in comparison to not.

Keywords: early warning and rapid response system (EWRR) , choice experiment, willingness to pay, invasive alien species, Slovenia

THE LIFE PROGRAMME AND IAS

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The LIFE Programme is the EU's financial instrument supporting environmental, nature conservation and climate action projects and it is the only EU programme exclusively dedicated to environmental issues. Since its start in 1992, LIFE has co-financed more than 4500 projects with more than 5 billion EUR. The main objective of LIFE projects focused on nature protection is the implementation of EU nature protection policies: Birds and Habitats directives and EU Biodiversity Strategy. The EU has recognized IAS as a major threat to biodiversity, human health and economy hence projects implementing actions targeting IAS are eligible for funding through LIFE Programme. There are 16 LIFE projects currently being implemented in the Republic of Croatia with five of them dealing with nature protection and biodiversity issues. Total value of these five projects is over 23 million EUR of which over 7 million EUR is allocated to activities implemented by Croatian beneficiaries. Two of these projects deal with Drava river management while the other three deal with species conservation (bear, lynx and sea turtles). The aim of this lecture is to bring the LIFE Programme closer to potential applicants, especially because there are no LIFE projects dealing on the IAS threat implemented in the Republic of Croatia so far. The lecture will provide the basic information on the LIFE Programme, types of projects that can be funded and review several successful LIFE projects dealing with the IAS threat.

Keywords: EU projects, EU grants, nature and biodiversity, concrete conservation measures

WHAT'S NEW ABOUT TROPICAL *Pistia stratiotes* IN EUROPE?

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Summer occurrence of tropical macrophyte *Pistia stratiotes* L. (Araceae) has been observed occasionally in the temperate zone during hot summers. In 2007, we reported about the first successful overwintering of this species in 2003 in a natural thermal stream in Slovenia, in an area with an average January air temperature of -6 °C, reaching minimum temperatures as low as -15 °C. We predicted then that, since plants flowered and produced frost-tolerant and viable seeds, they would present a potential source for further vegetative and sexual spread. Further on we assumed that climate change, causing warmer conditions, might create new problems: the species might extend its range to other thermally abnormal water bodies and even to non-thermal slow-floating shallow streams and canals. After 2007, new records of overwintering *P. stratiotes* plants were published for a thermally abnormal river in Germany, where it reappeared after brief occurrence in 1981, and plants were spotted in numerous other countries within the temperate climate zone. Here we present a review of *P. stratiotes* current distribution. Additionally, for any tropical plant species to become naturalized in a temperate climate, adequate temperature and air humidity must prevail. Therefore, we measured eco-physiological parameters on *P. stratiotes* plants along the temperature gradient in a thermal stream in Slovenia. We present data about seasonal chlorophyll fluorescence, plant growth, and surface cover. In this stream plants have to cope with changing seasonal temperatures, including extremes these plants are able to survive.

Keywords: invasive species, aquatic plant, chlorophyll fluorescence, biomass

POTENTIAL THREAT OF ALIEN PLANT SPECIES IN DISTURBED FORESTS IN SLOVENIA

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In recent decades, forest management in Slovenia has been small-scale oriented and close-to-nature, without clearcuttings and significant introduction of alien tree species in forests. However, before this period, in the middle of the 20th century, the planting of some alien tree species was more common due to different benefits. Currently, the growing stock of alien tree species represents only 1% of the total growing stock of forests in Slovenia. The invasive *Robinia pseudoacacia* is the most widespread (0.6%), followed by *Pinus strobus* and *Pseudotsuga menziesii*. In total, 93 alien plant species were determined in 72% of all forest site types. The highest number of alien plant species was recorded in riparian forests. Among 74 forest site types, willow-poplar communities on the river banks are under the highest pressure from alien plant species. Due to different human impacts, (peri-) urban forests are also highly exposed to the invasion of alien species. Since 2014, forests in Slovenia have been significantly changed because of a massive ice storm and subsequent bark beetle attacks. Natural disturbances and sanitary felling have consequently created a high share of open areas in forests, which are sensitive to invasions of alien plant species, which may adversely affect forest habitats and outcompete native plant species, and modify both the structure and functions of forest ecosystems. To draw the attention to alien plant species possibly presenting a risk to forests and to achieve an early warning system, 51 plant species were identified for the alert list for Slovenian forests.

Keywords: forest, natural disturbance, alien plant species, alert list

INVASIVE ALIEN PLANT TAXA WITHIN *HERBARIUM CROATICUM* AND *HERBARIUM IVO AND MARIJA HORVAT*

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The oldest and largest herbarium collections in Croatia, *Herbarium Croaticum* (ZA) with over 200.000 specimens, and *Herbarium Ivo and Marija Horvat* (ZAHO) with almost 78.000 specimens, incorporate valuable data on invasive alien plant taxa in Croatia. Following the new trend in the herbaria worldwide, the digitisation of the collections in the aforementioned herbaria has recently begun. The invasive alien plants were digitised and analysed during 2018, in order to present the taxonomical, spatial and temporal data. All herbarium sheets were digitised and georeferenced within GIS environment, while the metadata were deposited and published in Flora Croatica Database (FCD). The analysis revealed as many as 1062 herbarium sheets containing invasive alien plant taxa within the ZA collection, including 70 out of the 75 taxa currently listed as invasive in Croatia (Nikolić, 2018). The most often collected species is *Veronica persica*, while the most prolific contributors are Ljerka Marković, Vedran Šegota and Ludovico Rossi. Only 43 herbarium sheets containing 16 invasive alien taxa were found in the ZAHO collection. The species *Amaranthus blitoides*, *Conyza sumatrensis*, *Epilobium ciliatum*, *Opuntia ficus-indica* and *Reynoutria sachalinensis* were not found in any collection, although they were frequently reported in the literature. The majority of analysed examples originated from Croatia and neighbouring countries. The oldest sheet in ZA dates back to 1851, however as much as 67 % of the collection has been collected from the Second World War onwards. Completion of the digitising process, including scanning and uploading into publically available FCD and ZA & ZAHO Virtual Herbaria is planned for 2019.

Keywords: digitisation, alien species, botanical collections, virtual herbarium

ALIEN AND INVASIVE BENTHIC MACROINVERTEBRATES IN CROATIAN FRESHWATER

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Freshwater worldwide has been invaded by many alien macroinvertebrates with major consequences for native species, ecosystem processes, and often resulting in high economic losses. Knowledge on alien species distribution and dispersal dynamics is a prerequisite for prevention of future invasions, and for prediction and reduction of their undesirable impact. The aim of our study was to prepare an updated list of alien and invasive freshwater macroinvertebrate species in Croatia based on literature and field data, and to analyse the origin, distribution and potential vectors of spread, as well as possible impact of the invasive species. The 28 recorded alien species belong to five phyla: Crustacea (15 species), Mollusca (7), Annelida (4), Cnidaria (1), and Platyhelminthes (1). Most of the species are of Ponto-Caspian origin (18 spp., 64%), five are from North America, four are from Asia, while one species is from New Zealand. Distribution data indicated that 11 species (39%) are widespread and 19 species are considered invasive (Mollusca-5, Crustacea-11, Annelida-2, Cnidaria-1). The most important and widespread invasive species are the bivalves *Corbicula fluminea*, *Dreissena polymorpha* and *Sinanodonta woodiana*, amphipods *Dikerogammarus villosus* and *Chelicorophium curvispinum*, isopod *Jaera istri*, and decapods *Pacifastacus leniusculus* and *Faxonius limosus*. Only three species, of which one invasive (the snail *Potamopyrgus antipodarum*), were found in the Adriatic Sea basin. Impoundments represent ‘stepping stone’ systems, from which *D. polymorpha* and *P. antipodarum* invade downstream river courses. Only few studies report about impact of the invasive macroinvertebrates; future studies should be focused on the dispersal dynamics and ecological impact.

Keywords: checklist, distribution, non-native, aquatic species

MANAGING INVASIVE CRAYFISH *Procambarus clarkii*: CAN MANUAL STERILIZATION SORT THE PROBLEM?

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Management of invasive alien crayfish is challenging, as once they are established their eradication or control is difficult, even impossible in some areas. Sterile Male Release Technique has been previously assessed in crayfish with encouraging results, without, however, reaching the complete sterility of males. The present study explores whether manual removal of male gonopods, appendages responsible for sperm transfer, as sterilization technique, might affect male competitiveness and sexual behavior as well as reproductive potential in the red swamp crayfish *Procambarus clarkii.* We analysed the agonistic and sexual behaviour of sterilized and control males, under controlled laboratory conditions, coupled with a female in single pairs, and together with females in a natural-like social context. Removal of gonopods partly altered sexual behavior, affecting duration of copulation in the single pair and the social context experiment, and decreasing competitiveness in treated males. On the contrary, male readiness to initiate sexual interaction with females in the single pair and the social context experiment was not affected by the treatment. Treated males needed to spent longer time involved in low intensity agonistic interactions with females in the single pair experiments and to initiate more low intensity agonistic interactions with females is social context, probably to successfully dominate female for the copulation to take place. Females coupled with treated males did not produce any offspring compared to females coupled with control males. Treated males were able to regenerate removed gonopods, even if sometimes only partially or malformed gonopods. Females mated with treated males having regenerated gonopods did not produce any juveniles. Since equal number of males gain the opportunity to mate in both experiments and majority of females showed to not compensate for shorter and potentially unsuccessful copulation, but mated with one male as expected, we support the further testing of the technique in the field.

Keywords: crayfish, invasive species, management, Sterile Male Release Technique

CAN BACTERIA FROM CRAYFISH SURFACE PROTECT THEIR HOST FROM INVASIVE OOMYCETE *Aphanomyces astaci*, CAUSATIVE AGENT OF CRAYFISH PLAGUE?

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The invasive oomycete *Aphanomyces astaci* (Schikora, 1906) is listed among the 100 worst invasive alien species in the world. It causes the crayfish plague, a lethal disease responsible for rapid declines of many native European crayfish populations. It came to Europe with the North American invasive crayfish that are mostly resistant to the disease and act as *A. astaci* carriers. During the infection process, *A. astaci* hyphae are penetrating through the crayfish cuticle. We hypothesised that bacteria naturally present on the cuticle can help in the protection of the host from *A. astaci*. To test this, we took swabs of cuticle biofilm from five individuals of narrow-clawed crayfish, *Astacus leptodactylus* Eschscholtz, 1823 and five individuals of signal crayfish, *Pacifastacus leniusculus* (Dana, 1852), inoculated them on PG1 agar, and subsequently, isolated morphologically different individual colonies from the mixed cultures. We identified the isolates by MALDI–TOF mass spectrometry and 16S rRNA gene sequencing and tested their potential to inhibit the growth of *A. astaci* mycelium *in vitro*. Out of 40 isolates from narrow-clawed crayfish, 15 exhibited great potential for *A. astaci* inhibition (37.5%), while out of 31 isolates from signal crayfish, only four showed great inhibition potential (12.9%). Most of the potent inhibitors belonged to the genus *Pseudomonas*. In conclusion, we have characterised cultivable bacterial communities from the crayfish cuticle for the first time and have shown their potential as a source of anti-oomycete compounds. Chemical basis of *A. astaci* inhibition by pseudomonads should be studied in the future.

Keywords: *Aphanomyces astaci*, bacterial isolates, crayfish plague, Oomycetes, plate inhibition assay

MONITORING OF CRAYFISH PLAGUE IN THE PLITVICE LAKES NATIONAL PARK

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Two protected indigenous freshwater crayfish species, the noble crayfish *Astacus astacus* and the stone crayfish *Austropotamobius torrentium*, inhabit waterbodies of the Plitvice Lakes National Park. Native European crayfish populations are in decline, amongst others due to the lethal disease crayfish plague caused by pathogen *Aphanomyces astaci* (Oomycetes). The presence of this pathogen has been already recorded in the Plitvice Lakes, but previous research included a limited *A. astacus* sample. Thus, our goal was to analyse the presence of *A. astaci* on both crayfish species for two years monitoring period, using a larger sample size, at multiple locations within the Park. *Astacus astacus* was sampled at Burgeti (72 individuals), Prštavci (17) and Bakinovac (3) and *A. torrentium* at Prijeboj (22), Sartuk (18) and Rječica (2). New, non-invasive method, based on collecting swabs of mixed epibiotic microbial communities from crayfish carapace, was applied for *A. astaci* detection. DNA was isolated from swab samples and PCR was used to detect the presence of pathogen's DNA. The pathogen was detected mainly in noble crayfish (12/92) in two out of three tested locations. Also, one positive individual was detected in the stone crayfish population of Rječica (1/42). Positive samples were classified into semi-quantitative categories of pathogen load by quantitative PCR. Further, microsatellite genotyping identified presence of As strain of *A. astaci* which is consistent with previous results. Obtained results will be used in future management plans aiming to protect vulnerable native species in the National Park, with focus on prevention of unintentional spread of the pathogen to adjacent streams and crayfish populations.

Keywords: *Aphanomyces astaci,* indigenous crayfish species, new non-invasive detection method

APPLICATION OF INVASIVE PRUSSIAN CARP IN METAL EXPOSURE ASSESSMENT OF THE ILOVA RIVER

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Metals present one of the major threats for aquatic systems due to their persistence, toxicity and potential to bioaccumulate. Their effects might be seen in organisms exposed to even low concentrations and commonly used bioindicators are native fish species. In this study we assessed biological responses to existing anthropogenic impact in the Ilova River, using the Prussian carp (*Carassius gibelio*), a common invasive alien fish. Selected target organ was the intestine, as a site of dietary metal uptake. A multi-biomarker approach, involving biomarkers of metal exposure (metallothioneins, MT) and of oxidative stress (total glutathione, GSH, and malondialdehyde, MDA), with the addition of metal measurement in cytosols of intestine, was applied in autumn and spring at two sampling sites, reference and contaminated site. The measurement of metals was performed by HR ICP-MS and measurement of biomarkers by spectrophotometry. Physical and chemical parameters and metal concentrations mostly pointed to more disturbed environmental conditions at the contaminated site, with significantly higher intestinal concentrations of Ca, Cd, Cu, Fe and Rb in both seasons. Regarding biomarkers, significantly higher MDA concentrations were found in fish from the contaminated site, pointing to oxidative stress. At the same site higher MT concentrations indicated fish exposure to metals, although not significantly, while GSH did not show a clear trend. The presented study provides initial data on influence of pollution on biota in the Ilova River by using invasive alien fish in environmental quality assessment, which indicated potential risk for the protected area of nearby Nature Park “Lonjsko Polje”.

Keywords: invasive fish, oxidative stress, metal contamination, bioindicator, biomarkers

CITIZEN SCIENTISTS CAN IMPROVE THE EARLY DETECTION OF IAS IN FORESTS

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The detection of invasive alien species (IAS) in forests at the early stage after introduction is a challenge. In many countries, professionals are already surveying for the presence of regulated invasive fungi and insects in the frame of plant protection (Directive 2000/29/EC); however, for species falling under the IAS EU regulation 1143/2014 such network does not yet exist in several countries. Even when experts are employed, they cannot cover the whole country area. Therefore, "more eyes" are needed in the field, and citizen scientists can help look for invasive alien species. In the project LIFE ARTEMIS, we setup a system which supports citizen scientists to find IAS as a part of an early warning and rapid response system in forests. First, we prepared an alert list and an observation list of IAS. Then we developed an information system including an Android application, "Invazivke". In 14 meetings and workshops with volunteers throughout the whole country we showed the information system "Invazivke" and the species of interest for recognition together with additional information. Up to now, 143 observers are actively reporting IAS in the information system Invazivke. A total of 5718 observations were submitted and checked via the website or the mobile app (last access 12th September 2018). The mobile phone app was mostly used and 94.4% of the data was correct. Here, we present the first results of this project and discuss them in the context of the early warning of IAS and citizen science, showing how this data can be used in further research and actions.

Keywords: citizen science, mobile application, Android, forests, invasive plants, invasive insects, invasive fungi

CITIZEN SCIENCE HELPED REVEAL THE WIDESPREAD OCCURRENCE OF THE BROWN MARMORATED STINK BUG (*Halyomorpha halys*) IN HUNGARY

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The brown marmorated stink bug, *Halyomorpha halys* (Hemiptera: Pentatomidae), native to East Asia, was first detected in Europe in 2004. In Hungary, the species was first recorded in the capital, Budapest, in 2013. *Halyomorpha halys* is an invasive polyphagous species, which is able to cause severe damage to a wide range of cultivated plants, and it is also considered an urban pest in America and Europe. In the past few years, the pest has received significant media coverage in Hungary due to the increasing nuisance problems. However, detailed and reliable information on its occurrence and spread in the country were still missing. Therefore, in 2016, an extensive survey was initiated to obtain data on the distribution of *H. halys* in Hungary. Data was collected primarily through citizen science, and this was completed with information received from the members of professional organizations as well as with data collected actively by the authors. The results of this first extensive survey indicated the widespread distribution of *H. halys* in Hungary, with mass occurrence of the species at several locations throughout the country, especially in the region of Budapest. These information highlight the rapid dispersal of *H. halys* and call for attention to the threat the pest poses to urban environments as well as to plant production in Hungary.

Keywords: alien species, BMSB, Pentatomidae, distribution, mass occurrence

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AWARENESS OF THE INVASIVE ALIEN SPECIES PROBLEM AMONG FARMERS: CURRENT STATE AND FUTURE PROSPECTS

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Good agricultural practice recognises invasive alien species (IAS) as a threat to agriculture in Croatia and tackles the issue to a certain extent through the provisions of the Rural Development Programme. To achieve the direct financial support in agriculture, farmers are obliged to remove some IAS from their land, playing a significant role in IAS control. Frequent farmers' inquiries to Croatian Agricultural and Forestry Advisory Service about IAS confirm the inadequate knowledge of farmers, while the information provided by the advisors often influences the attitudes of farmers on IAS. The aim of this research was to assess the attitudes and perceptions of farmers and agriculture advisers on IAS and define preferred methods and topics for further education of both groups. For that purpose, two questionnaires were designed, one for farmers and other for agriculture advisers. The results indicate that agriculture advisers and farmers are familiar with IAS issue, but the majority of both groups feel that they need additional education and capacity building. The respondents identified major gaps and issues of concern as well as preferred methods for addressing the IAS issue. The results highlight the relevance of the topic for the farmers and indicate the need to further address it by the competent institutions. Based on the findings, appropriate methods for communicating the topic to the advisors and farmers are proposed.

Keywords: Advisory service, agriculture, IAS control, education

WHEN AND WHERE TO LOOK FOR POTENTIAL NEW INVASIVE ALIEN PESTS

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Early warning against potentially harmful organisms of woody plant species is important for the prevention of pest introduction via the international trade in live plants. Recent studies of sentinel plants illustrate that this can be achieved by sampling woody plants in exporting countries. However, it is unclear where sentinel plants can best be located, and how many samples are required for the detection of pest risk or for an assessment of the diversity of organisms associated with the target plant species. It is also unclear when sampling should take place for the optimal detection of such organisms. The occurrence of organisms associated with a woody plant species is affected by global, regional and local factors, including climate or seasons, elevation, soil type, site management and plant genetic diversity. Therefore, such factors should be considered when deciding on the sampling design for early detection of harmful organisms. However, it is unknown which factors are most influential for the selection of locations and number of units for sampling for species diversity. We explored the importance of selected geographic and temporal factors, as well as costs for the design for sampling of organisms associated with any woody plant species using data from four case studies. Based on these case studies, we propose a generic scheme for the identification of optimal sampling locations and periods for potential harmful organisms. The scheme can be used irrespective of the targeted plant species or importing country.

Key words: Optimal sampling design, woody plants, temporal and spatial patterns, international trade, plants for planting

WHEN A NATIVE SPECIES BEHAVES LIKE INVASIVE – BARK BEETLE *Orthotomicus erosus* IN THE MEDITERRANEAN PINE FORESTS IN CROATIA

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It has already been documented that climate change has negatively influenced forest health and enabled the establishment of non-native forest pests in Europe, especially wood-boring beetles coming from tropical and subtropical areas. But what if a native bark beetle species becomes invasive as a consequence of climate change? With the recent and ongoing outbreak of the bark beetle *Orthotomicus erosus* we would like to show a case of a native European forest pest that has strong potential to become invasive in Europe due to climate change. Several other native forest pests have already invaded large parts of Europe (e.g., *Thaumetopoea processionea, Thaumetopoea pityocampa*), while other native pests are waiting for the trigger (e.g., *Abraxas pantharia, Lymantria dispar).* It is predicted that Mediterranean forests will be more vulnerable to bark beetle attacks than temperate and boreal forests. Currently, Mediterranean forests are under severe threat from climate change and it is predicted by FAO that they will suffer from its impacts by 2050. Climate change could indirectly and negatively influence forest ecosystems through range expansion and changing of seasonal phenology of insect pests, and may result in faster development and higher feeding rates of phytophagous insects. Recent unusual heavy attacks by *Orthotomicus erosus* in Croatia seem to be associated with increased temperature and frequency and intensity of drought. Various early warning systems for invasive insect pests are continuously being developed and used, so an important question arises accordingly: should we also invest more into developing an early warning system for native pests that could behave like invasive?

Keywords: climate change, early warning system, expansion

HIGH FREQUENCY AND DIVERSITY OF INSECTS AND FUNGI IN TRADED TREE SEEDS

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The trade of forest tree seeds is considered relatively safe from the phytosanitary point of view, compared with the trade in other live plants. The majority of forest tree seeds are thus freely traded without any protective measures to mitigate the risk of introducing alien pests being applied. The pests potentially carried by seeds are, however, not well known and additional knowledge would be valuable for improved phytosanitary regulation of the seed trade. We assessed insects and fungi in 58 commercially traded seed lots of eleven tree species from North America, Europe and China. Insects were detected by x-raying, extracted and specimens were identified by sequencing the mtDNA COI region. The fungal community was assessed using high-throughput sequencing of DNA extracted from each seed lot, and by growing fungi from seeds on non-selective agar. Fungi were identified by sequencing the rDNA ITS region. About 30% of the seed lots contained insect larvae, mostly *Megastigmus* chalcids and midges. High-throughput sequencing revealed fungi in all seed lots and fungi grew on non-selective agar from 96% of the seed lots. The results provide evidence for the movement of pests to the areas they were not recorded before. Highly diverse fungal communities, largely composed of OTUs unique to each of the three continents, large fraction of unidentified OTUs and presence of pathogenic genera such as *Siroccocus*, *Fusarium* and *Diplodia*, indicate that new introductions will continue to occur and highlight the need for measures to mitigate the risk of introducing new pests.

Keywords: seed-borne insects and pathogens, biological invasions, trade, Pest Risk Analysis

MONITORING OF INVASIVENESS OF OAK LACE BUG *Corythucha arcuata* IN SPAČVA BASIN, CROATIA BY MODIS SATELLITE

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Oak lace bug *Corythucha arcuata (*Heteroptera: Tingidae), is an alien invasive insect in Europe that originates from North America. It produces three to four generations per year. As it has no natural enemies in Europe and insecticides are mostly ineffective, it spreads quickly. It was recorded for the first time near the eastern Croatian border in 2013. In 2014, it expanded over 30.000 ha trough Spačva basin, EU's largest and most valuable forest complex of pedunculate oak (*Quercus robur*). In 2015 it has spread all over the Spačva basin (more than 60.000 ha). We have identified the intensity and "hot spot" locations of the invasion of the oak lace bug in the period between 2013-2017. The identification of the invasion was mapped by analyses of the MODIS satellite images (16 day NDVI composite). Several methods for the identification of oak lace bug invasion were tested. The most accurate method is the difference between late-summer NDVI values and the multi-annual average of the late-summer NDVI vegetation index. With this method the temporal, spatial and intensity of the invasion of oak lace bug in Spačva basin was identified. This methodology is applicable to the whole territory of Croatia and these results (although just on Spačva basin level) were already used for recommendations of the further forest management practice that could improve control and/or reduce the oak lace bug populations.

Keywords: remote sensing, NDVI, monitoring, alien invasive species

FIRST DATA ON SPIDER SPECIES AS POTENTIAL PREDATORS OF THE ALIEN INVASIVE OAK LACE BUG (*Corythucha arcuata*) IN THE CLONAL SEED ORCHARD 'PETKOVAC'

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Oak lace bug (*Corythucha arcuata*) is a pest introduced from North America in Europe. It was first recorded in Italy in 2000. It was first found in Croatia in 2013 in the area of forest management division 'Vinkovci', where pedunculate oak (*Quercus robur*) has been damaged most severely. Due to the favourable climatic conditions and the lack of natural enemies, the pest could establish and spread in the newly invaded area. During a preliminary monitoring program carried out in winter 2018., potential oak lace bug predators (spiders) have been noticed under cardboards placed on three pedunculate oaks in the clonal seed orchard 'Petkovac' (forest management division 'Vinkovci', forest department 'Otok'). A feeding experiment in a laboratory was designed to investigate whether predators found in the local ecosystem could accept oak lace bug as a prey. Three spider species have been revealed during the study, one of which has been proved to be a predator of the oak lace bug. The research is continued with the aims of monitoring natural predators on a regular basis and identifying trophic interactions in the areas invaded by the oak lace bug.

Keywords: *Quercus robur*, non-native bug species, monitoring, trophic interactions

WILD BOAR IN CROATIA, INVASIVE SPECIES OR NOT?

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In the Mediterranean basin and Western Europe, the numbers and impacts of wild boar (*Sus scrofa*) have grown constantly since 1980 even though it is a native species. Wild boar occupies an exceptionally wide range of habitat types, feeds opportunistically on plant and animal species and has the highest reproductive rate among ungulates. Its local density can double in just one year. Consequently, there is considerable damage to agriculture and biodiversity. Due to above mentioned characteristics wild boar can have an effect comparable to an invasive species. However, because it is not an alien species there is little scientific research about its impacts in Croatia. According to Massei et al. 2015, fewer than 3000 wild boars were harvested in Croatia in 1990, but these numbers increased to over 20 000 in 2012. Due to the lack of exact data about the increase of the wild boar population in Croatia between 1990-2012, we calculated its potential increase based on land cover (Corine Land Cover) and land-use changes in each county.

Keywords: wild boar, Corine Land Cover, Land use, Croatia, biodiversity

BLOW OF WIND OR BUZZ OF BEES: UNEXPECTED WIND CONTRIBUTION TO THE BEE-POLLINATED *Acacia longifolia*

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For the first time, the possible contribution of wind was assessed on the entomophilous *Acacia longifolia*. This Australian species shows a massive yellow flowering, occurring in invaded areas (i.e. Portugal) at the end of the winter. A period unsuitable for insect activity: then, to what extent do bees contribute to seed set? We conducted field observations and experiments by a) surveying flowering plants to spot active pollinators; b) carrying on focal observations of bees collecting flower resources; and c) carrying on exclusion experiments to detect wind and insects relative contribution to seed set. *A. longifolia* seed set needs a pollen vector, as corroborated by the exclusion experiments. Our data emphasized wind as an active contributor, even if its contribution was more than doubled by that of bees. Results highlighted low bee abundance; honey bees were only present on 36.2 % of 174 plants. Notwithstanding, during focal observations honey bees were observed transferring pollen when visiting the inflorescences. Pollen transfer partly occurred also when they visited extrafloral nectaries. Previous studies neglected the contribution of wind, but the latter could have been crucial for the invasion on the windy coasts of Portugal. *A. longifolia* may be addressing to multiple vectors, biotic and abiotic, for its sexual reproduction. Bees contribution to seed set was impressive, and ambophyly is predicted as a back-up strategy to enhance pollen transfer especially when pollinators are lacking for different reasons. Comparative studies should be carried on in the genus *Acacia* to highlight the extension of this strategy.

Keywords: pollination, pollen transfer, ambophyly, exclusion experiments

ALIEN ANT SPECIES IN CROATIA

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Ants are ecologically dominant terrestrial invertebrates, with 13,450 known species inhabiting the planet. Because of their small size they are frequently unintentionally transported outside of their native range through global trade, and because of their numerically large and ecologically dominant colonies many species establish population in new areas and become invasive. Invasive alien ant species have tremendous impact on native species (invertebrate community, birds, amphibians, and plants), agriculture, and human housing worldwide. We review the literature, databases, and risk assessments at the European Union level to assess the current status of alien ants in Croatia, as well as potential future invaders. There are three alien ant species currently known in Croatia: *Monomorium pharaonis*, *Lasius neglectus,* and *Nylanderia vividula*. One of the world's worst invasive species, the Argentine ant – *Linepithema humile*, is widespread in Mediterranean Europe, currently present in northern Italy, and has a high potential for introduction to Croatia. Three fire ant species of genus *Solenopsis*: *S. invicta*, *S. geminata*, and *S. richteri*, are currently proposed for the Union List, one of the major legal documents on IAS at the level of European Union. We present the shared biological traits of highly invasive ants, discuss the impacts and current knowledge of IAS ants in Croatia, and propose methods for early detection and monitoring.

Keywords: Formicidae, invasive, Croatia, early detection, Argentine ant

UNDERSTANDING DENSITY-DEPENDENT POLYPHENISM IN MELANISM IN SUB-ARCTIC RANGE EXPANDING POPULATIONS OF THE WINTER MOTH *Operophtera brumata*: AN ECOPHYSIOLOGICAL PERSPECTIVE

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Density-dependent polyphenism of cuticle melanization is a widespread phenomenon in Lepidopteran larvae. In the sub-Arctic Fennoscandian birch forest, where the winter moth (*Operophtera brumata*) is expanding northward and exhibits 10-year cyclical outbreaks, crowding has been associated with the promotion of melanized spanworms. No such striking polyphenism has been reported at lower latitudes, possibly due to lower densities. However, dark pigmentation does not seem to prevail either in populations currently invading North America despite outbreak densities, which raises questions on the adaptive function of polyphenism in Fennoscandia. The evolutionary significance of melanism at high densities is not fully understood, but evidence is accumulating in a number of species that it can be associated with increased immunity, predator avoidance (camouflage, warning), or thermoregulation. In the winter moth, however, the camouflage and immunity hypotheses have been rejected, and melanization even appeared to increase vulnerability to enemies. We hypothesized that melanization might be an intra- and interspecific advantage over pale competitors during outbreaks if better absorption of solar radiation results in higher body temperature and earlier nymphosis (before total defoliation), especially at midnight sun latitudes. Such thermal melanism was tested by comparing metabolic rate and phenology among larval phenotypes. Metabolic rate was found to vary greatly but was 150% higher in melanized versus pale larvae under artificial light. The causal relationship with radiation absorption was further explored using respirometry with no light, and thermography. Preliminary results on the phenology of either phenotypes will be presented. Our findings suggest ecophysiological benefits of melanization that may offset its costs on resistance to enemies during outbreaks. Sliding selection regimes caused by cold summers and cyclic dynamics at the northern front likely contribute to maintaining phenotypic heterogeneity, a parameter largely neglected in attempts to predict expansions and invasions.

Keywords: metabolic rate, phenotypic plasticity, range expansion, respirometry, thermoregulation

INVASIVE INSECTS IN GREECE: THEIR BIOLOGY, INTERCEPTION AND CONTROL

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Several invasive species are recorded in Greece. Insects comprise the most numerous taxon in this group since they are imported as contaminants of plant material (potted ornamentals, and soil improving organic matter), wooden structures (picture frames and building blocks), and wood packaging material (pallets, boxes, and grates). The most recent inventory of invasive insects includes 266 non-native species in Greece and 11 on the Greek islands with the vast majority of them on Crete Island. This is a low number given that in Italy are reported 700 non-native insects and in France 690 species. However, these numbers are a crude approximation of the reality. They are actually reflecting several policies including the resistance of ecosystems to potential invaders due to many native species. This means many natural enemies of invasive insects; a low number of empty niches for newcomers; and the most important factor, which is the scarcity of forest entomologists and associated projects in Greece, which restrict the invasive insects only to those of agricultural importance. The true picture is very different from official reports. For example, a recent interdisciplinary research of scientists from Fribourg Switzerland, CIHEAM MAICh Greece, Greek Forest Directorates and IMFE Greece on the conservation of the endemic tree species *Zelkova abelicea* (Ulmaceae) of Crete (a tertiary relict with isolated sibling species in Italy, Armenia-Georgia, and East Asia) revealed that more than 15 non-native insect species are found only on this tree. This fact reflects the scarcity of entomological work on insects in the natural environment rather than an occasional discovery, which is the result of detailed study of the entomofauna of a plant species. We shall present an example case of a classical biological control program employing native natural enemies of the invasive species on *Eucalyptus* sp. (Myrtaceae) in an urban park in Peristeri municipality.

Keywords: invasive insects, biological control, ecosystem resistance, natural enemies

BLACK LOCUST (*Robinia pseudoacacia* L.) IN PRIVATE FORESTS OF CENTRAL CROATIA - CURRENT SITUATION AND POSSIBILITY FOR REMOTE SENSED MONITORING

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Black locust (*Robinia pseudoacacia* L., Fabaceae) was introduced to Europe in 17th century and in Croatia earliest literature records date from the end of 19th century. It is currently widespread in Croatia and it can grow rapidly on open areas where it can express its invasive potential, primarily on abandoned agriculture land. Records of the black locust in private owned forest in Central Croatia were analysed. In 16 Forest management units with total area of private forests around 23 000 ha out of 17 247 measured field plots, there were 2743 plots where black locust was dominant or co-dominant tree species by volume. Of these field plots, 25 % had black locust as the dominant species with the volume ratio from 80 to 100 %. Other parameters such as the average diameter, height, number of trees and the volume ratio in each of the management units are explored. The results show high level of presence of the black locust in private owned forests in Central Croatia. Potential use of the Sentinel 2 satellite images for the classification of the black locust as dominant species is examined. In addition, the accuracy of the classification method was tested according to which the potential for monitoring of species is assessed. Using Weka software for data mining of satellite imagery data, accuracy of the model for detection of pure black locust forest stands was 75% and 62% for forest stands where black locust was present with more than 60% of volume.

Keywords: alien invasive species, remote sensing, distribution monitoring, Sentinel 2

SEARCHING FOR ALIENS – UPDATE ON *Egeria densa* PLANCHON AND *Myriophyllum heterophyllum* MICHX. IN THE NERETVA RIVER DELTA (SOUTHERN DALMATIA)

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The *Neretva River Delta* represents the largest complex of wetland habitats in the Croatian coastal zone. In addition to being a Ramsar site, the Delta is protected on the national level as one of a few preserved wetland areas in the Mediterranean region of Europe. The area is nowadays greatly transformed into agricultural land, with most water bodies well interconnected, as a result of numerous anthropogenic interventions since the 19th century onward. First records of alien aquatic plants *Egeria densa* and *Myriophyllum heterophyllum* in the Delta occured in 2013 and 2016, respectively. Prior to our survey, *E. densa* was recorded on five sites, while *M. heterophyllum* was recorded on one site in the delta. For the purpose of detailed mapping of these taxa, we carried out a survey of the Neretva River Delta in August 2018. Our search has revealed a greater abundance than previously recorded, indicating the recent spread of the two taxa. *Egeria densa* was rather frequent, recorded in over 12 sites, often forming dense monodominant populations, with the largest one recorded in the Norin River, a right bank tributary of the Neretva River, extending almost continuously for approximately 7 km from the Prud Spring to the settlement Romići. *Myriophyllum heterophyllum* was recorded in eight sites, however morphologically dubious specimens of *Myriophyllum* were found in additional 20 sites, possibly hybrids between alien *M. heterophyllum* and native *M. verticillatum*. Both *M. heterophyllum* and *E. densa* were recorded in bloom, with the latter developing only male flowers. Interestingly, *E. densa* was frequently found in springs, with water temperature below 20 °C.

Keywords: alien plants, aquatic invasions, hybrid, mapping, new records

POTENTIALLY INVASIVE PLANT NEWCOMERS IN CROATIA

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The study provides information about three climbing ornamental alien plants, studied in Croatia from 2016-2018. *Senecio angulatus* L. f. and *Delairea odorata* Lem. are perennial climbers originating from South Africa, classified as naturalized aliens in southern and western Europe. *Senecio angulatus* was first reported in Croatia in 2005, however approximately fifteen new populations (mostly in Northern Dalmatia) have been found since, mostly as decorative or rarely as a garden escapee. A small population of *Delairea odorata* was only reported in 1999, growing on the island of Lošinj. Here, we report large established populations of both species on Lošinj, displaying their invasive nature through vegetative propagation. They cover the Mediterranean evergreen forest understories, sometimes climbing over shrubs or even up to tree canopies, but mostly along disturbed forest edges and openings. We assume that both species have invaded through careless disposal of garden waste (fragments of stems and rhizomes that easily root); however, cultivated plants on Lošinj are very rarely found. *Humulus japonicus* Sieb. et Zucc. is an annual vine native to East Asia, reported as a casual alien in Europe since the late 19th century. It is naturalized only in a few localities, with no proof of invasiveness outside Hungary. We are here reporting a population found in 2018 as the first record for Croatia. The species was found along the Drava River oxbow, South-East from the village of Legrad (N Croatia) near the Croatian-Hungary border. It occupies temporarily inundated riparian habitat, growing along with several other invasive plant species.

Keywords: alochtonous plants, *Delairea odorata*, *Humulus japonicus*, *Senecio angulatus*

POSTERSKA PRIOPĆENJA

POSTER PRESENTATIONS

DEVELOPMENT AND TESTING OF METHODS FOR MONITORING OF ALIEN ANIMAL SPECIES AS PART OF THE BULGARIAN BIODIVERSITY MONITORING SYSTEM

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The increased protection of native biodiversity and ecosystem services against invasive alien species (IAS) has been addressed in numerous binding international documents, such as the EU Regulation No 1143/2014. In the frame of the project 'Improving the Bulgarian Biodiversity Information System' (IBBIS), a new national IAS database module has been created as part of the Bulgarian Biodiversity Monitoring System. This module will allow to collect, store, retrieve and analyse IAS data, in order to timely inform decision makers and to gain support in the society for management actions against IAS in Bulgaria. Our aim was to develop a methodology for surveillance of alien animal species in terms of early detection of and rapid response to newly introduced species, as well as of long-term monitoring of already established alien species. A total of 50 protocols for monitoring and assessment of the status and impact of selected alien animal species of different taxonomic and ecological groups (marine, freshwater, terrestrial invertebrates and vertebrates) were developed. The protocols include information about the aims of the monitoring, the alien taxon and other parameters to be monitored, places and periods for the monitoring, necessary equipment, and safety instructions. The following parameters, general and specific for each taxon are described in detail in the protocols: presence/absence, quantitative characteristics (abundance, biomass, coverage, etc.), age/size structure, habitat and community characteristics, presence of rare, endemic and threatened species, and the ecological impact (based on the IUCN–EICAT scheme). Some results of the testing of the methods are presented and discussed.

Keywords: IAS national information system, methodology, monitoring parameters, ecological impact

OVERVIEW OF "INVASIVE SPECIES" PRESENCE IN THE CROATIAN SCIENTIFIC BIBLIOGRAPHY (CROSBI) DATABASE

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Croatian Scientific Bibliography – CROSBI (https://www.bib.irb.hr/) is an on-line bibliography that since its launching in 1997 collects scientific publishing of Croatian researchers. Here, we have analysed its content until July 2018, when it contained over 500.000 bibliographic units. Our focus was on "invasive species" term contained in title, abstract or keywords using the CROSBI query form. We have manually excluded those that did not deal with invasive species, but rather with e.g. "invasive diagnostic techniques in medicine" etc. afterward we ended with 515 units. Highest portion (45%) of items belongs to abstract at conferences, followed by papers in journals (30%) and thesis (13.6%). Most surveyed organisms were plants (39% of bibliographic units), followed by insects and crayfish (15% each). Beside fishes and molluscs (8% each), all other groups of organisms were present in less than 5% of the bibliographic units. Most surveyed were terrestrial (52%) and least marine habitats (13%), with rest of the 35% belonging to the freshwater habitats. In year 2006, for the first time number of scientific contributions dealing with "invasive species" exceeded ten items, and continuously rise. We can expect that overall number of contributions on the topic will keep the current, increasing trend. Ratios among different habitat types and group of organisms, probably better reflects the number of active researchers dealing with it, and not the number of invasive species in particular habitat type or its systematic position. However, number of contributions dealing with invasive mammals or birds will most likely going to increase in future from current less than 0.5%.

Keywords: scientific literature, Croatia, habitats, IAS

A PEAK INTO PUBLIC AWARENESS OF IAS PLANTS IN CROATIA

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To get some insight into public awareness of invasive alien plants in Croatia, we have conducted a public survey using direct interviews with structured questionnaire. 107 interviews were performed from May-September 2018 on several locations in the city of Zagreb, including Maksimir park on May 19th during event dedicated to the day of biological diversity (35 interviews), and Bundek during the "FloraArt" trade expo (Maj 28 – June 03) dedicated to horticulture (36 interviews). Overall, 64% of participants declared that they are aware of invasive plants, which is a increase in comparison to 40% in 2013 survey conducted by former State Institute for Nature Protection. However, when analysed at subsamples level (Maksimir vs. Bundek vs. other), this percentage varied from as much as 91% at Maksimir respondents, to 44% at random participants interviewed through the City. Latter indicates that in general public there is still a serious lack in the awareness of this problem. Most frequently known invasive plants were ragweed, tree of heaven and black locust. Less than 25% of the paricipants grow plants in their apartments, while the rest grow them in their gardens, balconies and terraces from where plants can escape and spread. Among those who grows plants, as much as 44% of respondents recognised at least one invasive alien plant shown on photos as those they have in their gardens and not being aware that those are invasive plants. Plant nurseries were most frequently (38%) reported as a source of plants, while exchange with other people were reported in 26% of cases. Based on these preliminary results, it is obvious that there is still huge challenge in raising public awareness on IAS in general, and in educating people involved in horticulture.

Keywords: Zagreb, public survey, ornamental plants, invasive plants

SURVEY OF PUBLIC AWARENESS OF INVASIVE SPECIES IN ZAGREB AND ITS SURROUNDINGS

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People are largely responsible for the spread of invasive species, so public perception and awareness are important components of invasive species management. In order to assess public awareness of invasive species, we launched a survey during *Biology night 2018* – an open door to the Department of Biology. This event attracts people of all age groups interested in biology, mostly from Zagreb and surrounding area. Survey participants were chosen randomly and were given a set of five questions. Collected data were analysed by age groups: i) children (≤14 years), ii) youth (15-20 years), and iii) adults (>20 years). We compared our data to a field survey of public perception of invasive species of 1,000 randomly chosen participants performed by Croatian Agency for the Environment and Nature (CAEN) in 2013. Out of 147 participants 24% had never heard about invasive species, compared to 63% from the survey by CAEN. We assume that these differences stem from non-random sample in our study – all survey participants had an interest in biology, since they visited the event and were thus more likely to know about invase species. However, recognition of species that are invasive in Croatia seems to be a problem. Most commonly recognized invaders were the red eared slider and mongoose, which were recognized only by 36,7% of participants. Overall, the children demonstrated the least knowledge about invasive species, which indicates that there is a lack of information regarding this important topic in primary schools.

Keywords: public perception, questionnaire, Croatia, Biology night

HABITAT MANAGEMENT OF ALLUVIAL MEADOWS ALONG THE TISZA RIVER FOR CONTROLLING ALIEN SPECIES

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Alluvial meadows are vulnerable habitats along the Tisza river. Taking into account the small extention of such habitats and the continuous presence of invasive alien species, the adequate management is important in order to achieve the conservation goals. One of the sample sites is at the Pély Bird Reserve; it is managed (grazed) by hungarian gray cattle since 2005, mainly in order to maintain the habitat and controll false indigo (*Amorpha fruticosa*). Alluvial habitats are mainly threatened by the spread of green ash (*Fraxinus pennsylvanica)*, box elder (*Acer negundo*) and false indigo. Besides grazing, mechanical methods are also applied regularly. The poster gives an overview of the methods, results and the influencing factors. In 2005, before the start of the management only 70 ha of alluvial meadow habitat was presented at the area. Due to the systematic eradication of invasives and continuous grazing, the area of the grasslands increased by more then 60 hectares till now.

Keywords: *Amorpha fruticosa, Fraxinus pennsylvanica, Acer negundo,* grazing, mechanical treatment

GLOBAL PATTERNS IN INSECTS AND FUNGI OF DORMANT TWIGS OF NATIVE AND EXOTIC TREE SPECIES

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Live plants are often traded in their dormant stage, among other reasons to reduce the introduction of new pests. However, the pests associated with this pathway are largely unknown. Risk mitigation relies on pest risk assessments which can only be performed for known pests. It is therefore important to identify potential pests before the introduction occurs. In addition, post arrival host shifts are very difficult to predict. Several studies attempted to estimate the likelihood of host shifts based on existing literature data on known pest-host associations, but the

number of pests in these studies was often limited and the data were unlikely collected in the same place and at the same time. To overcome these problems, we performed a global study which aimed at detecting potential insect pests and fungal pathogens on selected congeneric native and exotic tree species in 33 countries. Samples were taken in botanical gardens and arboreta on the Northern and Southern hemisphere. At each location, twenty 50 cm long twigs were collected from tree species of up to six genera and kept in containers with water at room temperature for insect emergence. Emerged insects were collected and identified based on morphology and DNA barcoding of the mitochondrial DNA COI region. DNA was also extracted from pooled buds, twig parts and needles for the identification of fungi based on the ribosomal DNA ITS region using a high-throughput sequencing approach. Here, we present the first results of this study and discuss them in the context of pest risk assessment.

Keywords: woody plants, trade, insect pests and fungal pathogens, host shift, pest risk assessment

PORTUGUESE PROTEACEAE PLANTATIONS CONTAINS SOUTHERN HEMISPHERE FUNGAL SPECIES

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The African genera *Protea*, *Leucospermum* and *Leucadendron*, grouped under the commercial name of Proteas, are the most cultivated taxa of Proteaceae, a large Southern Hemisphere plant family who's germplasm has been used to develop flowers production industry in different countries of the World. The most important producers are Australia and South Africa, followed by Portugal and Spain. In order to understand if plants used to establish Proteas plantation in Portugal host fungal pathogens from the Southern Hemisphere, samples were collected both in Portuguese farms where propagation material imported from South Africa was used in the late nineties and in South African farms that originally produced and send this material to the European country (mainly rooted and unrooted cuttings). Twigs were collected during spring 2017 and analysed with a Metabarcoding approach. Seventeen fungal species have been identified in the study. Six species were exclusively detected in Portugal farms while other six species were exclusively found in South Africa. Five more species were obtained both in Portuguese and South African. Results showed that Portuguese Proteas plantations checked in this work contained many diseases agents associated to Proteaceae and that the majority of these were known to be distributed only in the Southern Hemisphere... We concluded that European Proteas farms should produce the new propagation material from their own mother plants, avoiding the introduction of new propagation material from overseas.

Keywords: non-native fungi; plant pathogens; hitchhikers; flower cuttings

PATHOGENICITY OF CROATIAN ISOLATES OF *Neofusicoccum parvum* AND *Botryosphaeria dothidea* ON *Sequoiadendron giganteum*

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Neofusicoccum parvum and *Botryosphaeria dothidea* (Ascomycota: Botryosphaerialeas: Botryosphaeriaceae) are important pathogens of urban trees and shrubs, including *Sequoiadendron giganteum*. These fungi have recently been isolated from ornamental *S. giganteum* trees showing symptoms of die-back, wood discoloration and branch flagging in Zagreb, Croatia. Subsequently, the fungal species have been characterized using multigene phylogeny and morphology. The aim of the current study was to test pathogenicity of *N. parvum* and *B. dothidea* on *S. giganteum*. Ten *S. giganteum* seedlings per isolate were inoculated using two isolates of *B. dothidea* and *N. parvum*. The test was conducted on 2-years old seedlings under controlled conditions in a climate chamber. Ten control plants were mock-inoculated with only an agar plug. The results showed that *N. parvum* was more aggressive compared to *B. dothidea* and isolate B8F killed all the inoculated plants within seven weeks after inoculation. Botryosphaeriaceae species have recently been shown responsible for the disease of *S. giganteum* in Serbia and *N. parvum* has been shown to be introduced into the Western Balkans. *Sequoiadendron giganteum* is endangered of extinction due to the population decline and the species has been listed in the IUCN red list of threatened plants. This research adds to the concerns regarding the impact of pathogens, such as *N. parvum* on these trees.

Keywords: Botryosphaeriaceae, inoculation, pathogenicity test, invasive tree pathogens

BIODIVERSITY OF FUNGI INHABITING THE STUMPS OF BLACK CHERRY (*Padus serotina* EHRH)

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One of the most important invasive species in Europe is Black Cherry (*Padus serotina*). Black Cherry appearing en masse in the understory limits the growth and development of native tree species. The aim of the research was to research the fungal communities inhabiting Black Cherry stumps. Recognizing the role and function of individual components of the fungal colonies that inhabit tree stumps can be a price indication for integrated plant protection and for limiting the occurrence of Black Cherry. Abundance and diversity of fungi were studied in 72 Black Cherry stumps collected in in the Podanin Forest District (19°28'00″E 52°04'00″N). DNA was extracted with Plant Genomic DNA Purification (Thermo Scientific) Kit, according to instructions. ITS 1/2 rDNA amplification was performed with fungi-specific primers. The PCR products were purified and sequenced using the Illumina system in the Genomed S.A. (Warsaw). The results were bioinformatic and statistical analysis. This resulted in the creation of a table of OTUs. Sequences were identified by comparison with reference sequences from UNITE database. In total, 449910 sequences were obtained. Frequency of Zygomycota was 0.81-0.00%, of Ascomycota 88.42-38.47% and of Basidiomycota was 52.71-5.8%. The most common taxon of fungi were Tumularia sp. (86% -0.00%), Ascomycota sp. (66.33% -0.00%), *Menispora ciliata* (32.138% -0.00%), *Mycena galericulata* (32.2% -0.00%), *Hypholoma fasciculare* (27.9% -0.00%), Dothideomycetes sp. (23.68% -0.00%), *Mollisia cinerea* (22.78% -0.00%), *Herpotrichia juniperi* (18.43%) -0.00%), Sebacinales (14.35% -0.00%), Blastobotrys sp. (13.65% -0.00%), *Tubeufia cerea* (11.82% -0.00%), *Penicillium citreonigrum* (10.47% -0.00%). The dominant share of fungi associated with the decomposition of wood indicates the decomposition process occurring in the stumps, but until now the rate of Black Cherry distribution by the decomposition of wood taxa has not been recognized.

Key words: fungal communities, invasive species, understory, antagonistic fungi

FRESHWATER CRAYFISH PATHOGENS AS POTENTIAL INVASIVE SPECIES – A REVIEW OF EXISTING STUDIES

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Invasive non-indigenous crayfish species (NICS) impact native crayfish populations through competition and hybridization, but more importantly, through transmission of pathogens which can spread rapidly and have a detrimental effect on existing native species/populations. The impact of pathogens on freshwater crayfish has been studied extensively, especially in species important for aquaculture. However, for many alleged pathogens, the pathogenicity has never been experimentally confirmed since the infection trials have never been conducted. Detection of a potential pathogen in moribund or dead crayfish has often led to the assumption that the organism is able to cause disease. Therefore, the aim of this study was to analyze the available literature to determine which microbes (bacteria, viruses and fungi) can be classified as 'proven' pathogens for freshwater crayfish, and which of them are classified inadvertently or incorrectly. We analyzed over 70 scientific publications and classified the alleged crayfish pathogens into the following categories: a) pathogen – pathogenicity confirmed by infection trials, b) potential pathogen – although classified as pathogen in literature, no infection trials have been recorded, c) non-pathogen – infection trials failed to prove pathogenicity for crayfish and d) indirect pathogen/opportunist – infection trials indicate possible crayfish mortality under stress conditions. We recorded 39 microbial species belonging to these categories, with the majority of them (41 %) classified as pathogens, including bacterial, viral and fungal representatives. We discuss our results in the context of microbial potential effects on both invasive non-indigenous and native crayfish populations during the range expansion of the invasive NICS to the novel environment.

Keywords: pathogenicity, infection trials, freshwater invasion, literature review

EFFECTS OF ANTIDEPRESSANT CITALOPRAM ON AGGRESSIVE BEHAVIOR OF THE SIGNAL CRAYFISH (*Pacifastacus leniusculus*)

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Antidepressants are common pharmaceutic pollutants in freshwaters. They enter aquatic systems through wastewater discharges and act via alterations in serotonergic metabolism and receptors. Recent studies have demonstrated their effects on freshwater organisms at environmentally relevant concentrations. This study aims to examine if commonly used antidepressant citalopram could affect agonistic behavior of the most successful crustacean invader of European freshwaters, the signal crayfish (*Pacifastacus leniusculus*). Serotonin plays an important role in aggression in many species – in crayfish it reduces the likelihood of retreat and increases the duration of fighting. To determine the effects of citalopram on aggressive behavior, we staged 15 minute agonistic interactions between size-matched pairs, with one competitor exposed to citalopram and the other pair member non-exposed (control). We compared specific characteristics of interactions (fight duration, fight number and time required to engage in fighting) as well as identity of interaction winners between pairs exposed to i) environmentally relevant (low) and ii) therapeutic (high) concentration of citalopram. We measured these parameters after i) short (24 h) and ii) long (7 days) exposure time. In pairs with individuals exposed to high concentrations, fight duration was significantly longer after short exposure time (24h), potentially demonstrating acclimatization of individuals to citalopram. Furthermore, significantly less fights and shorter time to engage in fights was observed for pairs exposed to high compared to low citalopram concentrations, and the pattern was similar at both exposure times. We discuss our findings in the context of their potential implications on invasion success of signal crayfish.

Keywords: agonistic interaction, freshwater invasion, serotonin, pharmaceuticals

INVASIVE CRAYFISH SPECIES AND CLIMATE CHANGE IN CROATIA – WHAT CAN WE EXPECT IN THE FUTURE?

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Indigenous crayfish species (ICS) in European freshwater are under significant decline in both population numbers and sizes across their ranges due to negative anthropogenic pressure onto their habitats, climate change and non-indigenous crayfish species (NICS). Being more aggressive and fecund in competition for space and food NICS outcompete ICS. Also NICS transfer the lethal disease crayfish plague onto ICS. Croatian freshwater harbours four out of five European ICS, and previous molecular-phylogenetic studies have shown high genetic diversity within three of them. Nowadays, in Croatian freshwater three NICS have been recorded, and their expansion is documented. The goal of this study was to predict the potential current and future distribution of two NICS (signal crayfish and spiny-cheek crayfish) in order to develop management programmes. Therefore, Species distribution models (SDMs) were developed. SDMs were built based on the presence only records of the two NICS and a set of environmental predictors that were selected according to their ecological relevance. The SDMs obtained permitted the evaluation of the potential present-day range of the two NICS, as well as the effect of climate change onto their future distribution in Croatian freshwater. This facilitated the prioritisation of locations where NICS have high probability of establishment and where their negative impact onto ICS will be most pronounced. The results indicate that ICS in the rivers of continental Croatia will be under the highest pressure by NICS. Conservation efforts should be focused on the highly diverse populations of stone crayfish and noble crayfish in tributaries of larger lowland rivers.

Key-words: *Pacifastacus leniusculus*, *Faxonius limosus*, species distribution modelling, freshwater, *Astacus astacus*, *Austropotamobius torrentium*

ENSEMBLE FORECASTING OF WORLDWIDE DISTRIBUTION OF AMERICAN BULLFROG, *Lithobates catesbeianus* (Shaw, 1802): PREDICTING THE POTENTIAL DISTRIBUTION OF *L. catesbeianus* IN EUROPE TO INDICATE POTENTIAL MANAGEMENT MEASURES TO COMBAT THE THREAT

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Global biodiversity is at risk as a consequence of climate change and the introduction of invasive alien species. Freshwater ecosystems are especially vulnerable and niche-based models have been developed to predict species distribution as an important tool for conservation and management of aquatic ecosystems. In this work, we determine at global level the current and future climatic suitability areas of the invasive American bullfrog (*Lithobates catesbeianus*), known for adverse ecological and economic impacts. The species distribution models (SDMs) utilized nine different algorithms from the BIOMOD2 package, which were summarized in an ensemble forecasting approach. We consider six climatic and ecologically meaningful variables for building the SDMs. Three timeframes (current, 2050 and 2070) were modelled using two increasing CO2 emission scenarios: RCP2.6 (rcp26) and RCP8.5 (rcp85). The individual model performance was fair according to the area under the receiver operating characteristic curve (AUC) and true skill statistics (TSS). The best performing model was random forest (RF) for both AUC (0.985) and TSS (0.907). The most important variables for predicting bullfrog occurrence were temperature seasonality, minimum temperature of the coldest month, maximum temperature of the warmest month and precipitation of the driest month. Temperature variables describe the availability of thermal energy. Minimum temperature of the coldest month and maximum temp of warmest month gives us information about species thermal tolerance. Likelihood of establishment of bullfrog populations is negatively correlated to maximum temperature of the hottest month, while increase of minimum temperature of the coldest month will benefit the spread of suitable areas. Precipitation variable describes the water availability during driest month. Availability of permanent water bodies is related to bullfrog establishment since tadpoles overwinter in water.The results show a future expansion of suitable areas is expected at higher latitudes, especially in North America and Central Europe and a concomitant decrease in the Mediterranean. Globally the current suitable areas for the species represent 3.8% and these are expected to increase up to 5.2% in 2070 in the high emission scenario, although some part of the area with the greatest concentration of threatened amphibian species in Europe, such as Apennine peninsula and NW Balkan coast, will become more climatically suitable, same as the big part of area with the highest species richness in central Europe. Overall, the results indicate that climate change will favour the expansion of *L. catesbeianus* into new river basins, and conservation efforts should take place in order to stop future spread and minimize negative impacts of bullfrog presence in the area with established populations and protect native amphibian species under threat.

Keywords: biodiversity, climate change, invasive species, modelling

RECENT CHANGES OF LONGITUDINAL DISTRIBUTION OF INVASIVE AMPHIPODS IN CROATIAN LARGE RIVERS

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Ponto-Caspian amphipods are one of the most successful groups of invaders in European freshwaters, but rates of their spread and especially their impacts are still understudied in Croatia. The aims of this study were to establish longitudinal distribution changes of invasive amphipods *Dikerogammarus haemobaphes*, *D. villosus*, *Chelicorophium curvispinum* and *C. sowinskyi*, in Drava, Sava and Kupa River using our results and comparing them to previous studies. Qualitative benthos samples were collected using hand net (25x25 cm, ⌀500 μm) in shallow bank area at 63 sites of three large rivers in June, July and August 2018. Sampling started from sites where each species was found previously, moving upstream until new distribution front was found. Distribution front of *D. haemobaphes* in the Sava River, the most upstream distributed invasive amphipod, has progressed forward for 13.7 km (4.6 km year^{-1}). Distribution of *D. villosus*, *C. curvispinum* and *C. sowinskyi* is now better known in Sava (16.6 km upstream from the last site in 2016) and could be connected to the location of the most upstream river port from where *D. villosus*, and probably also *C. curvispinum*, had spread downstream. In the Drava River, *D. villosus* was found 3.6 km more upstream then in 2017, while distribution of *D. haemobaphes* in the Kupa River did not change. Therefore, longitudinal range extension of invasive amphipods is still ongoing and future studies should examine whether this tendency will continue and how it will affect macroinvertebrate assemblages in Croatian large rivers.

Keywords: Ponto-Caspian invaders, range extension, benthos, distribution front

DISTRIBUTION AND IMPACT OF TRANSLOCATED PREDATORY FISH SPECIES IN THE DALMATIA ECOREGION

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Fish translocation from the Upper and Lower Danube to the Dalmatia ecoregion in Croatia is not well documented, and distribution and impact of many species are still not clear. The Dalmatia ecoregion, which contains over 20 endemic freshwater fish species, has been recognised by IUCN as part of the Mediterranean biodiversity hotspot. Previous results reveal that 33 fish species were translocated from the Upper and Lower Danube to the Dalmatia ecoregion, including top predators, such as: European catfish *Silurus glanis*, pikeperch *Sander lucioperca* and Northern pike *Esox lucius*. According to FISK risk assessment, European catfish and pikeperch represent a very high risk, while Northern pike, a moderately high risk to the Dalmatia ecoregion. Northern pike were translocated in the 18th century, while European catfish and pikeperch in the 1950s. The reason for first translocation of Northern pike is not clear while first translocation of European catfish and pikeperch was performed because of aquaculture. All three species were further translocated by anglers on repeated basis. The impact has been reflected in predation upon native endemic species, and upon occupation of a trophic niche–primarily reserved for native predators, e.g. endemic trout. Thus, such new fish community structure may have consequences for the interspecific relationships within the predatory guild, and for the functional organisation of biological communities. The recommendation is to reinforce control for preventing translocations, to provide good management measures for eradication of already translocated species, and to implement enhanced conservation measures for native and endemic fish species in Dalmatia ecoregion.

Keywords: Dalmatia, inland water, alien fish, transplantations, angling

ANALYSIS OF GOLDEN JACKAL OCCURRENCE ON GREEN BRIDGES AS AN INDICATOR OF THEIR RANGE EXPANSION

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There are two populations of golden jackal (*Canis aureus*) in Europe, Pannonian and Mediterranean, both present in Croatia. Between the 1950s and 1970s, golden jackal populations began to grow and spread along the Pannonian plain. In the last 15 years, a significant population increase of golden jackals was observed in Croatia, along with an expansion of their range. One of the methods for monitoring changes in carnivore population size is recording their occurrence on green bridges, also known as wildlife crossings. During the period from 2008 to 2018, crossing of animals on five green bridges on the highway A1, section Bosiljevo – Dugopolje was recorded using camera traps. Until 2015, no golden jackals were recorded overpassing any of the green bridges, while in the period from 2016 to 2018, cameras on all five green bridges recorded golden jackal individuals in increasing numbers: 20 photographs of golden jackal in 2016, 41 in 2017, and 47 till September 2018th. These results indicate a rapid population dispersion, range expansion, but also an increase in population density, and might indicate the invasiveness of this species.

Keywords: golden jackal, wildlife crossings, camera traps, monitoring, invasive species

RACCOON DOG IN CROATIA: INDIVIDUAL OCCURRRENCES OR ESTABLISHED POPULATION?

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The raccoon dog (*Nyctereutes procyonoides* Gray), a species native to East Asia, has been introduced because of its fur to the western Soviet Union in the first half of the 20th century. Since then, it became widespread throughout Europe. Because of its adaptation capacity, omnivore diet, and high reproductive potential, the raccoon dog has become one of the most successful alien carnivores in Europe, and was hence listed by the DAISE project amongst the top 100 most damaging invasive species in Europe. The first record in Croatia of the raccoon dog by camera trap was in Mrkopalj in 2016. During the mammal biodiversity study in the Northern Velebit National Park, raccoon dog was recorded with a camera trap in January 2018 (44°41'39.2"N 14°58'01.6"E). Although there was a high number of photos of other animal species, raccoon dog was only recorded once; this is the southernmost record of this species in Croatia. Apart from these two reliable confirmations, there were two more unconfirmed sighting reports in the last two years; one in Lonjsko polje and one near Gerovo. Together, these records suggest the possibility that it is not just the presence of unrelated migratory individuals. Given the results above and the invasion potential of this species, it is necessary to establish as soon as possible a systematic monitoring to determine whether the raccoon dog population is beginning to establish in Croatia. Based on monitoring results, action plans for successful control and eradication should be created.

Keywords: raccoon dog, *Nyctereutes procyonoides*, occurrence, Croatia

A FIRST INSIGHT INTO MITOCHONDRIAL DNA CONTROL REGION DIVERSITY OF BARBARY SHEEP (*Ammotragus lervia*) INTRODUCED IN EUROPE

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The Barbary sheep is a caprine (sheep-antelope) ungulate whose native range covers mountains of North Africa where it is considered vulnerable by the IUCN. Its population has been decreasing due to habitat destruction and exposure to poaching. The species was introduced to Europe in the 20th century mainly as a game species since its morphological features make it attractive for trophy hunters. Since then a large free-ranging population was established in Spain and smaller ones were established in Croatia, the Czech Republic and Italy. Possible future negative impacts on the ecosystem were suggested through parasite transmission, competition with native fauna and alteration of the herbaceous plant community. To address populations dispersal potential in non-native habitats it is important to gain information regarding the genetic diversity of European populations. In order to investigate mitochondrial DNA diversity, 66 samples were analyzed, 32 of which were from Mosor Mountain in Croatia, 19 from the Iberian Peninsula (Almeria and Sierra Espuña) and 15 from the Canary islands. Four haplotypes were found in total. Haplotype Amle01 was the only one found in Croatian and the Canarian samples, indicating their possible common origin. Samples from Almeria were monomorphic for the Amle02 haplotype, while samples from Sierra Espuña exhibited three haplotypes (Amle01, 03 and 04) with a gene diversity of 0.71. Future implementation of microsatellite data analysis could reveal more information on illegally introduced Barbary sheep population origin and European population structure.

Keywords: population genetics, caprine, alien species, mtDNA

COLLABORATION EFFORTS TOWARDS EFFECTIVE MONITORING SYSTEM OF INVASIVE MOSQUITOES

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Globalisation and climate change enabled the rapid spread of invasive species which now present a significant threat to biodiversity and human health. In the seventies, a tiger mosquito *Aedes albopictus*, native to the tropical areas of Southeast Asia appeared for the first time in Europe. Under changing environmental and climatic conditions this species established and became invasive. Since then, tiger mosquito has spread to at least 25 European countries and besides other invasive species can be a vector for viral pathogens. Inventarisation and management of such species require high financial and human resources with often uncertain outcome. A timely notification of population and ecosystems changes requires a centralized system for monitoring. In 2015, scientists initiated The Invasive Species Centre (ISC) in Poreč, the centre with the aim of educating and raising public awareness of the invasive species and their impacts on human health and the environment. This year the ISC established the collaboration with the Institute of Public Health of the Istrian County and joined the project of the National Monitoring System of invasive species of mosquitoes. The main goal is to identify and to monitor main breeding sites in Istrian County and through public education reduce the number of breeding sites at private yards. The idea is to create interactive database and map of breeding sites for better control of mosquito population and timely detection of new invasive species like *Aedes japonicus*. This paper present a monitoring system progress towards a better control and management of invasive species.

Keywords: tiger mosquito, invasive species centre, breeding sites, data collection

NEW, INTRODUCED AND IMMIGRANT INSECTS IN THE PANNON BIOGEOGRAPHICAL REGION

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New species of introduced or immigrant insects, especially mosquitoes, bugs and beetles, are detected annually in the pannon biogeographical region. Some of them hide in isolation for a while, others can spread rapidly. The formation of invasive characteristics and population dynamics of these species are important scientific and nature conservation issues. The appearance of new insect species is mostly unintentional and connected to the development of commercial network, increasing merchandise and travel, and sometimes global climate change. For many reasons, it is not possible to find out exactly the exact time of the appearance, and also the method of settlement can only be presumed. Some of the new insect species occupy largely unloaded niche, and sometimes live on introduced plant species (like *Leptinotarsa decemlineata*). The *Aphis nerii* with increasing population in the Carpathian Basin, originated from the south feed exclusively on *Asclepias syriaca.* Some of the invasive species have significant impact on the habitat status, these species has higher conservation importance. One of them is the *Metcalfa pruinosa.* Other species act as potential food or habitat competitors for native species, which can be more problematic permanently or temporarily depending on the spread of the new species, like in the case of *Harmonia axydiris* or *Nezara viridula.* Tracking and monitoring of new species is more likely in the case of having agricultural or health aspect. In many other cases, the spread or other characteristics of the new insect species only attracts a narrow range of professionals. For example, the *Trichoferus campestris* is introduced from Asia about one decade ago, and now spreads gradually.

Keywords: invasive species, global climate change, arthropods, *Metcalfa pruinosa*

DISTRIBUTION OF *Harmonia axyridis* (PALLAS, 1773) IN CROATIA - TEN YEARS AFTER THE FIRST FINDINGS

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The harlequin ladybird, *Harmonia axyridis* (Pallas, 1773), is native to Asia and was widely introduced into European countries as a biocontrol agent of aphid and coccid populations. Since 2008, *H. axyridis* has established its populations in Croatia. First data clearly indicated gaps in the distribution of this species in the country. Thus, we intended to complete the data on the distribution of the species by random collecting and using UV lamps. Ten years after, with prior data included, *H. axyridis* was recorded at 292 localities, with 569 findings in total. It was found in the Continental, Mediterranean and Alpine biogeographical regions of Croatia. Most records were from the Continental region (390), followed by the Mediterranean (164) and the Alpine regions (15). It was found at various altitudes, from 0 to 1637 m a.s.l., but mostly recorded in lowlands from 0 to 199 meters a.s.l. The number of specimens decreased with the increase of the altitude, which is likely to be the consequence of more favourable climatic conditions and a higher diversity of habitat types at lower altitudes. Specimens were also found on several islands, most likely due to anthropogenic effects. It is known that *H. axyridis* affects native species. The fauna of Croatian ladybirds has been poorly researched, its impact has not yet been investigated. Future studies should focus on systematic inventory and ecological research, as well as red listing of native ladybird species and the potential impact of *H. axyridis* on local ladybird populations arising from interspecific competition.

Keywords: invasive species, Coccinellidae, ladybirds, range extension

ALIEN DROSOPHILID SPECIES OF THE EXPERIMENTAL FIELD "JAZBINA"

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The vinegar flies (Diptera: Drosophilidae) were identified as pests in grape and wine production since they often appear in vineyards and wine cellars. The most well-known species from this family is *Drosophila melanogaster*, which transmits bacteria responsible for acidic rot of grapes. Affected grapes have acetic odour, and vinification is often impossible. The species composition of vinegar flies was not clearly known in Croatia until 2010, when the invasive *Drosophila suzukii* was found and then the research of drosophilids was intensified. *Drosophila suzukii* attacks ripening fruit and can cause economic damage to grapes and finally wine production. Populations of drosophilids have never been investigated in vineyards of Zagrebačka county, and the status of *D. suzukii* in this wine growing area was unknown. The main aim of this research was the monitoring of alien species of drosophilid flies in the vineyards of the experimental field "Jazbina" (Faculty of Agriculture). Drosophilids were collected from March until October of 2017 by using traps based on apple vinegar. Altogether 121 specimens belonging to five species (*D. suzukii*, *D. melanogaster*, *D. hydei*, *D. busckii* and *Chymomyza amoena*) from two genera were identified. Alien species represented about 30% of the total number of collected drosophilids. Among alien species the polyphagous pest *D. suzukii* was the most abundant one, which poses a serious threat to grape production in the studied field "Jazbina". Findings of alien vinegar flies represent the new records of these species in the area, and contribute to the knowledge of drosophilid flies in Croatia.

Keywords: Diptera, alien species, new records, vineyards, Croatia

OCCURRENCE OF *Neodryinus typhlocybae* (ASHMEAD) (HYMENOPTERA: DRYINIDAE) IN BULGARIA

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Since its introduction in Europe in 1987, *Neodryinus typhlocybae* (Ashmead) (Hymenoptera: Dryinidae), a parasitoid of the citrus flatid planthopper, *Metcalfa pruinosa* (Say), has been successfully released in urban and agricultural areas in several European countries. This North American parasitoid was reported for the first time from Bulgaria in 2016. It was found on *M. pruinosa* in the region of Varna. *Neodryinus typhlocybae* was released in 2017 for biocontrol of *M. pruinosa* in the same region where the pest has dramatically reduced the ornamental value of urban vegetation over the past five years. During the period 2017–2018, more than 20 sites covered by semi-natural vegetation and ornamental plants infested with *M. pruinosa* were surveyed in urban areas and their surroundings to assess the distribution of *N. typhlocybae* and the rate of parasitism of *M. pruinosa* in Bulgaria. The parasitoid was detected in the regions of Dobrich, Dolni Dubnik, Lukovit, Pleven, Plovdiv, Sofia and urban areas along the Black Sea coast. Our results showed that the parasitoid is still in the expansion phase of its invasion process in Bulgaria. The hyperparasitoid *Pachyneuron muscarum* (L.) (Hymenoptera: Pteromalidae) was reared from cocoons of *N. typhlocybae* collected from areas in North-East Bulgaria and along the Black Sea coast. Rates of parasitism and hyperparasitism as well as the pathways of introduction of *N. typhlocybae* in Bulgaria are discussed.

Keywords: alien, Insecta, parasitoid, distribution, hyperparasitoid

THE BROWN MARMORATED STINK BUG *Halyomorpha halys* (STÅL, 1855) CONTINUES TO INVADE CROATIA

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The invasive brown marmorated stink bug *Halyomorpha halys* (Hemiptera: Heteroptera: Pentatomidae), native to Asia, was observed in Croatia in the city of Rijeka in winter 2017 for the first time. In 2018, it has been observed and collected in Zagreb, the capital (130 km NE of Rijeka), with two additional photo records from Split-Dalmatia county (250 km SE of Rijeka) (Facebook page "Koji je ovo pauk/kukac?"). As it was recorded in the neighbouring countries (Italy, Hungary and Serbia), its arrival was expected in Croatia. In addition, the part of mitochondrial *COI gene of* individuals from the city of Rijeka were compared with other haplotypes present in the GeneBank database to determine the possible points of entry. The analysis showed that the population from Rijeka had the same haplotype that is the most frequent within Hungarian populations, and is also present within Italian populations. With the new specimens collected from Zagreb, it will be possible to expand the haplotype network for the populations in Croatia and give us new insight in the dispersal of the pest.

Keywords: alien invasive species, distribution, haplotype network, urban habitats, Facebook

FEEDING INTENSITY AND PREY-SIZE SELECTIVITY OF *Rapana venosa* (VALENCIENNES, 1846), AN EXPERIMENTAL APPROACH USING MUSSELS

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The veined rapana whelk, *Rapana venosa* Valenciennes, 1846, is a gastropod native to the Sea of Japan, which was accidentally introduced in the Black Sea in the 1940s–1950s. The gastropod has expanded its range since, currently becoming a widespread species. Its predatory behaviour causes concern due to the potential impact on the native fauna of molluscs in the invaded regions. The current study investigated the feeding habits of *R. venosa* under laboratory conditions, using native mussels *Mytilus galloprovincialis* Lamarck, 1819 as prey. Observations were carried out on 26 *R. venosa* individuals, divided in two groups based on their size (large and small). Ten individuals were included in Group 1 (large – average wet weight 125.54g±23.54) and 16 individuals in Group 2 (small – average wet weight 22.09g±6.58). Each gastropod was fed with 10 mussels of different sizes, daily (Group 1) or every 5 to 7 days (Group 2). All molluscs were kept in the laboratory in similar conditions (temperature: 21-25^{0}C; photoperiod: 12h/12h; salinity: 16–17‰). The large *R. venosa* had an average consumption of 2.7g (±0.56) of mussel flesh daily (representing 2% of their body mass), while small gastropods ate on average 0.8g (±0.2) daily (representing 3% of their body mass). The food conversion index suggested a higher efficiency in feeding of the smaller snails, about four times higher than in larger individuals. *R. venosa* manifested preferences in feeding, selecting the larger mussels. Our study indicated differences in feeding intensity and selectivity in feeding in this invasive species.

Keywords: veined rapa whelk, *Mytilus galloprovincialis*, predation

INVASIVE *Magallana gigas* AND NATIVE *Ostrea edulis* OYSTERS IN THE NORTHERN ADRIATIC SEA – IS THERE AN OVERLAP IN THEIR DISTRIBUTION?

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In the Adriatic Sea non-native invasive oyster *Magallana gigas* started to spread mostly in the Northern Adriatic. A spread of invasive species could pose a threat to the ecosystem stability and function that in the case of *M. gigas* could be expressed through competition for space and food with other species, habitat modification, etc. Given the high invasion success of *M. gigas*, the aim of this study was to investigate whether the native and non-native oysters are in competition for space in their natural habitats. The distribution and abundance of oysters were determined along Istria west coast by in-situ visual counts at 3 depth zones (surface, 3m, 6m) of 6 locations (2 within the Lim estuary, 2 on Istria coastline north and 2 on coastline south to the estuary). *Ostrea edulis* mostly occurred as solitary specimens and density slightly increased with depth. *Magallana gigas* were found exclusively at the surface layer where it formed thick, dense clusters resulting in much higher densities compared to *O. edulis* in all locations (10.4±4.9 to 141.7±31.2ind/m^2 vs. 0.5±1.8 to 1.0±2.4ind/m^2) except to the north of estuary where the distribution and abundance of two species resembled (0.5±1.8 to 3.6±5.0ind/m^2 vs. 1.6±2.8 to 2.1±3.1ind/m^2). Results suggested that there is no overlap in depth distribution and *Magallana gigas* were located always in the medio-littoral zone while all recorded *O. edulis* were below the low–tide line. This study presents first quantitative assessment of *M. gigas* in the Adriatic and provides a base for monitoring changes in its distribution.

Keywords: *Crassostrea gigas*, pacific oyster, Lim Bay, Istria, depth distribution, abundance

LESSEPSIAN MIGRANT FISH SPECIES IN THE EASTERN ADRIATIC SEA

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During the last few decades, various factors including climate change, anthropogenic activity and spread of non indigenous fish species 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, 12 Lessepsian fish migrants were recorded in the Eastern Adriatic Sea. *Fistularia commersonii*, *Siganus luridus* and *Lagocephalus sceleratus* established their populations in the southern part of the Adriatic Sea. The potential impact of them on populations of native communities is still unknown, but considering relatively the fast pace of its spread through the Mediterranean and invasive character it is possible that in the near future their impact could be significant also in the Adriatic Sea.

Keywords: *Fistularia commersonii*, *Siganus luridus*, *Lagocephalus sceleratus*, Croatia

WHERE DO ALIENS COME FROM? THE CASE OF *Thalia orientalis*

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A planktonic tunicate determinated as *Thalia orientalis* Tokioka, 1937 was recorded for the first time in the Adriatic in 2007, when prevalent circulation pattern in the North Ionian Gyre was changing from cyclonal to anticyclonal, thus starting to bring more of western Mediterranean waters into the Adriatic Sea. Since *T. orientalis* is present in Red Sea as well as in Atlantic, it was hard to determine where from exactly did it arrive. In order to determine the origin of the Adriatic specimens we sequenced 757 nucleotide long fragment of 18S rRNA gene from the Adriatic and Pacific specimens of the *T. orientalis*. Uncorrected p-distance between sequences was 1.98 %, which suggests that the specimens are of separate entities. The Adriatic and Pacific specimens differ also morphologically in the shape of atrial palps and medioventral projections. As *Thalia orientalis* was described based on specimens from the Pacific, Adriatic specimens should be considered as a new, still undescribed species. Our results emphasize importance of DNA methods in determining the origin of alien species as well as the mechanisms of their dispersal.

Keywords: 18S, Thaliacea, alien species, cryptic species, Adriatic Sea

FLOWER PHENOLOGY OF THE INVASIVE *Acacia longifolia* IN PORTUGAL

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Acacia longifolia is an Australian leguminous species considered to be one of the most aggressive invaders worldwide. This species' high invasive success is linked to many variables, such as investment in sexual reproduction by abundant flowers and seed production. However, information about flower development and pollination strategy is still lacking. In this study, we characterized flower phenological stages, pollen viability and stigma receptivity as preliminary tasks in an overall study of *A. longifolia*'s sexual reproductive strategy. We defined 6 stages of flower development (S0-S5) based on the relative position of petals, style and stamen, with pollen release from S3 through S4. We germinated pollen from closed and open anthers in an appropriate medium to check pollen viability, and we checked stigma receptivity through the 3% hydrogen peroxide test. Pollen from closed anthers showed reduced viability in early flowering stages and an increase from S2 to S3. Germination of pollen from opened anthers revealed that viability is maintained for 6h after collection, followed by a steady decrease. The stigma is highly receptive through stages S2-S4, with a significant decrease in S5. Our results suggest that *A. longifolia* has a protogynous development, balancing short viability of pollen with sequential flowering of inflorescences. Pollination success and seed production are potentially increased by the long receptivity of stigma, ensuring a prolonged timing of availability. This is in accordance with previous findings of higher reproductive success related to timing of phenology of whole inflorescences at different sites and wind contribution to pollination.

Keywords: sexual timing, stigma receptivity, pollen viability, phenological stages

MORPHOLOGICAL VARIABILITY OF LEAVES OF *Reynoutria japonica* HOUTT. AND *Reynoutria* × *bohemica* CHRTEK ET CHRTKOVÁ FROM THE CITY OF ZAGREB, CROATIA

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Reynoutria species (=knotweeds) are classified amongst worst invasive plants in Europe. Three taxa of *Reynoutria* occur in Croatia: *R. japonica* Houtt., *R. sachalinenis* (F. S. Petrop.) Nakai in T. Mori and *R.* × *bohemica* Chrtek et Chrtková, the latter being a hybrid between the two former ones. Because of its great resemblance to the parental species, botanists have been mistakenly referring to hybrid specimens as parental taxa for decades. It is believed that, in comparison with the parents, the hybrid is more difficult to control, while in the same time, the hybrid is the most widespread knotweed in Croatia. Here, we have measured the leaf traits (largest width, length from the apex to the largest width, total length, leaf area, length of the heart-shaped part) from main and secondary axis of *R. japonica* and *R.* × *bohemica,* using leaves from 10 localities per taxon, and analysed them using descriptive statistics and ANOVA. All measured traits showed higher values in hybrid populations (e.g. mean largest width: 13.42 vs. 10.23 cm; mean total length: 15.8 vs. 11.34 cm; mean leaf area: 171.74 cm^2 vs. 87.54 cm^2, all measures from main axis leaves). Because of their greater morphological variability, leaves from secondary axis are less reliable in the determination of taxa. The shape of the leaf base, in most cases more or less heart-shaped in hybrid populations, is a good indicator of the hybridogenous origin.

Keywords: comparison, identification, knotweeds, morphology

USE OF INVASIVE PLANT SPECIES JAPANESE KNOTWEED (*Reynoutria japonica* Houtt.) BIOMASS IN ENERGY PRODUCTION

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Japanese knotweed (*Reynoutria japonica*, Houtt.) is considered to be one of the most dangerous invasive allochthonous plant species, introduced to Europe. Thanks to its high vegetative rhizome propagation ability, high regeneration and invasiveness rate, and ability to adapt and occupy diverse habitats, this species is widespread in the area of continental Croatia; therefore it produces a large amount of potential biomass. Apart from energy production usage, biomass is an ecologically acceptable way of disposing and exploiting biomass of invasive weed species. It could be great option to eradicate it and also use it as a quality raw material for energy production. There are currently no data on the possibility of using biomass of Japanese knotweed. Therefore, the aim of this study was to determine its energy potential in the production of energy by direct combustion and pyrolysis after its mechanical removal from nature. During the research of dry matter content of this plant species biomass, low water (6.78 – 19.02%), and low ash content (1.00 – 3.38%), low percentages of fixed carbon (11.15 – 15.93%,) , as well as a low percentage of cellulose (37.47 – 44.37%) and hemicellulose (15.93 – 22.86%), were recorded. Compared to other species, high content of coke (14.25 – 17.18%) and high calorific value (14.51 – 16.79 MJ/kg), as well as low values of lignin (26.93 – 30.5%) and volatile substances (66.83 – 78.36%), have also been noted. The results of this research have shown excellent fuel properties and therefore great energy potential of Japanese knotweed, which classifies this type of allochthonous invasive plant species as a high-quality material in energy production by combustion and pyrolysis, making it a possible material for both processes, i.e., production of biochar and bio-oil.

Keywords**:** invasive species, biomass, direct combustion, pyrolysis, energy potential

THE SPREAD OF INVASIVE ALIEN SPECIES IN NATURAL FOREST RESERVES (NFR) IN AUSTRIA

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In Austria, there are 192 Natural Forest Reserves (NFR) — forest areas designated for natural development of the forest ecosystem in which no sylvicultural measures are allowed. Goals include incorporating the diversity of Austrian forests in a representative network of Natural Forest Reserves and support the development of biodiversity and natural forest growth. Existing since 1995, the Austrian NFR programme currently comprises a total area of 8.355 ha (approximately 0.2% of the Austrian forest area). The sizes of individual NFR range from 0.9 to 966.8 ha. Since 2013, the NFR are being repeatedly surveyed using a standardized methodology to determine population dynamics, changes in species composition, vegetation development, deadwood accumulation, and natural regeneration processes and disturbances. In total, 1.463 vascular plants and 84 forest communities have been recorded within the NFR, comprising 30 alien species, among them 16 invasive alien species (IAS). The spread of IAS in NFR is concentrated at lower altitudes in the east of Austria, in riparian forests and location of silicate bedrock. The populations of the affected NFR show a vital occurrence of *Acer negundo* and *Fraxinus pennsylvanica*. In summary, IAS were found to inhabit the NFR that could develop into a factor influencing the natural development of native forest communities.

Keywords: forest reserves, successional trends, natural forests, unmanaged habitats

HUMAN SETTLEMENTS NEAR FOREST FRAGMENTS PROMOTE PLANT INVASIONS

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Heterogenic urban and peri-urban areas promote the introduction and expansion of non-indigenous plants because of many disturbed and nutrient rich habitats that facilitate their establishment. Alien plant propagules can come from many sources and gardeners are significant players in the alien plant distribution and establishment. Residential gardens near natural and semi-natural forests increase the propagule pressures, especially by the dumping of garden waste. Additionally, human activity in creating forest edges and increasing light availability within forests are facilitating plant invasions. In our study, we report about forest fragments embedded into a landscape of expanding settlements, agricultural land and highways near the town of Maribor. Fragments are experiencing disturbances and habitat modifications by humans, mainly because of forest roads, walking paths and recreational activities. We present the composition of invasive alien plant species related to forest fragment characteristics. The most common herbaceous aliens were *Phytolacca americana* L., *Impatiens parviflora* DC. and *Duchesnea indica* (Andrews) Focke, occasionally forming dense stands. Vicinity of settlements was related to the occurrence of alien shrub species, common for gardens, such as *Prunus laurocerasus* L. and *Symphoricarpos albus* (L.) S.F.Blake. Our results show that forest fragments in rural/urban matrix are under high risk of invasions and should be monitored in the future.

Keywords: alien plant species, garden waste, garden escape, naturalization

SPONTANEOUS VEGETATION ON SLAG HEAPS IN SOUTH CROATIA

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Phytosociological investigation of the spontaneous vegetation was carried out on seven years old ferro-manganese and *silico-manganese* slag heaps at the area of the former Electrode and Ferroalloy Factory in the city of Šibenik and the landfill in the village of Biljane Donje, south Croatia, in May 2018. There were 64 plant taxa in total. Two non-indigenous species were noted: *Papaver rhoeas* L. and *Conyza canadensis* (L.) Cronquist. The latter species was considered invasive. Ruderals and weeds that are characteristic for the phytosociological classes *Chenopodietea* and *Artemisietea vulgaris*, as well as taxa of dry open habitats (the classes *Festuco-Brometea* and *Sedo-Scleranthetea*) were dominant in the vegetation. In addition, a limited number and cover of woody taxa suggests the presence of an early successional stage in the process of development of natural vegetation. However, we recommend removing the heaps from the area and initiating soil remediation according to Croatian laws, EU standards and obligations.

Keywords: phytosociology, ruderal vegetation, industrial waste, Mediterranean climate, Eastern Adriatic

CONTRIBUTION TO THE KNOWLEDGE OF INVASIVE ALIEN FLORA OF THE DRAVA RIVER IN CROATIA

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The potential negative impact of invasive alien plant species (IAS) on native flora and habitats has been heavily documented and multiple studies have shown that they seem to thrive along particular corridors, such as linear infrastructure and inundation areas. Therefore, Drava River with its inundation may represent a potential corridor with the abundant invasive flora. As part of the biomonitoring of the River Drava (LIFE14 NAT/HR/000115 DRAVA LIFE – Integrated River Management) a research of flora and habitats was conducted. Four field excursions – one in the October 2016 and three in 2017 (April, May, July) were carried out. In total, 26 invasive alien plant species (Flora Croatica Database – Nikolić ed. 2018) were recorded on seven project localities along the Drava River – 15 species at Otok Virje, 20 at Stara Drava – Varaždin, 17 at Donja Dubrava – Legrad, 17 at Most Botovo, 17 at Novačka, 12 at Miholjački Martinci and 14 at Podravska Moslavina. Eight species were recorded on all seven localities: *Acer negundo*, *Amorpha fruticosa*, *Conyza canadensis*, *Echinocystis lobata*, *Erigeron annuus*, *Impatiens glandulifera*, *Robinia pseudoacacia* and *Solidago gigantea.* Distribution of recorded IAS on project localities is presented, as well as an overall assessment of their family affiliation, land of origin, life form, CSR strategy, hemeroby index and type of dispersion. Thus, results obtained during this research contribute to the knowledge of distribution of invasive alien species in Croatia, but also to future assessments aiming to better understand the significance of the role that Drava River plays in the spread of IAS.

Keywords: invasive alien plant species, riverine habitats, anthropogenic pressures, linear infrastructure

COLONISATION OF INVASIVE ALIEN PLANTS ON THE REVETMENT NEAR GAT IN THE LOWER FLOW OF RIVER DRAVA

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Colonization of invasive alien species was monitored on the riprap revetment in the lower flow of River Drava near Gat, in the period from its construction in 2014 till 2018. The 100 m long revetment is positioned on the 65th river kilometer of the River Drava and has an area of approximately 600 square meters. Standard methods of plant collection, determination and recording were applied. The plants have covered during the first two years, from 2014 to 2016, around 30% of the revetment surface. Predominantly were present herbaceous invasive plants such as *Ambrosia artemisiifolia* L*., Erigeron annus* (L.) Pers., *Conyza canadensis* (L.) Cronquist and *Solidago giganthea* Aiton. Till June 2018 herbaceous plants were gradually replaced by woody invasive taxa *Amorpha fruticosa* L, *Acer negundo* L., and *Ailanthus altissima* (Mill.) Swingle, that together with other plants cover around 80% of the revetment. Allergenic plants predominate among them. The greatest number of plants belongs to the *Asteraceae* family (almost 33%, of 12 species). Analysis of the origin of the invasive alien species has shown that 83%, of 12 alien invasive species originate from Northern America. All these plants prefer bright anthropogenic habitats. Comparison of the monitored revetment with older ones has shown that *Amorpha fruticosa* L. suppresses Boxelder - *Acer negundo* L. Such overgrown revetment is gradually colonized by autochthonous plants typical for this area (ash, oak and other).

Key words: river banks, revetment, diversity of invasive flora

INVASIVE ALIEN FLORA OF JAZBINA EXPERIMENT STATION IN ZAGREB

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Jazbina Experimental Station, a research and teaching testing site of the University of Zagreb, Faculty of Agriculture, is situated in the foothills of Mount Medvednica (also known as Zagrebačka Gora), and it's part of the "Zagreb Wine Roads". With a southern and southwestern exposures, and with a maximum elevation of 302 m a. s. l., the Jazbina Station is ideal for fruit and grape growing. The aim of this study was to complete the list of invasive plant species of vineyards and orchards in Jazbina area. The research was carried out in 2017-2018, the collected plant taxa are available online in ZAGR (http://herbarium.agr.hr/). Altogether, 15 invasive alien plant taxa (13.4% of total flora) have been noted on the Jazbina Station, some of them (*Ambrosia artemisiifolia* L., *Chenopodium ambrosioides* L., *Conyza canadensis* (L.) Cronquist, *Erigeron annuus* (L.) Pers., and *Robinia pseudoacacia* L.) have become quite naturalized, and appeared here in a large number of individuals. The registered invasive plants are mostly of North American origin and bulk of them belongs to family Asteraceae.

Keywords: allochthonous flora, vineyard, orchard, Croatia

SHRUB COMMUNITY *Humulus lupulus-Echinocystis lobata* IN THE RAMSAR SITES OF SERBIA

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Monitoring of negative factors (*e.g.* pollution, overharvesting, invasive species) in Ramsar sites is vital due to a numerous reasons, such as great biodiversity importance and conservation and providing ecosystem services. The aim of this study was to determine the presence of invasive shrub species and establishment of their communities in the Ramsar sites of northern Serbia. Research of the invasiveness revealed the significant presence of lyana *Echinocystis lobata* (Michx.) Torr. et Gray, classified as highly invasive. The species was found in 146 plots in four of six investigated Ramsar sites. Phytosociological studies, using Braun-Blanquet approach, of selected riparian areas were made in the five-year period (2011-2015). The analyzed matrix of the dominant invasive shrub species contained 65 relevés and 189 taxa. Numerical analyzes separated 19 relevés with the dominance of *E. lobata* (frequency 100%, Ic index > 80), in which a total of 94 taxa were recorded. Phytosociological characteristics of the obtained group of relevés where *E. lobata* dominates, were defined as: for diagnostic species Phi index > 0.20, for dominant species D% index > 5, and constant species had frequency > 50%. The association is assigned an informal name *Humulus lupulus-Echinocystis lobata* community. Based on the floristic composition, it is mostly approaching forest invasive communities of the alliance *Chelidonio-Acerion negundo* L. Ishbirdin et A. Ishbirdin 1989 (class *Robinietea* Jurko ex Hadač et Sofron 1980). Association with the dominance of invasive *E. lobata* has not been described so far. However, further research is required with the aim to verify a syntaxonomy of the association.

Keywords: Invasive lyana, shrub stands, wetlands, riparian forests

CONTRIBUTION TO THE KNOWLEDGE ON THE DISTRIBUTION OF THE COMMON MILKWEED (*Asclepias syriaca* L.) IN CROATIA

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Based on available literature data, the common milkweed (*Asclepias syriaca* L.) is mostly present in north-western and eastern Croatia. Introduced as a horticultural element from North America, nowadays it has been listed among invasive plants in many European countries, and made its way on the list of invasive alien species of Union concern (2017/1263). This paper reports of new sites in the area of Pokupsko and eastern part of Slavonija. Comparison of the sites reveals presence of the species along sunny forest edges and roads as well as inundation zones. This linear distribution is probably greatly aided by vehicles used for forest and water management work. In order to limit/terminate its further spreading, we propose further education and awareness raising among different stakeholders (farmers, beekeepers, foresters, water managers, etc.) on negative effects of spreading of common milkweed into natural habitats, as well as measures which can be taken by stakeholders to minimise the risk of further spreading of common milkweed into natural habitats. Additional research is required for efficient removal of common milkweed since many sources mention mowing as ineffective; moreover, it actually intensifies its distribution. In places such as the observed sites, where it grows either individually or in small groups, the proposal is pulling entire plants out before the fruit is developed and safe disposal of uproot plants.

Keywords: common milkweed, invasive alien plants, invasive flora mapping, secondary distribution

GARDEN LUPIN (*Lupinus polyphyllus* LINDL.) - CASUAL OR NATURALIZED ALIEN PLANT AT VLASINA PLATEAU?

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Garden lupin (*Lupinus polyphillus* Lindl.) was introduced in Europe during the 19th century, and today is recognized as one of the 100 worst alien species in Europe. Protected landscape Vlasina in southeastern Serbia is distinguished by a large artificial lake and small settlements surrounding it, where during the 70s of 20th century, garden lupin has been introduced as an ornamental plant. For the past two years, we conducted preliminary field research on mapping the populations of garden lupin sorting them into 3 classes: i) Cultivated - individuals within private gardens; ii) Cultivated/escaped - individuals within private gardens and surrounding area of that private property; iii) Escaped - populations outside from private properties with minimum distance of 50 m from the nearest cultivated population. We also counted the number of individuals per each population. A total number of 70 populations have been georeferenced including 32 cultivated populations, 26 cultivated/escaped and 12 populations established in nature. Within private gardens, the highest number of individuals is 30, while this number goes up to 330 individuals for semi-natural populations. In addition, we registered native pollinators from the genus *Bombus* and *Apis* so as leaf beetle from genus *Chrysolina*. Considering the fact that wild populations of garden lupin with a high number of individuals have been established in nature over the past years and due to the presence of native pollinators, we can assume that this alien species should be classified as naturalized for Vlasina plateau; it represents the first such record for Serbia to date.

Keywords: IAS, naturalization, Protected landscape Vlasina

INVASIVE PLANT SPECIES IN THE SCHOOL GARDENS

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Group of primary school students have observed for years a large number of alochtonous species in the vegetable and flower gardens of the school. These plant species were utilizing water and nutrients through the gardens maintenance, and owing to their high abundances and growth rate overshadowed the cultivated species. In the period from 2016 to 2018, these species have been regularly monitored and mechanically removed from the gardens. Altogether, 10 invasive plant species have been recorded: *Acer negundo*, *Amaranthus retroflexus*, *Aster squamatus*, *Bidens subalternans*, *Carpobrotus acinaciformis, Conyza bonariensis*, *C. canadensis*, *C. sumatrensis*, *Euphorbia prostrata* and *Parthenocissus quinquefolia*. Among them, we were able to eradicate five: *Acer negundo*, *Amaranthus retroflexus*, *Aster squamatus*, *Bidens subalternans* and *Parthenocissus quinquefolia*. The species of *Conyza*, particularly *Conyza sumatrensis*, could not be removed from the school gardens. *Conyza sumatrensis* prefers arid and sunny niche, hence had optimal ecological conditions for growth and development in our gardens. We strongly recommend measures to remove the invasive plants from the school gardens and their vicinity. In addition, these activities can actively engage students and locals in learning about invasive species.

Keywords: education, vegetable garden, flower, Mediterranean climate, Eastern Adriatic

THE MOST ABUNDANT INVASIVE ALIEN PLANTS OF THE URBAN PARTS OF SAMOBOR AND BREGANA (NORTHWEST CROATIA)

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Here we present the results of the distribution of the most abundant invasive alien plants of the urban parts of two small towns in the Zagreb County (Samobor and Bregana): *Acer negundo* L., *Amorpha fruticosa* L., *Robinia pseudoacacia* L. and *Reynoutria* spp. The research was conducted during the vegetation seasons of 2010 and 2011 (only in the Samobor area), and 2018 as well (in both towns). For all specimens of each recorded taxon, GPS location and habitat type according to the Classification of habitats in the Republic of Croatia were noted. The investigated invasive alien species were recorded within 31 different habitats in the Samobor area and in ten habitats in the Bregana area. Regarding the number of habitats, *Acer negundo* dominates in the Samobor area while *Robinia pseudoacacia* dominates in the Bregana area. *Amorpha fruticosa* was recorded in only one locality in the area of Bregana. It was not recorded in the Samobor area. The number of localities of investigated plants in the area of Samobor was lower in 2018 in comparison with the first research periods and they were not found on two previously investigated localities along the Gradna river, probably due to regulation of that part of the river, and more frequent landscaping and cleaning of public areas as well.

Key words: monitoring, invasive flora, woody plants, urban habitats

SPATIAL DISTRIBUTION OF THE INVASIVE SPECIES *Ambrosia artemisiifolia* L. IN THE TOWNS OF ZAGREB COUNTY

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Research of spatial distribution of *Ambrosia artemisiifolia* in the nine towns of Zagreb County was conducted during the years 2012 and 2016 on plots of 250x250 m^2. The number of inhabitants ranges from 14548 in Ivanić Grad to 63517 in Velika Gorica. Altogether, 541 plots were investigated. Among them, *A. artemisiifolia* was found at 271 plots (50.1%). In Ivanić Grad, the species was established on 31 of 73 surveyed plots (42.5%), in Jastrebarsko on 27 of 48 plots (56.2%), in Sveti Ivan Zelina on 21 of 44 plots (47.7%), in Sveta Nedjelja on 17 of 31 plots (54.8%), in Velika Gorica on 39 of 76 plots (51.3%), in Vrbovec on 19 of 48 plots (39.6%), in Zaprešić on 28 of 58 plots (48.3%), in Dugo Selo on 30 of 54 plots (55.5%), and in Samobor on 58 of 109 surveyed plots (53.2%). The comparative analysis of spatial distribution of *A. artemisiifolia* between Dugo Selo and Samobor showed that during the study period the number of new plots with ragweed has increased by 7.4% in Dugo Selo, and by 21.1% in Samobor. The increase of ragweed was more significant in urban parts of the towns, and less in the suburban-rural areas. This was the first organised research of invasive plants in Zagreb County, which has pointed to the need for more intensive monitoring and control of the IAS distribution and spread in order to mitigate their negative impact in the both towns of Zagreb County and the city of Zagreb.

Key words: ragweed, invasive alien plants (IAS) , distribution patterns, urban areas, Croatia

URBAN INVASIVE FLORA OF DARUVAR AND VIROVITICA

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The aim of the study was to compare the presence of invasive plant taxa in Daruvar and Virovitica- during 2017. The students and parents of the Technical School Daruvar and Primary school 'Ivana Brlić-Mažuranić, in cooperation with the employees of the Public Health Institute 'Sv.Rok', carried out the action of collecting data about ragweed (*Ambrosia artemisiifolia* L.) around Virovitica and Daruvar's area. Standard methods of collecting, determination and recording of plant taxa have been used. There were 11 invasive herbaceous plants taxa recorded with eight in Daruvar and eleven invasive taxa in Virovitica. *Asclepias syriaca* L, *Echinocystis lobata* (Michx.) Torr. et Gray and *Solidago gigantea* Aiton were recorded only in Virovitica. The most frequent were terophytes present in both cities, 5 plant taxa (*Ambrosia artemisiifolia* L. *Erigeron annuus* (L.) Pers., *Chenopodium ambrosioides* L., *Conyza canadensis* (L.) Cronquist and *Galinsoga ciliata* (Raf.) S.F.Blake). From 11 invasive plant taxa six are terophytes, two plant taxa geophytes and hemicrocytophytes and one plant taxa hamephytes. The analysis of the origin of invasive taxa suggests that most taxa (90.9%) originate from America, and only a sabotage carpover (*Carprobrotus acinaciformis* (L.) L. Bolus) originates from Africa. The most common invasive taxa in the majority of habitats in both cities is ragweed. It was recorded in a slightly larger number of different habitats in Virovitica than in Daruvar.

Key words: continental Croatia, Ambrosia, habitats

NEOPHYTES IN THE FLORA OF THE TOWN OF IMOTSKI

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Of the 321 explored plant taxa in the flora of Imotski, 35 taxa (11%) are neophytes which are constantly spreading and becoming naturalized in the composition of natural and anthropogenic habitats. The increasing urbanization of Imotski, the transport and transhipment of goods by sea, land and air, and the greater development of tourism are expected to increase the number of neophytes in the total flora. The largest numbers of neophytes originate from the American continent, accounting for 22 neophytes (63%), or 11 neophytes each from North and South America. Other neophytes originate from Asia, accounting for 10 species (28%), the Mediterranean, making up 2 species (5.7%), and Africa, accounting for 1 species (2.8%). Some neophytes of the allochthonous flora have been progressively spreading to the detriment of the autochthonous flora over the last few decades, and have become invasive species and show a further tendency to spread. One of the most invasive species in the flora of Croatia and of Imotski is *Ailanthus altissima* which has spread almost in all the habitats of the urban flora of Imotski. Other invasive species are *Aster squamatus, Conyza canadensis, Conyza bonariensis, Bidens subalternans, Paspalum paspalodes, Heliantus tuberosus, Ambrosia artemisifolia,* and others.

Keywords: neophytes, invasive species, anthropogenic habitats, allochthonous flora

INVASIVE ALIEN PLANT SPECIES KUDZU (*Pueraria montana* var. *lobata*) IN SLOVENIA

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The legume *Pueraria montana* var. *lobata* (kudzu) is one of the worst plant invaders on a global scale. This highly aggressive perennial vine, with an extraordinary growth capacity, originates from Southeast and East Asia. Where spreading invasively, it can overgrow and outcompete native vegetation, leading to the formation of large mono-specific stands. Kudzu constitutes a major problem in the south-eastern United Stated, whereas in Europe local infestations have been observed in Switzerland and northern Italy. The presence of this invasive plant species in Slovenia was not documented until recently. Last summer, however, first two confirmed records of kudzu were reported in the Invazivke.si database, where the information on invasive alien species is collected as part of the LIFE Artemis project. Both sites, where kudzu was found, are located in the Sub-Mediterranean phytogeographic region of Slovenia. At one site, kudzu smothers mature trees in a small forest patch. At the other location, the plant covers much larger area (~500 m^2). It spreads along the railroad and forms very dense cover. According to substantial diameter of woody stems we assume that kudzu has been present there for many years. Based on the EU regulations, kudzu is on the official list of alien species with a high risk of causing significant adverse impacts in the environment. Due to its potential to become abundant and harmful in climatically suitable areas, any occurrence of the plant should be carefully detected. Early detection and rapid response in the initial stages of the invasion are key activities that largely contribute to the effective mitigation of the uncontrolled spread and subsequent negative ecological and economic impacts of invasive alien species.

Keywords: kudzu, first detection, invasive potential, EU regulation, Invazivke.si

FIRST RECORD OF *Pistia stratiotes* L. (ARACEAE) IN CROATIA, WITH THE CONSIDERATION OF POSSIBLE INTRODUCTION PATHWAYS

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Pistia stratiotes L. (Araceae) is South American (or pan-tropical) free-floating, aquatic macrophyte, present on all continents, except Antarctica, today. In Europe it occurs casually in many countries, but it has established populations only in thermally abnormal waters in Slovenia, France and Germany. In the present study the first record of the species in Croatia is reported. It was recorded during autumn (September and November) of 2017 on several microlocalities on two lakes in the Sava-Strmec Special reserve (Zagreb County). On each microlocality several small colonies were found. All colonies consisted of a mother plant with attached daughter plants of different sizes, which would mean that the species was vegetatively reproducing on the site during the season. Flowers were not observed. Although the exact introduction pathway is not known, several possible pathways are taken into consideration and discussed. For now, the species should be treated as a casual alien species in Croatia.

Keywords: alien species, casual alien plant, Croatia, flora, water lettuce

Cardamine occulta HORNEM. - A NEW ALIEN PLANT TAXON IN CROATIA

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The Genus *Cardamine* L. (Brassicaceae) contains around 200 taxa distributed worldwide. Some taxa are invasive, e.g. *Cardamine impatiens* L. in the USA. In Europe, there are eight *Cardamine* taxa, which have an alien status outside their native European range. In the last decade of the 20th century a new plant taxon for Europe - *C. occulta*, was recorded in Spain and soon afterwards in many other European countries. Most of the observations were recorded for Switzerland and Italy. In Spain *C. occulta* is evaluated as a potential invasive species, and Marhold et al. (2016) suggest its invasive potential. The only areas without data about its presence are Scandinavia and South-Eastern Europe. Therefore, *C. occulta* has not been observed in the wild in Croatia or the neighbouring countries (Slovenia, Hungary, Serbia, Bosnia and Herzegovina and Montenegro). In this work, we will present its findings in Croatia. The plant was discovered as s container weed in one plant nursery in the city of Zadar (Dalmatia), during the cultivation of pine seedlings. We assumed that seeds of *C. occulta* were imported within the soil substrate. Because of its potential invasive character and morphological similarity with two native taxa, *C. hirsuta* and *C. flexuosa*, the determination key for all three taxa, and photos of *C. occulta* were prepared. This will probably increase the chance of early detection of this species in the wild.

Keywords: Brassicaceae, invasive flora, non-native flora, plant nursery

Nassella neesiana (TRIN. & RUPR.) BARKWORTH (POACEAE, STIPAE) A NEW POTENTIALLY INVASIVE ALIEN SPECIES IN CROATIA

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Nassella neesiana (Trin. & Rupr.) Barkworth (=*Stipa neesiana* Trin. & Rupr.), a Chilean needle grass originating from South America was recorded for the first time in the Croatian flora. It was found within ruderal vegetation on the island of Veli Brijun (National Park Brijuni, Istria, NW Croatia). Collected herbarium specimens are deposited and digitalized in ZAGR herbarium. Although it is sometimes found in restricted number *N. neesiana* is able to form dense stands and spread very fast. The species is adapted to a wide range of climates and soil types, and tolerant to drought, fire and grazing. The species can cause environmental damage to native grasslands, outnumbering native grasses or can create a fire hazards in urban areas. Considering the species has already been naturalized in some European countries, and the fact that territory of Northern Croatia has been evaluated as suitable for its eastward expansion, it is of great importance to follow the spread of the species. Judging by the invasive behaviour of the species in Australia and New Zealand, and their breakthrough to Europe, the conclusion emerges that pastures, natural grasslands and river banks of temperate and Mediterranean European countries might be at risk.

Keywords: flora, National Park Brijuni, *Stipa neesiana*

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